PUBLIC VERSION

UNITED STATES INTERNATIONAL TRADE COMMISSION

WASHINGTON, D.C.

In the Matter of **CERTAIN SILICON PHOTOVOLTAIC CELLS AND MODULES WITH NANOSTRUCTURES, AND PRODUCTS CONTAINING THE SAME**	**Inv. No. 337-TA-1271**

INITIAL DETERMINATION ON VIOLATION OF SECTION 337 AND RECOMMENDED DETERMINATION ON REMEDY AND BOND

Chief Administrative Law Judge Clark S. Cheney

(September 1, 2022)

Pursuant to the Notice of Investigation, 86 Fed. Reg. 38356 (July 20, 2021), and 19 C.F.R. §§ 210.10(b), 210.42(a)(1)(i), this is the final initial determination in the matter of *Certain Silicon Photovoltaic Cells and Modules with Nanostructures, and Products Containing the Same*, Investigation No. 337-TA-1271.

For the reasons stated herein, I have determined that no violation of section 337 of the Tariff Act of 1930, as amended, has been demonstrated in the record of this investigation.

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Table of Abbreviations

CDX	Complainant's demonstrative exhibit
CIB	Complainant's initial post-hearing brief
CPX	Complainant's physical exhibit
CRB	Complainant's responsive post-hearing brief
CX	Complainant's exhibit
Dep.	Deposition
JX	Joint Exhibit
RDX	Respondents' demonstrative exhibit
RIB	Respondents' initial post-hearing brief
RPB	Respondents' pre-hearing brief
RPX	Respondents' physical exhibit
RX	Respondents' exhibit
SIB	Staff's initial post-hearing brief
Tr.	Transcript

I. INTRODUCTION

A. Procedural History

On June 11, 2021, complainant Advanced Silicon Group Technologies, LLC ("Complainant" or "ASGT") filed a complaint alleging violations of section 337 based on the importation into the United States, the sale for importation, and the sale within the United States after importation of certain silicon photovoltaic cells and modules with nanostructures, and products containing the same. 86 Fed. Reg. 38356 (July 20, 2021); *see* EDIS Doc. ID No. 744611.

By publication of a notice in the *Federal Register* on July 20, 2021, pursuant to subsection (b) of section 337 of the Tariff Act of 1930, as amended, the Commission instituted this investigation to determine:

> whether there is a violation of subsection (a)(1)(B) of section 337 in the importation into the United States, the sale for importation, or the sale within the United States after importation of certain products identified in paragraph (2) by reason of infringement of one or more of claims 15, 17, 23–25, and 27 of the '599 patent [U.S. Patent No. 8,450,599]; claims 1, 2, 4, 13, 18, 23, 26, and 27 of the '981 patent [U.S. Patent No. 8,852,981]; claims 1, 4, 11–14, and 16–18 of the '640 patent [U.S. Patent No. 9,601,640]; claims 1, 2, and 10 of the '331 patent [U.S. Patent No. 9,768,331]; claims 1, 2, and 7–11 of the '995 patent [U.S. Patent No. 10,269,995]; and claims 1, 7, 8, 10, and 15 of the '971 patent [U.S. Patent No. 10,692,971], and whether an industry in the United States exists or is in the process of being established as required by subsection (a)(2) of section 337.

86 Fed. Reg. 38356 (July 20, 2021) ("Notice of Investigation").

Pursuant to section 210.10(b)(1) of the Commission's Rules of Practice and Procedure, 19 C.F.R. § 210.10(b)(1), the plain language description of the accused products or category of accused products, which defines the scope of the investigation, is "silicon photovoltaic cells and modules containing such cells . . . in which at least one surface of the silicon photovoltaic cell has nanostructures." 86 Fed. Reg. 38356.

The Notice of Investigation named the following parties as respondents:

1. Canadian Solar, Inc., of Ontario, Canada;
2. Canadian Solar International Limited of Hong Kong, People's Republic of China;
3. Canadian Solar Manufacturing (Changshu) Co. Inc. of Changshu, Jiangsu, People's Republic of China;
4. Canadian Solar Manufacturing (Luoyang) Inc. of Luoyang, Henan Province, China;
5. Canadian Solar Manufacturing (Thailand) Co. Ltd. of Chon Buri, Kingdom of Thailand;
6. Canadian Solar Manufacturing Vietnam Co. Ltd. of Hai Phong City, Socialist Republic of Vietnam;
7. Canadian Solar Solutions, Inc., of Ontario, Canada;
8. Canadian Solar Construction (USA) LLC of Walnut Creek, California;
9. Canadian Solar (USA) Inc. of Walnut Creek, California;
10. Recurrent Energy Group, Inc., of San Francisco, California;
11. Recurrent Energy LLC of Walnut Creek, California;
12. Recurrent Energy SH Proco LLC of Walnut Creek, California;
13. Hanwha Q CELLS & Advanced Materials Corp. of Seoul, Republic of Korea;
14. Hanwha Q Cells GmbH of Bitterfeld-Wolfen, Federal Republic of Germany;
15. Hanwha Q Cells Malaysia Sdn. Bhd. of Selangor, Malaysia;
16. Hanwha Q Cells (Qidong) Co., Ltd., of Jiangsu, People's Republic of China;
17. Hanwha Solutions Corporation of Seoul, Republic of Korea;
18. Hanwha Energy USA Holdings Corp. of Irvine, California;
19. Hanwha Q Cell EPC USA LLC of Irvine, California;
20. Hanwha Q Cells America Inc. of Irvine, California;
21. Hanwha Q Cells USA Corp. of Irvine, California;
22. Hanwha Q Cells USA Inc. of Dalton, Georgia;
23. HQC Rock River Solar Holdings LLC of Irvine, California;
24. HQC Rock River Solar Power Generation Station, LLC of Beloit, Wisconsin;
25. Boviet Solar Technology Co., Ltd., of Bac Giang Province, Socialist Republic of Vietnam;
26. Ningbo Boway Alloy Material Co., Ltd., of Zhejiang Province, People's Republic of China;
27. Boviet Renewable Power LLC of San Jose, California; and

28. Boviet Solar USA Ltd. of San Jose, California.

The Commission Investigative Staff ("Staff") is a party to this investigation. *Id.*

The target date for completion of this investigation was originally set at approximately 14.8 months, *i.e.*, October 14, 2022. *See* Order No. 3 (Aug. 13, 2021). Accordingly, the original due date for the final initial determination was June 14, 2022.

The Commission affirmed the following initial determinations:

- Order No. 6 (Initial Determination Extending the Target Date (Corrected)) (Oct. 14, 2021) (granting joint motion to extend the target date), *aff'd*, Commission Determination Not to Review an Initial Determination Extending the Target Date in This Investigation (Nov. 3, 2021);

- Order No. 7 (Initial Determination Granting Motion for Partial Termination of the Investigation Based on Withdrawal of the Complaint as to U.S. Patent No. 10,692,971) (Feb. 1, 2022), and Order No. 8 (Initial Determination Granting Motion to Terminate Certain Respondents Based on Withdrawal of the Complaint) (Feb. 1, 2022),[1] *aff'd*, Commission Determination Not to Review Two Initial Determinations Terminating the Investigation as to U.S. Patent No. 10,692,971 and Terminating the Investigation as to Certain Respondents (Feb. 22, 2022); and

- Order No. 12 (Initial Determination Granting Motions for Partial Termination of the Investigation Based on Withdrawal of the Complaint) (May 31, 2022), *aff'd*, Commission Determination Not to Review an Initial Determination Partially Terminating the Investigation (June 21, 2022).

A prehearing conference was held on April 6, 2022, with the evidentiary hearing in this investigation commencing immediately thereafter. The hearing concluded on April 11, 2022. *See* Order No. 5 (Oct. 13, 2021); P.H. Tr. 1-29; Tr. 1-976. The parties were requested to file initial

[1] The following respondents were terminated as a result of Order No. 8: Canadian Solar, Inc.; Canadian Solar Manufacturing (Changshu) Co. Inc.; Canadian Solar Manufacturing (Luoyang) Inc.; Canadian Solar Solutions, Inc.; Canadian Solar Construction (USA) LLC; Recurrent Energy Group Inc.; Recurrent Energy, LLC; Hanwha Q Cells GmbH; Hanwha Q Cells (Qidong) Co.; Ltd.; Hanwha Energy USA Holdings Corp. (d/b/a 174 Power Global Corporation); Hanwha Q Cells USA Corp.; HQC Rock River Solar Holdings LLC; HQC Rock River Solar Power Generation Station, LLC; and Hanwha Q CELLS & Advanced Materials Corp.

post-hearing briefs not to exceed 300 pages in length, and to file responsive briefs not to exceed 80 pages in length. *See* Order No. 10 (Mar. 28, 2022). On April 26, 2022, the parties filed a joint outline of the issues to be decided in the final initial determination. *See* Joint Outline of Issues to be Decided in the Initial Determination ("Joint Outline") (EDIS Doc. ID No. 769241). On May 6, 2022, the parties filed a joint outline for the responsive briefs. *See* Joint Outline of Issues to Be Decided in the Initial Determination ("Joint Responsive Outline") (EDIS Doc. ID No. 770136).

On June 23, 2022, the investigation was reassigned to me. *See* Notice to the Parties (June 23, 2022) (EDIS Doc. ID No. 773726). In view of the reassignment, I extended the target date for completion of the investigation to January 3, 2023, making this initial determination due no later than September 2, 2022. *See* Order No. 13 (Aug. 1, 2022); Order No. 15 (Aug. 26, 2022).

B. The Private Parties

1. Complainant ASGT

The complainant in this investigation is Advanced Silicon Group Technologies, LLC ("ASGT"), a Delaware limited liability company having a principal place of business in Lowell, Massachusetts. Complaint, ¶ 8; CX-2407C (Bazelon WS) at Q/A 21. ASGT was formed by Dr. Marcie Black and Mr. William Rever in 2020 and is focused on monetizing its intellectual property rights in the solar industry. CX-2405C (Black WS) at Q/A 129 ("We hope that the revenue will mostly come from licensing and maybe consulting but likely will also come from pursuing our intellectual property rights."); CX-2406C (Rever WS) at Q/A 44 ("[W]e decided to explore the potential of a lawsuit or otherwise getting recovery from the use of our technology."). Dr. Black is the Chief Executive Officer of ASGT.

ASGT is relying upon the activities of its licensee Advanced Silicon Group, Inc. ("ASG") to support ASGT's allegations of a domestic industry in existence and a domestic industry in the

process of being established. *See* Complaint, Ex. 53 (Black DI Declaration), ¶ 1; CX-2405C (Black WS) at Q/A 151; CX-2407C (Bazelon WS) at Q/A 192. Dr. Black and Mr. Rever are the founders of ASG, a company currently focused on developing biosensors for the detection and measurement of proteins, nucleic acids, and potentially other biological molecules. Complaint, Ex. 53 (Declaration of Marcie Black Regarding Domestic Industry) ("Black DI Declaration"), ¶ 1; CX-2405C (Black WS) at Q/A 132; CX-2406C (Rever WS) at Q/A 5-6.

In 2020, ASG assigned the Asserted Patents[2] to ASGT and received back from ASGT a license to the Asserted Patents so that ASG could separately pursue its biosensor activities and ASGT could separately pursue its solar cell activities. *See* CX-2405C (Black WS) at Q/A 121-125; CX-2406C (Rever WS) at Q/A 44.

2. Respondents

a. Canadian Solar Respondents

Canadian Solar, Inc., terminated from this investigation, is a corporation organized under the laws of British Columbia with a principal place of business in Ontario, Canada. *See* Complaint, ¶ 9; Canadian Solar Response to Complaint, ¶ 9. Canadian Solar, Inc., is the parent company of the other Canadian Solar respondents in this investigation and purports to be one of the world's largest solar power plant developers. *See* CX-2407C (Bazelon WS) at Q/A 25; RX-0598C (Schoettelkotte RWS) at Q/A 18 ("Canadian Solar describes itself as one of the world's largest solar power companies and a leading vertically-integrated provider of solar power products, services, and system solutions."); RX-0602C (Koerner RWS) at Q/A 11 ("Canadian Solar was

[2] The "Asserted Patents" in this investigation are the '599 patent, the '981 patent, the '640 patent, and the '331 patent.

founded in 2001" and has "deployed more than 55 gigawatt of PV [(photovoltaic)] modules globally, which is equivalent roughly to 14 million residential homes being powered by solar.").

Canadian Solar International Limited ("Canadian Solar International") is a subsidiary of Canadian Solar, Inc., existing under the laws of Hong Kong, China, with a principal place of business in Hong Kong, China. *See* Complaint, ¶ 10; Canadian Solar Response to Complaint, ¶ 10. Complaint, ¶ 10.

Canadian Solar Manufacturing (Thailand) Co. Ltd. ("Canadian Solar Thailand") is a subsidiary of Canadian Solar, Inc., existing under the laws of Thailand with a principal place of business in Chon Buri, Thailand. *See* Complaint, ¶ 13; Canadian Solar Response to Complaint, ¶ 13. Complaint, ¶ 13.

Canadian Solar Manufacturing Vietnam Co. Ltd. ("Canadian Solar Vietnam") is a subsidiary of Canadian Solar, Inc., existing under the laws of Vietnam with a principal place of business in Hai Phong City, Vietnam. *See* Complaint, ¶ 14; Canadian Solar Response to Complaint, ¶ 14.

Canadian Solar (USA) Inc. ("Canadian Solar USA") is a corporation organized under the laws of the State of Delaware and a subsidiary of Canadian Solar, Inc. having a principal place of business in Walnut Creek, California. *See* Complaint, ¶ 17; Canadian Solar Response to Complaint, ¶ 17.

Recurrent Energy SH Proco LLC ("Recurrent Energy") is a limited liability company organized under the laws of the State of Delaware and a subsidiary of Canadian Solar, Inc., having a principal place of business in Walnut Creek, California. *See* Complaint, ¶ 20; Canadian Solar Response to Complaint, ¶ 20.

b. Hanwha Respondents

Hanwha Solutions Corporation ("Hanwha Solutions") is a corporation existing under the laws of the Republic of Korea with a principal place of business in Seoul, Republic of Korea. *See* Complaint, ¶¶ 21, 25; Hanwha Response to Complaint, ¶¶ 21, 25. Hanwha Solutions is the parent company of the other Hanwha respondents in this investigation and purports to be a leading global solar company. *See* CX-2407C (Bazelon WS) at Q/A 27; RX-0597C (Schwabedissen RWS) at Q/A 5; RX-0598C (Schoettelkotte RWS) at Q/A 20 (Hanwha Solutions is "a global leader in solar cell production that provides a full range of solar products and solutions.").

Hanwha Q Cells EPC USA LLC ("Hanwha Q Cells EPC") is a company organized under the laws of the State of Delaware having a principal place of business in Irvine, California. *See* Complaint, ¶ 27; Hanwha Response to Complaint, ¶ 27.

Hanwha Q Cells America Inc. ("Hanwha Q Cells America") is a corporation organized under the laws of the State of California having a principal place of business in Irvine, California. *See* Complaint, ¶ 28; Hanwha Response to Complaint, ¶ 28.

Hanwha Q Cells USA Inc. ("Hanwha Q Cells USA") is a corporation organized under the laws of the State of Delaware having a principal place of business in Dalton, Georgia. *See* Complaint, ¶ 30; Hanwha Response to Complaint, ¶ 30.

Hanwha Q Cells Malaysia Sdn. Bhd ("Hanwha Q Cells Malaysia") is a corporation existing under the laws of Malaysia having a principal place of business in Selangor, Malaysia. *See* Complaint, ¶ 23; Hanwha Response to Complaint, ¶ 23.

c. Boviet Respondents

Ningbo Boway Alloy Material Co., Ltd. ("Ningbo Boway") is a public company existing under the laws of the People's Republic of China having a principal place of business in Zhejiang

Province, People's Republic of China. *See* Complaint, ¶ 33; Boviet Response to Complaint, ¶ 33. Ningbo Boway is the parent company of the other Boviet respondents in this investigation and its "[p]roducts include solar cells and components." CX-2407C (Bazelon WS) at Q/A 29; RX-0598C (Schoettelkotte RWS) at Q/A 22 (Ningo Boway's "new energy offerings" include "solar energy-related products.").

Boviet Solar Technology Co., Ltd. ("Boviet Solar Technology Vietnam") is a corporation existing under the laws of Vietnam and a subsidiary of Ningbo Boway having a principal place of business in Bac Giang Province, Vietnam. *See* Complaint, ¶ 33; Boviet Response to Complaint, ¶ 33.

Boviet Solar USA Ltd. ("Boviet Solar USA") is a corporation existing under the laws of the State of Delaware and a subsidiary of Ningbo Boway having a principal place of business in San Jose, California. *See* Complaint, ¶ 35; Boviet Response to Complaint, ¶ 35.

C. The Asserted Patents

As noted above, ASGT asserts four patents in this investigation: the '599 patent, the '981 patent, the '640 patent, and the '331 patent.

1. U.S. Patent No. 8,450,599

The '599 patent, titled "Nanostructured Devices," issued on May 28, 2013, and names Brent Buchine, Faris Modawar, and Marcie Black as inventors. JX-0001 ('599 Patent) at Cover. The '599 patent issued from Application No. 12/619,092, filed on November 16, 2009, and claims a priority date of November 14, 2008. *Id.* The '599 patent was originally assigned to Bandgap. *Id*. As indicated above, the '599 patent was assigned subsequently to ASGT. Complaint, ¶ 43; CX-2405C (Black WS) at Q/A 121-25; CX-2406C (Rever WS) at Q/A 44.

ASGT asserts apparatus claims 15, 23, 24, and 27 of the '599 patent. *See* CIB. at 11-12, 125, 133, 136. The asserted claims read as follows:

> 15 [preamble]. A photovoltaic device comprising:
>
> [a] a crystalline semiconductor substrate comprising:
>
> [i] a bottom p-doped region;
>
> [ii] a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located at least about 30 nm from the bottom of the nanowires and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region; and
>
> [b] a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate.
>
> 23. A device as described in claim 15, wherein the device is fabricated using a process comprising metal enhanced etching in a solution comprising HF and an oxidizer.
>
> 24. A device as described in claim 15, wherein the p-n junction is located at least about 300 nm from the bottom of the nanowires.
>
> 27. A device as described in claim 15, wherein the crystalline semiconductor comprises polycrystalline silicon.

JX-0001 ('599 Patent) at claims 15, 23, 24, and 27.

2. U.S. Patent No. 8,852,981

The '981 patent, titled "Electrical Contacts to Nanostructured Areas," issued on October 7, 2014, and names Marcie Black, Joanne Forziati, Michael Jura, Jeff Miller, Brian Murphy, and Adam Standley as inventors. JX-0002 ('981 Patent) at Cover. The '981 patent issued from Application No. 13/622,864, filed on September 19, 2012, and claims a priority date of September 19, 2011. *Id.* The '981 patent was originally assigned to Bandgap. *Id*. As indicated above, the '981 patent was assigned subsequently to ASGT. Complaint, ¶ 51; CX-2405C (Black WS) at Q/A 121-25; CX-2406C (Rever WS) at Q/A 44.

Complainant asserts process claims 1, 13, 23, and 27 of the '981 patent. *See* CIB at 11-12, 113, 119, 122. The asserted claims read as follows:

> 1. A process comprising:
>
> (a) providing a substrate having a nanostructured material on a surface, the substrate being conductive and the nanostructured material being coated with an insulating material,
>
> (b) removing the nanostructured material and electrically insulating material at least partially from a portion of the surface, and
>
> (c) depositing a conductor on the substrate in such a way that the conductor is in electrical contact with the substrate through the portion of the surface where the nanostructured material and insulating material has been at least partially removed.
>
> 13. The process of claim 1, wherein the step of removing the nanostructured material and insulating material comprises heating or cooling.
>
> 23. The process of claim 1, wherein step (c) comprises screen printing.
>
> 27. A process comprising:
>
> (a) providing a substrate having a nanostructured material on a surface,
>
> (b) removing the nanostructured material from a portion of the surface, and
>
> (c) depositing an electrical contact in the portion of the surface from which the nanostructured material was removed.

JX-0002 ('981 Patent) at claims 1, 13, 23, and 27.

3. U.S. Patent No. 9,601,640

The '640 patent, titled "Electrical Contacts to Nanostructured Areas," issued on March 21, 2017, and names Marcie Black, Joanne Forziati, Michael Jura, Jeff Miller, Brian Murphy, and Adam Standley as inventors. JX-0003 ('640 Patent) at Cover. The '640 patent issued from Application No. 14/468,219, filed on August 25, 2014, and claims a priority date of September 19, 2011. *Id.* The application resulting in the '640 patent is a division of the same application that

lead to the ’981 patent and, as a result, the two patents share essentially the same specification. *Id.* The ’640 patent was originally assigned to ASG but was assigned subsequently to ASGT. Complaint, ¶ 57. CX-2405C (Black WS) at Q/A 121-25; CX-2406C (Rever WS) at Q/A 44.

Complainant asserts apparatus claims 1, 4, and 11-13 of the ’640 patent. *See* CIB. at 11-12, 66, 88, 102. The asserted claims read as follows:

> 1 [Preamble]. An optoelectronic device comprising:
>
> [a] a substrate including a first surface;
>
> [b] a nanostructured area including nanostructures on the first surface of the substrate, the nanostructured area including a first segment in which the nanostructures are intact and a second segment in which the nanostructures are at least partially broken or removed, the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate;
>
> [c] an electrically insulating layer atop the first surface; and
>
> [d] a conductor atop the electrically insulating layer over the second segment.
>
> 4. The optoelectronic device of claim 1, wherein the conductor makes electrical contact to the substrate through the insulating layer over the second segment.
>
> 11. The optoelectronic device of claim 1, wherein the nanostructures comprise silicon.
>
> 12. The optoelectronic device of clam 1, comprising a photovoltaic cell.
>
> 13. The optoelectronic device of claim 11, wherein the nanostructures comprise silicon nanowires.

JX-0003 (’640 Patent) at claims 1, 4, and 11-13.

4. U.S. Patent No. 9,768,331

The ’331 patent, titled “Screen Printing Electrical Contacts to Nanowire Areas,” issued on September 19, 2017, and names Michael Jura, Marcie Black, Jeffrey Miller, Joanne Yim, Joanne Forziati, Brian Murphy, and Richard Chleboski as inventors. JX-0004 (’331 Patent) at Cover. The

'331 patent issued from Application No. 14/338,752, filed on July 23, 2014, and claims a priority date of February 14, 2012. *Id.* The '331 patent was originally assigned to ASG but was assigned subsequently to ASGT. Complaint, ¶ 64; CX-2405C (Black WS) at Q/A 121-25; CX-2406C (Rever WS) at Q/A 44.

Complainant asserts apparatus claim 1 of the '331 patent. *See* CIB. at 11-12, 141, 144, 146. The asserted claim reads as follows:

> 1 [Preamble]. A silicon nanostructured device comprising:
>
> [a] a non-nanostructured substrate;
>
> [b] a nanostructured area disposed on and contacting a surface of the substrate;
>
> [c] a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride,
>
> [d] one or more contacts comprising a comb-like pattern of metal directly contacting the nanostructured area; and
>
> [e] a p-n junction below the nanostructured area.

JX-0004 ('331 Patent) at claim 1.

D. The Technologies at Issue

Photovoltaic cells use semiconductor material to convert light to electricity. JX-0001 ('599 Patent) at 1:14-27. As described in the Complaint, the '599 patent relates to "an improved version of a photovoltaic cell" (or "solar cell") that is "made of a special type of silicon that absorbs light, typically sunlight, to produce electricity." Complaint, ¶ 44. The '981 patent provides "an improved process for forming electrical contacts on nanostructured silicon surfaces." Complaint, ¶ 53. The '640 patent provides "an improved process for contacting nanostructures on a surface of an optoelectronic device." Complaint, ¶ 60. The '331 patent relates to "a nanostructured silicon device with screen printed electrical contacts" and discloses that "short nanowires provide

desirable anti-reflection and scattering properties, while being compatible with a screen-printing process." Complaint, ¶ 67.

E. The Accused Products

1. Canadian Solar Accused Products

ASGT accuses Canadian Solar of infringing the Asserted Patents by importing and selling solar modules that incorporate passivated emitter rear cell (PERC) technology. Canadian Solar refers to the solar cells in such modules as P4 solar cells. ASGT and Canadian Solar have stipulated that the following Canadian Solar modules incorporate P4 solar cells and were imported in the United States: CS3K-P; CS3U-P; CS3U-PB-AG; CS3W-P; CS3W-PB-AG; CS6L-P; CS6P-PX; CS6U-P; CS6XH-P; and CS6X-P ("Canadian Solar Accused Products"). *See* Final Joint Submission Regarding Accused Products at 6-7 (Dec. 7, 2021) (EDIS Doc. ID No. 758106); CIB at 19; RIB at 14; SIB at 19.

2. Hanwha Accused Products

ASGT accuses Hanwha of infringing the Asserted Patents by importing and selling polycrystalline cells and modules containing such cells with the following Hanwha model designations: Q.PLUS BFR G4.1, Q.PLUS DUO L G5.2, Q.PLUS G4, Q.PLUS G4.3, Q.PLUS L G4.1, Q.PLUS L G4.2. *See* Final Joint Submission Regarding Accused Products at 6 (Dec. 7, 2021) (EDIS Doc. ID No. 758106). ASGT provided analysis of only two Hanwha polycrystalline products, however: the Q.PLUS L G4.2 ("Hanwha 4.2 Products") and the Q.PLUS DUO L G5.2 ("Hanwha 5.2 Products"). *See* CIB at 19; RIB at 15; SIB at 19-20.

3. Boviet Accused Products

ASGT accuses Boviet of infringing the Asserted Patents by importing and selling the silicon photovoltaic cells and modules listed below:

Product Name	Product Name (Cont.)	Product Name (Cont.)
[1] 15M	[41] BVM6610P-270-A34- B-PERC-R6	[81] BVM6612P-320-E04-PERC-H4
[2] 15W	[42] BVM6610P-270-D00- B-R6	[82] BVM6612P-320-WW
[3] 15W-P	[43] BVM6610P-270-D05-B	[83] BVM6612P-325-B04-B
[4] 260W	[44] BVM6610P-270-D26-B	[84] BVM6612P-325-B36- B-PERC
[5] 6612P315WWR	[45] BVM6610P-275-D05-B	[85] BVM6612P-325-B36- M4
[6] 6612P320E04B	[46] BVM6610P-285	[86] BVM6612P-325-B36-B
[7] AS-6P30-250W	[47] BVM6612P 300W	[87] BVM6612P-325-B39-B
[8] B-grade BVM6610P- 250W	[48] BVM6612P-300	[88] BVM6612P-325-B42- B-PERC
[9] B-grade BVM6610P- 255W	[49] BVM6612P-300-WW	[89] BVM6612P-325-B42-B
[10] B-grade BVM6610P- 260W	[50] BVM6612P-305	[90] BVM6612P-325-D26
[11] BVM6610P-245-SWW	[51] BVM6612P-305CA	[91] BVM6612P-325-E04
[12] BVM6610P-245W	[52] BVM6612P-305-E15	[92] BVM6612P-325-E04-B
[13] BVM6610P-250	[53] BVM6612P-305W	[93] BVM6612P-325-E36-B
[14] BVM6610P-250-BB	[54] BVM6612P-305-WW	[94] BVM6612P-330-B36-B
[15] BVM6610P-250-BW	[55] BVM6612P-310	[95] BVM6612P-330-B42- B-M4
[16] BVM6610P-250-D10	[56] BVM6612P-310-C00	[96] BVM6612P-330-B42- B-PERC
[17] BVM6610P-250W	[57] BVM6612P-310CA	[97] BVM6612P-330-E04
[18] BVM6610P-250W-SWW	[58] BVM6612P-310-E04	[98] BVM6612P-330-E04-B
[19] BVM6610P-250-WW	[59] BVM6612P-310-E08	[99] BVM6612P-330-E15
[20] BVM6610P-255	[60] BVM6612P-310-E15	[100] BVM6612P-330-E36-B
[21] BVM6610P-255-BW	[61] BVM6612P-310-E27	[101] BVM6612P-335-B36- B-PERC
[22] BVM6610P-255-W	[62] BVM6612P-310-SBB	[102] BVM6612P-335-B36- B-PERC-M4
[23] BVM6610P-255-WW	[63] BVM6612P-310W	[103] BVM6612P-335-B36-B
[24] BVM6610P-260	[64] BVM6612P-310-WW	[104] BVM6612P-335-B39- B-PERC
[25] BVM6610P-260-BW	[65] BVM6612P-315	[105] BVM6612P-335-B39-B
[26] BVM6610P-260-D08	[66] BVM6612P-315BW	[106] BVM6612P-335-B42- B-PERC
[27] BVM6610P-260-SBB	[67] BVM6612P-315-E04	[107] BVM6612P-335-B42- B-PERC-M4
[28] BVM6610P-260-SBW	[68] BVM6612P-315-E15	[108] BVM6612P-335-E04
[29] BVM6610P-260-SWW	[69] BVM6612P-315-UPM	[109] BVM6612P-335-E04-B
[30] BVM6610P-260W	[70] BVM6612P-315W	[110] BVM6612P-335-E04-B-PERC
[31] BVM6610P-260WP	[71] BVM6612P-315-WW	[111] BVM6612P-340-B36- B-PERC
[32] BVM6610P-260-WW	[72] BVM6612P-315-WW (RMA)	[112] BVM6612P-340-B36-B
[33] BVM6610P-265	[73] BVM6612P-320	[113] BVM6612P-340-B39- B-PERC
[34] BVM6610P-265-A08	[74] BVM6612P-320-4BB	[114] BVM6612P-340-B42- B-PERC
[35] BVM6610P-265-D08	[75] BVM6612P-320-B36- B-PERC	[115] BVM6612P-345-B39- B-PERC
[36] BVM6610P-265-WW	[76] BVM6612P-320-B36-B	[116] BVM6612P-345-B42- B-PERC
[37] BVM6610P-270-A04-B	[77] BVM6612P-320-B39-B	[117] BVM6612P-350
[38] BVM6610P-270-A05-B	[78] BVM6612P-320-E04	[118] PHOTOVOLTAIC Module ORION SERIES Polycrystalline Module
[39] BVM6610P-270-A08-B	[79] BVM6612P-320-E04- D-J1	[119] P-SOLAR MODULE-15
[40] BVM6610P-270-A31- B-PERC-R6	[80] BVM6612P-320-E04-B	[120] UPS6610P-255-BW

(collectively, "Boviet Products"). *See* Final Joint Submission Regarding Accused Products at 2-5 (Dec. 7, 2021) (EDIS Doc. ID No. 758106); CIB at 20; RIB at 15-16; SIB at 20-21.

F. The Domestic Industry Products

To demonstrate satisfiaction of the domestic industry requirement of section 337, ASGT alleges that the ASG LightSense Biosensor is protected by at least one claim of each of the

Asserted Patents. *See* Complainant's List of Products It Will Rely Upon To Satisfy The Domestic Industry Requirement (Nov. 15, 2021).

Although ASGT relies upon only the ASG LightSense Biosensor chip to demonstrate satisfaction of the technical prong of the domestic industry requirement, ASGT relies upon investments related to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader to demonstrate satisfaction of the economic prong of the domestic industry requirement. *See, e.g.*, CX-2407C (Bazelon WS) at Q/A 32-35; CX-2410C (Rotello WS) Q/A 25-28. ASGT's economic expert, Dr. Coleman Bazelon, admitted that the ASG LightSense Biosensor chip reader itself does not practice any claim of any Asserted Patent, but he argued that the reader must be used with the ASG LightSense Biosensor chip for the chips to succeed in the market. CX-2407C (Bazelon WS) at Q/A 33 ("I considered the sensor and reader together for my analysis of the domestic industry economic activity, because they would need to be used in concert to be successful on the market.").

II. JURISDICTION AND IMPORTATION

A. Subject Matter Jurisdiction

Section 337 of the Tariff Act prohibits the importation, the sale for importation, or the sale after importation of articles that infringe a valid and enforceable patent if an industry exists in the United States relating to articles protected by the patent. 19 U.S.C. §§ 1337(a)(1)–(2). The complaint states a cause of action under section 337 by alleging that Respondents import and sell after importation certain silicon photovoltaic cells and modules that infringe the Asserted Patents. *See* Complaint, ¶¶ 9-35, 83-148. Respondents do not contest that the Commission has subject matter jurisdiction over this investigation. *See* RIB at 16.

I determine the Commission has subject matter jurisdiction over this investigation.

B. Personal Jurisdiction

By filing a complaint and amended complaint and participating in the investigation, Complainant has consented to personal jurisdiction at the Commission. *See Certain Toner Cartridges, Components Thereof, and Systems Containing the Same*, 337-TA-1174, Initial Determination at 35, *not reviewed*, Comm'n Determination Not to Review an Initial Determination Granting Complainants' Motion for Summary Determination of a Violation of Section 337, EDIS Doc. ID 728235 (Dec. 17, 2020). By appearing and participating in this investigation and not contesting the Commission's jurisdiction over it, Respondents have each consented to personal jurisdiction at the Commission. *See* RIB at 16 ("Respondents do not dispute jurisdiction."). I therefore determine that the Commission has personal jurisdiction over all parties. *See, e.g.*, *Certain Strontium-Rubidium Radioisotope Infusion Systems, and Components Thereof Including Generators*, Inv. No. 337-TA-1110, Initial Determination at 9, USITC Pub. No. 5025 (Feb. 2021), *not reviewed in pertinent part*, EDIS Doc. ID 689653 ("*Radioisotope Infusion Systems*").

C. Importation

A violation of section 337 based on patent infringement requires "[t]he importation into the United States, the sale for importation, or the sale within the United States after importation by the owner, importer, or consignee" of infringing products. 19 U.S.C. §§ 1337(a)(1)(A)–(B). All Respondents have stipulated that they have imported the Accused Products into the United States, imported, sold for importation, or sold after importation at least one Accused Product. *See* JX-0019 (Stipulation Between Complainant and Canadian Solar Respondents Regarding Importation and Inventory; JX-0020 (Stipulation Between Complainant and Hanwha Respondents Regarding Importation and Inventory); JX-0021 (Stipulation Between Complainant and Boviet

Respondents Regarding Importation and Inventory). I determine the importation requirement of section 337 has been satisfied.

D. *In Rem* Jurisdiction

Respondents do not dispute that the Commission has *in rem* jurisdiction over the accused products. RIB at 16. I therefore find the Commission has *in rem* jurisdiction over the Accused Products in this Investigation. *See Sealed Air Corp. v. Int'l Trade Comm'n*, 645 F.2d 976, 985–86 (C.C.P.A. 1981) (noting the Commission has jurisdiction over imported goods).

E. Standing

Ownership of the intellectual property claimed in the Asserted Patents has transferred several times. The history begins at Bandgap Engineering, Inc. ("Bandgap"), a company Dr. Black founded before she founded ASG (Complainant ASGT's licensee). The technology claimed in the Asserted Patents was developed at Bangap. *See* CX-2405C (Black WS) at Q/A at 19-34, 41. When Bandgap was winding down in 2014, a group of seven Bandgap noteholders, including Dr. Black, acquired Bandgap's intellectual property assets. *See* CX-2405C (Black WS) at Q/A 116-18; CX-1911C; CX-2493.2; CX-1912C; CX-1907C. The property acquired included the Asserted Patents. *See* CX-1912C.19-21; CX-2405C (Black WS) at Q/A 116-18.

In 2015, the former Bandgap noteholders, who then owned the Asserted Patents, entered into a "Patent Rights Transfer and Payment Agreement" with ASG. *See* CX-1913C ("2015 Payment Agreement") at ASG_000030836, ASG_000030848. The 2015 Payment Agreement with ASG was accompanied by a Patent Rights Assignment ("Rights Assignment"). *See* CX-1913C at ASG_000030836 (2015 Payment Agreement) and ASG_000030852 (Rights

Assignment).[3] In 2020, ASGT assumed the rights and obligations of ASG under a separate agreement. *See* CX-1719C ("2020 Assignment and Assumption").

Respondents contend that "ASGT lacks standing to bring this action in its own right because the agreements under which it now claims the right to sue for infringement did not convey all substantial rights in the Asserted Patents." RIB at 260. Specifically, Respondents focus on the 2015 Payment Agreement, which provided that the former Bandgap noteholders retained certain rights, including: [redacted] CX-1913C.01-03 (§§4-7); 3 (§9); 4 (§11); 4 (§13); 5 (§15.e). Respondents thus conclude that "[t]hese collective restrictions give the former noteholders an element of control that exceeds that of a passive security interest, thereby establishing that ASGT does not have all substantial rights and lacks standing to bring this action on its own without the former noteholders." RIB at 264.

"An assignment of an interest in an invention secured by letters-patent, is a contract, and like all other contracts is to be construed so as to carry out the intention of the parties to it." *Nicolson Pavement Co. v. Jenkins*, 81 U.S. 452, 456 (S. Ct. 1871). To determine the intention of the parties, a tribunal must consider the "totality" of the agreement. *Lone Star Silicon Innovations v. Nanya Technology*, 925 F.3d 1225, 1229 (Fed. Cir. 2019). Because the standing inquiry "depends on the substance of what was granted," *see id*., different agreements can lead to different

[3] CX-1913C includes two different documents, *i.e.*, the 2015 Payment Agreement and the Rights Assignment.

outcomes. For example, in *Lonestar*, the Federal Circuit noted that restraints on a transferee's ability to bring suit and to alienate the patents—taken together—indicated that the transferor retained substantial rights in the patents and that the transferee lacked standing to sue in its own name. *Lone Star*, 925 F.3d at 1231. But in *Speedplay, Inc. v. Bebop, Inc*., the Federal Circuit determined that a requirement of consent before a licensee assigned the license did not defeat standing. *Speedplay, Inc. v. Bebop, Inc*., 211 F.3d 1245, 1251 (Fed. Cir. 2000). In *Speedplay*, the Federal Circuit interpreted the consent requirement as preventing "impairment" of the licensor's consideration for entering into the license, which included an on-going royalty stream. *Speedplay*, 211 F.3d at 1252.

Here, the plain language of the 2015 Payment Agreement demonstrates the breadth of rights the former Bandgap noteholders intended to give ASG. For example, in the accompanying Rights Agreement, the noteholders conveyed "absolutely all . . . right, title, and interest" to the patents, including "[a]ny rights to sue and recover for past, present, and future infringements." CX-1913C at ASG_000030852, § 1.f. Furthermore, section 10 of the 2015 Payment Agreement states that [redacted] CX-1913C at ASG_000030838, § 10 (emphasis added).

Respondents contend that the 2015 Payment Agreement includes an assignment provision that requires the parties to the agreement to obtain consent before assigning the agreement to a third party. *See* CX-1913C at § 15.e. But this consent provision is akin to the conset requirement in *Speedplay*: it simply protects the noteholders' consideration for entering into the agreement to transfer all substantial rights. *See* 211 F.3d at 1252. Here, the noteholders' consideration for

transferring their rights was the receipt of future revenue up to a limit of [redacted] just as the consideration at issue in *Speedplay* was a future royalty stream. *Compare id. with* CX-1913C at §§ 7, 8 ("Licensing Receipts," "Litigation Receipts," "Consulting Receipts," "Product Receipts"). Because the noteholders' consideration for entering into the 2015 Payment Agreement is only future revenue, the Agreement includes a consent provision to ensure that it will not be assigned to an entity unable to meet those payment obligations. Thus, in 2015, ASG obatained "absolutely all . . . right, title, and interest" to the patents, including "[a]ny rights to sue and recover for past, present, and future infringements." *Id.* at ASG_000030852, § 1.f.

In 2020, ASG assigned the Asserted Patents[4] to ASGT and received back from ASGT a license to the Asserted Patents. *See* CX-1719C (2020 Assignment and Assumption). Respondents make no claim that the transfer of rights from ASG to ASGT defeats standing.

Applying the Federal Circuit's totality-of-the-agreement analysis, I determine ASGT has standing to assert a claim of infringement in its own name, without joining former noteholders of Bandgap as a co-complainants.

III. LEVEL OF ORDINARY SKILL IN THE ART

The parties have agreed that a person of ordinary skill in the art at the time of the alleged invention of the Asserted Patents would have had (1) a bachelor's degree in electrical engineering, applied physics, chemistry, materials science, or a related field, and (2) at least three years designing, developing, or researching in the design or fabrication of semiconductors. CIB at 40; SIB at 32.34. An ordinary artisan might have a higher level of education and less experience a lower level of education and more experience. For example, an artisan with a master of science

[4] The "Asserted Patents" in this investigation are the '599 patent, the '981 patent, the '640 patent, and the '331 patent.

degree in any of the above fields and two years of practical experience would have been been an ordinary artisan at the relevant time.

For the purposes of this final initial determination, I adopt the agreed level of skill as the appropriate standard for the hypothetical ordinary artisan.

IV. CLAIM CONSTRUCTION – ALL ASSERTED PATENTS

"An infringement analysis entails two steps. The first step is determining the meaning and scope of the patent claims asserted to be infringed. The second step is comparing the properly construed claims to the device accused of infringing." *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 976 (Fed. Cir. 1995) (*en banc*) (internal citations omitted), *aff'd*, 517 U.S. 370 (1996). Claim construction resolves legal disputes between the parties regarding claim scope. *See Eon Corp. IP Holdings v. Silver Spring Networks*, 815 F.3d 1314, 1319 (Fed. Cir. 2016).

Evidence intrinsic to the application, prosecution, and issuance of a patent is the most significant source of the legally operative meaning of disputed claim language. *See Bell Atl. Network Servs., Inc. v. Covad Commc'ns Grp., Inc.*, 262 F.3d 1258, 1267 (Fed. Cir. 2001). The intrinsic evidence includes the claims themselves, the specification, and the prosecution history. *See Phillips v. AWH Corp.*, 415 F.3d 1303, 1314 (Fed. Cir. 2005) (*en banc*); *see also Markman*, 52 F.3d at 979. As the Federal Circuit explained in *Phillips*, courts examine the intrinsic evidence to determine the "ordinary and customary meaning of a claim term" as understood by a person of ordinary skill in the art at the time of the invention. *Phillips*, 415 F.3d at 1313.

"[T]he claims themselves provide substantial guidance as to the meaning of particular claims terms." *Id.* at 1314; *see Interactive Gift Express, Inc. v. Compuserve Inc.*, 256 F.3d 1323, 1331 (Fed. Cir. 2001) ("In construing claims, the analytical focus must begin and remain centered

on the language of the claims themselves, for it is that language that the patentee chose to use to 'particularly point[ ] out and distinctly claim[ ] the subject matter which the patentee regards as his invention.'"). The context in which a term is used in an asserted claim can be "highly instructive." *Phillips*, 415 F.3d at 1314. Additionally, other claims in the same patent, asserted or un-asserted, may also provide guidance as to the meaning of a claim term. *Id.*

The specification "is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term." *Phillips*, 415 F.3d at 1315 (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)). "[T]he specification may reveal a special definition given to a claim term by the patentee that differs from the meaning it would otherwise possess. In such cases, the inventor's lexicography governs." *Id.* at 1316. "In other cases, the specification may reveal an intentional disclaimer, or disavowal, of claim scope by the inventor." *Id*. As a general rule, however, the particular examples or embodiments discussed in the specification are not to be read into the claims as limitations. *Id.* at 1323. In the end, "[t]he construction that stays true to the claim language and most naturally aligns with the patent's description of the invention will be . . . the correct construction." *Id.* at 1316 (quoting *Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1250 (Fed. Cir. 1998)).

Only when the evidence intrinsic to the patent record does not establish the meaning of a claim may extrinsic evidence like treatises, inventor testimony, or expert testimony be considered. *Phillips*, 415 F.3d at 1317. Extrinsic evidence is generally viewed as less reliable than the patent itself and its prosecution history in determining how to define claim terms. *Id.* "The court may receive extrinsic evidence to educate itself about the invention and the relevant technology, but the court may not use extrinsic evidence to arrive at a claim construction that is clearly at odds with

the construction mandated by the intrinsic evidence." *Elkay Mfg. Co. v. Ebco Mfg. Co.*, 192 F.3d 973, 977 (Fed. Cir. 1999).

A. Asserted Claims

As noted, ASGT asserts apparatus claims 15, 23, 24, and 27 of the '599 patent. The disputed '599 patent claim terms are shown in context below with emphasis:

> 15 [preamble]. A photovoltaic device comprising:
>
> [a] a crystalline semiconductor substrate comprising:
>
> [i] a bottom p-doped region;
>
> [ii] a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located **at least about 30 nm** from the bottom of the **nanowires** and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region; and
>
> [b] a plurality of n-doped **nanowires** in direct physical contact with the top n-doped region of the crystalline semiconductor substrate.
>
> 23. A device as described in claim 15, wherein the device is fabricated using a process comprising **metal enhanced etching** in a solution comprising HF and an oxidizer.
>
> 24. A device as described in claim 15, wherein the p-n junction is located **at least about 300 nm** from the bottom of the **nanowires**.
>
> 27. A device as described in claim 15, wherein the crystalline semiconductor comprises polycrystalline silicon.

JX-0001 ('599 Patent) at claims 15, 23, 24, and 27 (emphasis added).

Complainant asserts process claims 1, 13, 23, and 27 of the '981 patent. The disputed '981 patent claim terms are shown in context below with emphasis:

> 1. A process comprising:
>
> **(a) providing** a substrate having a **nanostructured** material on a surface, the substrate being conductive and the **nanostructured** material being coated with an insulating material,

> **(b) removing** the **nanostructured** material and electrically insulating material at least partially from a portion of the surface, and
>
> **(c) depositing** a conductor on the substrate in such a way that the conductor is in electrical contact with the substrate through the portion of the surface where the **nanostructured** material and insulating material has been at least partially removed.
>
> 13. The process of claim 1, wherein the step of removing the **nanostructured** material and insulating material comprises heating or cooling.
>
> 23. The process of claim 1, wherein step (c) comprises screen printing.
>
> 27. A process comprising:
>
> **(a) providing** a substrate having a **nanostructured** material on a surface,
>
> **(b) removing** the **nanostructured** material from a portion of the surface, and
>
> **(c) depositing** an electrical contact in the portion of the surface from which the **nanostructured** material was removed.

JX-0002 ('981 Patent) at claims 1, 13, 23, and 27 (emphasis added).

Complainant asserts apparatus claims 1, 4, and 11-13 of the '640 patent. The disputed '640 patent claim terms are shown in context below with emphasis:

> 1 [Preamble]. An optoelectronic device comprising:
>
> [a] a substrate including a first surface;
>
> [b] a **nanostructured** area including **nanostructures** on the first surface of the substrate, the **nanostructured** area including a first segment in which the **nanostructures** are intact and a second segment in which the **nanostructures** are at least partially broken or removed, the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate;
>
> [c] an electrically insulating layer atop the first surface; and
>
> [d] a conductor atop the electrically insulating layer over the second segment.
>
> 4. The optoelectronic device of claim 1, wherein the conductor

> makes electrical contact to the substrate through the insulating layer over the second segment.
>
> 11. The optoelectronic device of claim 1, wherein the **nanostructures** comprise silicon.
>
> 12. The optoelectronic device of clam 1, comprising a photovoltaic cell.
>
> 13. The optoelectronic device of claim 11, wherein the **nanostructures** comprise silicon **nanowires**.

JX-0003 ('640 Patent) at claims 1, 4, and 11-13 (emphasis added).

Complainant asserts apparatus claim 1 of the '331 patent. The disputed '331 patent claim terms are shown in context below with emphasis:

> 1 [Preamble]. A silicon **nanostructured** device comprising:
>
> [a] a non-**nanostructured** substrate;
>
> [b] a **nanostructured** area disposed on and contacting a surface of the substrate;
>
> [c] a passivating layer coating the **nanostructured** area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride,
>
> [d] one or more contacts comprising a comb-like pattern of metal directly contacting the **nanostructured** area; and
>
> [e] a p-n junction below the **nanostructured** area.

JX-0004 ('331 Patent) at claim 1 (emphasis added).

B. Construction of Disputed Claim Terms

1. "nanowires" ('599 and '640 patents)

The term "nanowires" appears in asserted claims 15 and 24 of the '599 patent, non-asserted claim 4 of the '981 patent, and asserted claim 13 of the '640 patent. The parties have proposed the following constructions:

Complainant's Construction	Respondents' Construction	Staff's Construction
A feature on a substrate having a height of at least 50 nm and having two orthogonal diameters, where each diameter is less than 200 nm.	Wires with a dimeter that is no more than 200 nm along the length and at most modestly tapered. Alternately, indefinite.	Wires with diameters of no more than about 200 nm.

See CIB at 39-47; RIB at 21-31; SIB at 40-48.

Based on the parties' proposed constructions above, the parties' dispute over the interpretation of "nanowires" would appear to center on whether "nanowires" must be wire-shaped, as proposed by Staff and Respondents, or whether a "nanowire" could include another shaped "feature," as might be implied by ASGT's construction. As developed in the post-hearing briefing, however, all parties agree that an ordinary artisan at the time of the invention would have understood that "nanowires" are generally cylindrical in shape. *See* CIB at 41 (nanowires are "approximately cylindrical"); RIB at 21 (nanowires are "generally cylindrical in shape"); SIB at 41 (nanowires are "a basically cylindrical shape"). The parties also all agree that the diameter of the cylinder of a nanowire, as that term is used in the relevant patents, is no more than 200 nm. *See* CIB at 41; RIB at 26; SIB at 46 ("Staff does not object to limiting its originally proposed construction of 'nanowires' to diameters less than (or no more than) 200 nm.").

This much agreement is consistent with the record intrinsic to the '599, '981, and '640 patents. The patents contain illustrations of nanowires that were known in the art at the time of the invention. Figure 2 of the '599 patent "schematically depicts a solar cell with nanowires with concentric p and n regions," and Figure 3 of the '599 patent "schematically depicts a solar cell

with nanowires comprising p and n regions." JX-0001 ('599 Patent) at 3:9-12. The figures are reproduced below:

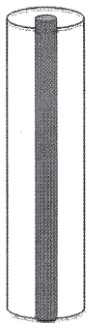


FIG. 2 (prior art)

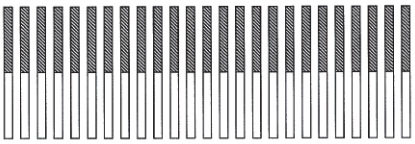


FIG. 3 (prior art)

Id., Figures 2-3. In both figures, the nanowires are illustrated as cylinders.

As another example, Figure 7 of the '599 patent, which is reproduced below, "schematically depicts with possible dimensions a silicon nanowire photovoltaic cell with a submerged contact":

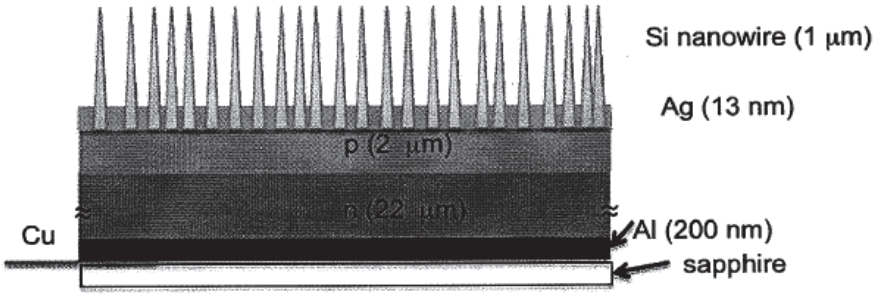


FIG. 7

JX-0001 ('599 Patent) at 3:21-22, Figure 7. In Figure 7, nanowires are shown as modestly tapering.

While the ’599 patent includes only diagrams of nanowires, the related ’981 and ’640 patents include micrographs of nanowires actually made by the inventors. In particular, Figure 1 of the ’981 patent “depicts an edge view scanning electron micrograph of silicon nanowires coated with alumina,” while Figure 10 of the ’981 patent “depicts an edge view scanning electron micrograph of silicon nanowires coated with alumina, where a portion of the nanowires has been removed in accordance with a process of the invention.” JX-0002 (’981 Patent) at 4:10-11, 4:30-33. Figures 1 and 10 of the ’981 patent are reproduced below:

FIG. 1

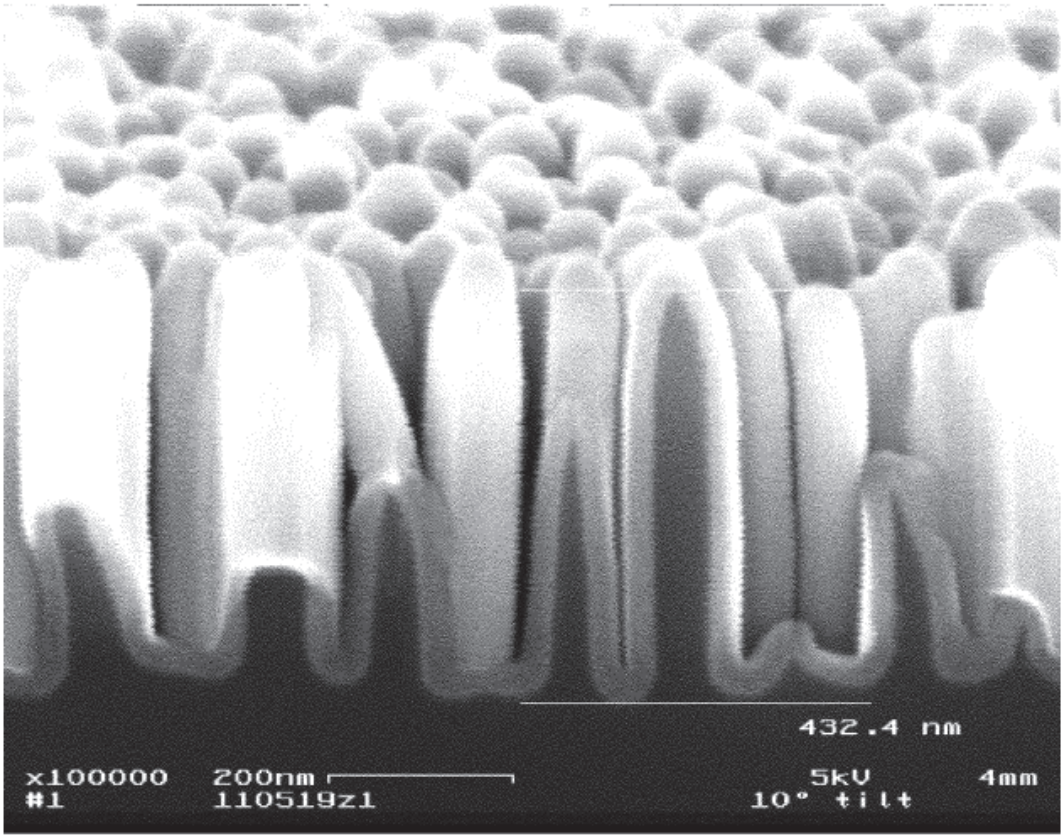
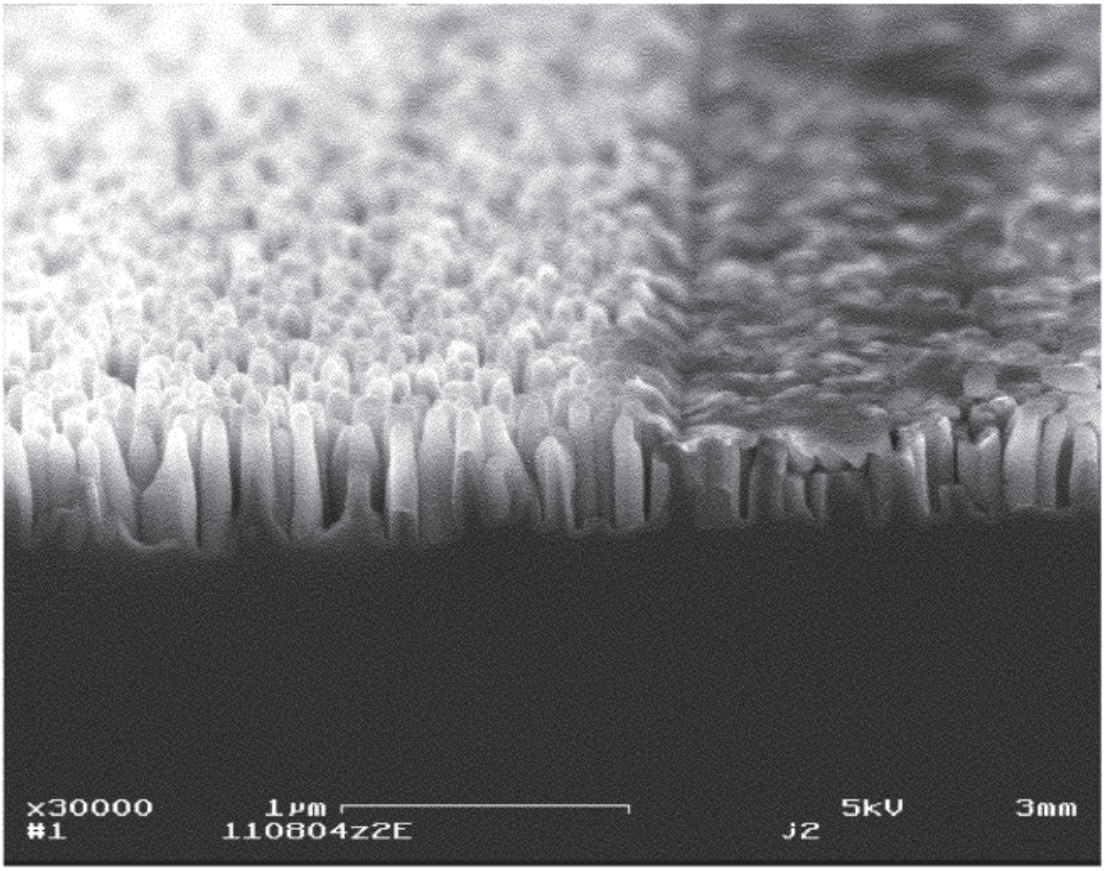


FIG. 10



Id., Figures 1 and 10; *see also* JX-0003 ('640 Patent) at Figure 1. As can be seen, the nanowires micrographed by the inventors are generally cylindrical. Some of the nanowires in the micrograph taper very slightly along their axis.

The figures in the relevant patents are consistent with the written description of the invention in the relevant patents. The '599 patent specification notes that "[w]hile the nanowires of the devices of the invention might have a constant diameter along their length, alternatively they might also have a modest taper." JX-0001 ('599 Patent) at 5:10-12. Similarly, the specification

common to the ’981 and ’640 patents describes the “nanowires” as being “of approximately cylindrical or frustoconical[5] shape.” JX-0002 (’981 Patent) at 1:17-22.

Two disputes remain: whether a nanowire must have an axis that is “necessarily longer” than the diameter of the cylinder, as urged by Respondents (*see* RIB at 22), and whether a nanowire must be at least 50 nm in heigh, as urged by ASGT (*see* CIB at 21).

As to the length of a nanowire, Respondents point to figures from the relevant patents showing line diagrams of nanowires that appear proportionally longer than their diameters (JX-0001 (’599 Patent), Figures 2, 3, and 7), micrographs of nanowires with scale indications showing the nanowires to be longer than their diameters (JX-0002 (’981 Patent), Figures 1 and 10), and a textual example from the ’640 patent stating “[a]n *exemplary* silicon nanowire array *might* consist of a collection of silicon nanowires on the order of 100 nm in diameter, on the order of several micrometers in height” (JX-0003 (’640 Patent) at 1:16-20 (emphasis added)).

None of the intrinsic evidence cited by Respondents suggests, however, that a nanowire *must* have an axis longer than its diameter. To the contrary, the patents at issue give examples of nanowire dimensions that would result in a nanowire with an axial length that is *not* greater than its diameter. Specifically, the ’599 patent specification lists examples of nanowires having diameters “*no more than about 50 nm* in diameter, no more than about 75 nm in diameter, no more than about 100 nm in diameter, or no more than about 200 nm in diameter.” JX-0003 (’640 Patent) at 4:57-61 (emphasis added). The very next paragraph explains “the nanowire array may have, for example, *a height between about 0.05 μm* and about 6 μm, or between about 0.1 μm and about 2.5

[5] A frustroconical shape is a cone whose tip has been truncated by a plane parallel to its base. RX-0601C (Neikirk RWS) at Q/A 212; Tr. (Banerjee) at 882:12-14. In other words, it is the same as a cylinder that tapers along its axis.

μm, or between about 0.5 μm and about 2 μm, or between about 1 μm and about 1.5 μm, as measured from the substrate." *Id*. at 4:65-5:2. A height of .05 μm is 50 nm.[6] Thus, within the range of examples given in the patent specification is a nanowire 50 nm in diameter with an axial length of 50 nm. Such a nanowire does *not* have an axis longer than its diameter, directly contradicting Respondents' position. Given the specific examples of nanowires in the relevant patents, persons of ordinary skill in the art would not confine their understanding of the disclosed and claimed nanowires to only a cylinder with an axial length longer than its diameter.

As to a construction that nanowires be at least 50 nm in height, ASGT suggests this minimum height requirement "avoids misidentifying as 'nanowires' any atomic scale roughness that may be present." CIB at 41. The relevant patent specifications give an example of a nanowire having "a height between about 0.05 μm and about 6 μm." *Id*. at 4:65-5:2. A height of .05 μm is 50 nm. Respondents admit this teaching provides "guidance regarding the dimensions of the nanowires" claimed. *See* RIB at 8. The patents do not identify any feature with a height of less than 50 nm as a nanowire. To the contrary, the '599 patent specification contrasts nanowires from nanoparticles. *See* JX-0001 ('599 Patent) at 1:59-65. Additionally, the specifications describe "areas between the nanowires," which implies that mere irregularities on the surface of the substrate are not nanowires. JX-0001 ('599 Patent) at 8:63-65. Neither Respondents nor Staff specifically argue a person of skill in the art would understand that the claimed nanowires could include a feature with a height of less than 50 nm.

Considering the overlapping positions of the parties and the evidence intrinsic to the relevant patents, I will construe "nanowires" in the '599, '981, and '640 patents as "generally

[6] 1 μm is 1×10^{-6} m. 1 nm is 1×10^{-9} m.

cylindrical or no more than modestly tapering wires having a height of at least 50 nm and a diameter of no more than 200 nm."

2. "nanostructures" and "nanostructured" ('640, '981, and '331 patents)

The term "nanostructures" appears in asserted claims 1 and 13 of the '640 patent. The term "nanostructured" appears in asserted claims 1, 13, and 27 of the '981 patent, asserted claim 1 of the '640 patent, and asserted claim 1 of the '331 patent. The parties have proposed the following constructions:

Complainant's Construction	Respondents' Construction	Staff's Construction
A feature on a substrate having a height of at least 50 nm and having at least one diameter that is less than 200 nm.	Structure(s) with a dimeter that is no more than 200 nm along the length and at most modestly tapered. Alternately, indefinite.	Structure(s) with diameter(s) of no more than about 200 nm.

See CIB at 47-49; RIB at 31-35; SIB at 49-54.

As can be seen in the chart above, ASGT contends that "nanostructures" are "features" having certain nano-scale dimensions, while Respondents and Staff argue that "nanostructures" are "structures" having certain nano-scale dimensions.

All parties agree that nanostructures are no more than 200 nm in diameter. CIB at 48; RIB at 31; SIB at 54. This comports with what an ordinary artisan would understand from the "nano" prefix of the term.

All parties also agree that nanowires are a species of "nanostructure." *See, e.g.*, CIB at 47 ("a 'nanowire' is a type of 'nanostructure'"); RIB at 34 ("a 'nanowire' is a specific type of nanostructure"), 144 ("a nanowire is a type of nanostructure"); SIB at 50 ("'nanowires' are one

form of 'nanostructures.'"). The evidence intrinsic to all of the Asserted Patents is consistent with that understanding. *See* JX-0001 ('599 Patent), 5:63-65 ("nanostructures which have forms other than nanowires"); JX-0003 ('640 Patent) Claim 13 ("wherein the nanostructures comprise silicon nanowires"): JX-0002 ('981 Patent) Claim 4 ("wherein the nanostructured material comprises nanowires"); JX-0004 ('331 Patent) Claim 3 ("wherein the nanostructured area comprises a nanowire array.").

Other evidence intrinsic to the record of all of the Asserted Patents demonstrates that the term "nanostructures" was an understood term in the field at the time of the invention. Specifically, the '599 patent (which is related to all other Asserted Patents) references prior art application U.S. Patent Application No 2008/0169017 ("Korevaar") (CX-2354C). JX-0001 ('599 Patent), 9:58-59, 10:13-15. Korevaar states that "'[n]anowires,' as defined herein, are generally elongated nanostructures typically sub-micron (< 1 μm) in at least two dimension and having a largely cylindrical shape." CX-2354C.

No party has explained how the difference, if any, between a "feature" and a "structure" is material to any issue that must be decided in connection with the "nanostructures" in this investigation. *Cf. U.S. Surgical Corp. v. Ethicon, Inc*., 103 F.3d 1554, 1568 (Fed. Cir. 1997) (a trial judge need not "repeat or restate every claim term"; claim construction "is a matter of resolution of *disputed* meanings and technical scope, to clarify and *when necessary* to explain what the patentee covered by the claims" (emphasis added)). Respondents and Staff contend that a nanostructure must be "a complete structure, not just a tip or topmost 'feature,'" but that argument is really a dispute with the evidence ASGT relies upon to show infringement. *Compare* RIB 33 *with* SIB at 73. Those factual questions are properly addressed in the factual findings of the infringement analysis below. *See Biotec Biologische Naturverpackungen GmbH & Co. KG v.*

Biocorp, Inc., 249 F.3d 1341, 1349 (Fed. Cir. 2001) (where the real "issue in dispute was the application of" the claim to the accused process, that "factual question of infringement" was not an issue of claim construction).

No party has cited any evidence that the '640 patent claims (or the Asserted Patents generally) use the term "nanostructures" in any way that differs from an ordinary understanding of that term in the art. Accordingly, I will interpret this claim term according to its plain and ordinary meaning. *See Biotec Biologische Naturverpackungen*, 249 F.3d at 1349 (where usage of a claim term did not "depart from its ordinary meaning," the remaing dispute was "a factual question of infringement").

3. Order of steps (a), (b), and (c) ('981 patent)

Claims 1 and 27 of the '981 patent recited certain method steps and label each step with an alphabetical index. The parties dispute whether the steps denoted by (a), (b), and (c) recited in asserted claims 1 and 27 must be performed in the order in which they are recited in the claims. The parties have proposed the following constructions:

Complainant's Construction	Respondents' Construction	Staff's Construction
There is no order of events within any of (a), (b), or (c). Furthermore, the events of (b) need not be completed across the entire substrate before the events of (c) begin somewhere on the substrate.	Separate steps that occur in order, such that step (a) is carried out before step (b), and step (b) is carried out before step (c).	Separate steps of the claimed process that occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)."

See CIB at 52-54; RIB at 35-39; SIB at 54-56.

Staff's and Respondents' proposed construction requires that the claimed steps (a), (b), and (c) occur in order such that step (a) is carried out before step (b), and step (b) is carried out before step (c). The setps of asserted claims 1 and 27 of the '981 patent are reproduced below:

> 1. A process comprising:
>
> (a) providing a substrate having a nanostructured material on a surface, the substrate being conductive and the nanostructured material being coated with an insulating material,
>
> (b) removing the nanostructured material and electrically insulating material at least partially from a portion of the surface, and
>
> (c) depositing a conductor on the substrate in such a way that the conductor is in electrical contact with the substrate through the portion of the surface where the nanostructured material and insulating material has been at least partially removed.
>
> 27. A process comprising:
>
> (a) providing a substrate having a nanostructured material on a surface,
>
> (b) removing the nanostructured material from a portion of the surface, and
>
> (c) depositing an electrical contact in the portion of the surface from which the nanostructured material was removed.

JX-0002 ('981 Patent) at claims 1, 27.

"[A]s a general rule the claim is not limited to performance of the steps in the order recited, unless the claim explicitly or implicitly requires a specific order." *Baldwin Graphic Sys., Inc. v. Siebert, Inc*., 512 F.3d 1338, 1345 (Fed. Cir. 2008). For example, where a claimed process requires that a "layer must already be in place in order to" perform other required steps, the claim should be construed to require steps to be performed in a certain order. *Loral Fairchild Corp. v. Sony Corp*., 181 F.3d 1313, 1321-22 (Fed. Cir. 1999). As discussed below, the later-recited steps in claims 1 and 27 of the '981 patent rely upon conditions established in the the earlier-recited steps, indicating that the claimed steps must be performed in order.

Step (a) recites "providing a substrate having a nanostructured material on *a* surface…" and step (b) recites "removing the nanostructured material…from a portion of *the* surface." '981 patent, claim 1, claim 27 (emphasis added). By using the definite article "the," step (b) requires that "the surface" from which nanostructure material is removed be the same surface "provid[ed]" in step (a). *See, e.g., Wi-Lan, Inc. v. Apple, Inc.*, 811 F.3d 455, 462 (Fed. Cir. 2016) (definite article "the" referred back to the same term recited earlier in the claim and imposed an ordering requirement). Nanostructured material cannot be removed from "the surface" of a substrate until after that substrate is first provided. Thus, the "providing" action in step (a) must be performed before the "removing" action of step (b).

Similarly, the claim language mandates that step (c) be performed after step (b). As noted above, step (b) recites "*removing* the nanostructured material . . . from a portion of the surface." '981 patent, claim 1, claim 27 (emphasis added). Step (c) recites "depositing a conductor . . . where the nanostructured material . . . *has been* at least partially *removed*," in the case of claim 1, and "depositing an electrical contact in the portion of the surface from which the nanostructured material *was removed*," in the case of claim 27. *Id*. (emphasis added). In both claims, step (c) refers to the removing step in the past tense, indicating the removing step (b) has already been performed. *Id.* at claim 1 ("material *has been* at least partially *removed*") (emphasis added); claim 27 ("material *was* removed") (emphasis added). This is strong evidence that the claim requires performance of step (b) before step (c).

Additionally, step (c) of both claims requires "depositing" in at least part of the same area where nanostructured material has been removed. Step (c) recites "depositing a conductor . . . in electrical contact with the substrate through *the portion of the surface where the nanostructured material . . . has been at least partially removed*," in the case of claim 1, and "depositing an

electrical contact in *the portion of the surface from which the nanostructured material was removed*," in the case of claim 27. *Id*. (emphasis added). Because step (c) links the area for depositing to the area where material is removed in step (b), the area for depositing is not defined until step (b) has been performed.

Consistent with the claims, the Summary of the Invention section discloses, "a substrate is provided having a nanostructured material on a surface, the substrate being conductive and the nanostructured material being coated with an electrically insulating material," "[a] portion of the nanostructured material is at least partially removed," and "[a] conductor is deposited on the substrate in such a way that it is in electrical contact with the substrate through the area where the nanostructured material has been at least partially removed." '981 Patent (JX-0002) at 2:46-55. Additionally, the Detailed Description Of The Invention section further teaches, "a substrate is provided having a nanostructured material on a surface, the substrate being conductive and the nanostructured material being coated with an insulating material," "[a] portion of the nanostructured material is at least partially removed," and "[a] conductor is deposited on the substrate in such a way that it is in electrical contact with the substrate through the area where the nanostructured material has been at least partially removed." '981 Patent (JX-0002) at 4:49-56.

Thus, based on the plain language of the claims, the steps denoted by (a), (b), and (c) appearing in asserted claims 1 and 27 of the '981 patent must be performed in the order in which they are recited in the claims. In the inventive method, step (a) is carried out before step (b), and step (b) is carried out before step (c).

4. "metal enhanced etching" ('599 patent)

The term "metal enhanced etching" appears in asserted claim 23 of the '599 patent. The parties have proposed the following constructions:

Complainant's Construction	Respondents' [7] Construction	Staff's Construction
Utilizing metal on a surface to increase the etching rate in certain areas of the surface, thereby forming features.	A process in which a metal film is deposited onto the surface of a substrate, and the metallized substrate is then contacted with an etching solution that includes hydrofluoric acid and an oxidizing agent, where the deposited metal enhances the etch rate.	A process in which a metal film is deposited onto the surface of a substrate, and the metallized substrate is then contacted with an etching solution, where the deposited metal enhances the etch rate.

See CIB at 51-52; RIB at 67-68, 98-100; SIB at 56-59.

The dispute over the claim term "metal enhanced etching" centers on whether the claim term is satisfied the use of metal in any manner to increase an etching rate, as proposed by ASGT, or whether, as proposed by Staff and Respondents, the phrase describes a two-step process requiring (1) deposition of a metal film onto a substrate, and (2) exposing the metallized substrate created by the first step to an etching solution.

The written description portion of the '599 patent specification does not mention the phrase "metal enhanced etching." The phrase appears in U.S. Provisional Application No. 61/141,082 ("the '082 Provisional Application"), filed on December 29, 2008, by the same inventors as are listed on the '599 Patent. RX-0204.05. The '599 patent incorporates the '082 Provisional Application by reference. JX-0001 ('599 Patent) at 10:5-16. The '082 Provisional Application describes the following:

> A process is provided for etching a silicon-containing substrate to form nanowire arrays. In this process, *one deposits nanoparticles and a metal film onto the*

[7] Respondent Hanwha apparently takes no position as to the construction of "metal enhanced etching" as claim 23 of the '599 patent is not asserted against Hanwha for infringement. *See* RIB at 21 n.1.

> *substrate* in such a way that the metal is present and touches silicon where etching is desired and is blocked from touching silicon or not present elsewhere. *One submerges the metallized substrate into an etchant aqueous solution HF and an oxidizing agent.*
>
> * * *
>
> FIG. 4 depicts the result of using *metal enhanced etching* of silicon to obtain microstructuring on a silicon wafer. Unintentional wires were formed inside the trenches.

RX-0204.05 (emphasis added). No party argues that the term "metal enhanced etching" was known in the art before the '082 Provisional Application.

The '599 patent describes "[a]n exemplary process for making a solar cell" that includes a similar description of the process that the '082 Provisional Application labeled as "enhanced metal etching." The similar process from the '599 patent includes the following steps, among others:

> 3) Place nanoparticles (e.g., iron oxide, silica) on the wafer surface. (Further details on one way to do this are provided in the alternative process below.) *A continuous layer of silver (e.g., 40 nm) is deposited* using physical vapor deposition such as sputtering *on top of the substrate* to cover both the bare silicon regions and the nanoparticles. It is also useful to Ar clean the surface in-situ prior to metal deposition in order to remove any oxide that might have reformed between BOE and pumping down the chamber.
>
> 4) *Place the silver coated silicon wafer inside the etch solution*. The substrate is *subsequently* submerged into an aqueous solution made up of 4-49 weight percent HF and 0.5-30 weight percent H2O2. Although the mechanism for enhanced etching of silicon is unknown, what is known is that the H2O2 will degrade the Ag, forming holes in the silver. Furthermore, where the Ag is in contact with the silicon, the H2O2 oxidizes the silicon, and the HF etches this oxide. Thus where the Ag contacts the silicon the etch rate is enhanced. Thus, the silicon will etch everywhere except for where the silver has a hole and at this location a nanowire will form as the silicon is etched around it. The etch is timed so that the nanowires are etched down to the junction, but not through it.

JX-0001 ('599 Patent) at 6:23-40.

As can be seen above, the '082 Provisional Application and the '599 Patent both describe a process that requires two steps to be performed in a certain order. First, "[a] continuous layer of

silver (e.g., 40nm) is deposited using physical vapor deposition such as sputtering on top of the substrate to cover both the bare silicon regions and the nanoparticles [that were placed on the substrate surface]." *Id.*, 6:23-31. Second, that "the silver [(metal)] coated silicon wafer [is placed] inside the etch solution [and] [t]he substrate is subsequently submerged into an aqueous solution made up of 4-40 weight percent HF and 0.530 weight percent H_2O_2," and "where the Ag [(silver)] contacts the silicon the etch rate is enhanced." *Id.*, 6:31-35.

The record contains no evidence that a person of skill in the art *at the time of the invention* would understand metal enhanced etching to mean some broader concept than what the inventors described in the passages recited above. Accordingly, I will construe the term "metal enhanced etching" as "a process in which a metal film is deposited onto the surface of a substrate, and the metallized substrate is then contacted with an etching solution, where the deposited metal enhances the etch rate."

5. "at least about [30/300] nm" ('599 patent)

The term "at least about [30/300] nm" appears in asserted claims 15 and 24 of the '599 patent. The parties have proposed the following constructions:

Complainant's Construction	Respondents' Construction	Staff's Construction
These terms are not indefinite under 35 U.S.C. § 112.	Indefinite.	These terms are not indefinite under 35 U.S.C. § 112.

See CIB at 49-51; RIB at 39-41; SIB at 59-62.

Claim 15 of the '599 patent requires that "the p-n junction is located at least about 30 nm from the bottom of the nanowires," and claim 24, which depends from claim 15, requires that "the p-n junction is located at least about 300 nm from the bottom of the nanowires." According to

Respondents, the recitation of "at least about 30 nm" lacks the precision necessary to inform a person of ordinary skill about the scope of the claims. RIB at 39-40. Boviet Respondents' expert Dr. Kanicki opined that the term "about" is the specific term in the phrase "at least about" that is not "well-defined" and, thus, indefinite. Tr. (Kanicki) at 644:3-645:2. ASGT and Staff contend otherwise. *See* CIB at 49-51; SIB at 59-62.

"About" is a term of degree. *See* Manual of Patent Examining Procedure, § 2173.05(b) (June 2020). "[R]elative terms and words of degree do not render patent claims invalid" so long as the claims inform those skilled in the art about the scope of the invention with reasonable certainty. *One-E-Way, Inc. v. Int'l Trade Comm'n*, 859 F.3d 1059, 1063 (Fed. Cir. 2017) (reversing Commission's determination that claim phrase "virtually free from interference" was indefinite); *see also W.L. Gore & Assocs., Inc. v. Garlock, Inc*., 721 F.2d 1540, 1557 (Fed. Cir. 1983) ("The use of 'stretching ... at a rate exceeding about 10% per second' in the claims is not indefinite."). "Patents with claims involving terms of degree must provide objective boundaries for those of skill in the art in the context of the invention." *Guangdong Alison Hi-Tech Co. v. Int'l Trade Comm'n*, 936 F.3d 1353, 1360 (Fed. Cir. 2019) (cleaned up). Intrinsic evidence—such as the claims, figures, written description, or prosecution history of a patent—can provide the necessary objective boundaries. *Id*.

The relevant claims use the term "about" in reference to a distance between the p-n junction and the bottom of the nanowires. The intrinsic evidence provides sufficient boundaries to inform one of skill in the art about the scope of the claim with reasonable certainty. The specification describes the prior art as having a p-n junction "*at the contact* of the nanowires and the bulk region" while the invention is arranged so that "the p-n junction lies *within* the bulk region" and "the nanowires do not extend all the way to the junction." *See* JX-0001 ('599 Patent) at 3:13-17, 54-58

(emphasis added), Figures 4 and 5. The specification states that an artisan would know from the prior art how to control junction depth, stating, "Those of skill in the art will understand that junction depth may be controlled by the choice of processing conditions with diffusion or ion implantation, for example as discussed in Franssila, reference (20), chapters 14 and 15." *Id*. at 5:28-32. The specification notes "[t]ypical processing conditions used for junction depth control" include control of the energy of the implanted ions and the duration and temperature of a drive-in period for the dopants. *Id*. at 5:32-35.

Most importantly, the specification gives numerical examples of junction depths and a point of reference from which to measure the distance: "Measured from the bottom of the nanowires after they are fabricated, it may range from about 30 nm to about 3 μm, from 300 nm to about 2 μm, or about 1 μm to about 1.5 μm." *See* JX-0001 ('599 Patent) at 5:24-28.

From the disclosures in the specification, a person of skill in the art at the time of the invention would understand the physical structures relevant to the claimed distance, the electrochemical properties relevant to identifying the claimed distance, and the degree of precision that would be relevant to the claimed distance. These are sufficient "objective boundaries for those of skill in the art in the context of the invention." *Guangdong Alison Hi-Tech Co*., 936 F.3d at 1360.

As for the clear and convincing standard for proving invalidity for indefiniteness, only Boviet Respondents' expert, Dr. Kanicki, took the position that these claim terms "at least about [30/300] nm" are indefinite. Tr. (Kanicki) at 644:3-645:2. Neither the Canadian Solar Respondents' expert, Dr. Neikirk, nor the Hanwha Respondents' expert, Dr. John, took a position on indefiniteness with respect to these claim terms. *See* Tr. (Neikirk) at 576:19-577:5; RX-0604C (John RWS) at Q/A 158-73, 202-15. In fact, Dr. John's testimony supports a conclusion that the

scope of the term would have been understood. He stated, "The claims require the p-n junction is 'located at least about 30 nm from the bottom of the nanowires.' That means to show infringement you have to know where the bottom of the nanowires are and where the p-n junction is and then you would measure the distance between them." RX-0604C (John RWS) at Q/A 165. Also, with respect to the claim term "at least about 300 nm," Dr. John testified: "As shown in RDX-0008.32C, the average adjusted depth for the Hanwha 4.2 products is 283.2 nm. As shown in RDX-0008.33C, the average adjusted depth for the Hanwha 5.2 products is 283.2 nm. *Both are less than the 300 nm required by the claims*." RX-0604C (John RWS) at Q/A 207 (emphasis added).

I determine that Respondents have not met their burden to show by clear and convincing evidence that the claim terms "at least about [30/300] nm" are indefinite under 35 U.S.C. § 112. *See BASF Corp. v. Johnson Matthey Inc*., 875 F.3d 1360, 1365 (Fed. Cir. 2017) (the burden of proving indefiniteness requires clear and convincing evidence).

V. COMPLAINANT'S SAMPLE PREPARATION AND SAMPLE TESTING

Respondents contend that ASGT's "sample preparation and testing of the Accused Products are deeply flawed" because those methods "necessarily alter the surface morphology of the Accused Products—rendering the samples useless." RIB at 41. Respondents further contend ASGT's "testing methodologies are inaccurate and incomplete." *Id*. ASGT does not agree with respondents' contentions. *See* CIB at 54-64. Staff contends ASGT's chemical etching during sample preparation and sample testing were flawed. *See* SIB at 62-67.

A. Complainant's Sample Preparation of Accused Products

1. Sample Extraction

Complainant's expert opining on infringement, Dr. Souri, testified about the preparation of testing samples of Respondents' Accused Products. *See* CX-2411C (Souri WS) at Q/A 38. Specifically, Dr. Souri testified about the extraction of smaller sections from the provided samples of Respondents' Accused Products. With respect to samples of Canadian Solar Accused Products, which were provided to Complainant without encapsulation, testing samples were created using a diamond scribe to dice approximately 0.25"x0.25" sections. *Id.* With respect to samples of both Hanwha Accused Products and Boviet Accused Products, which were provided to Complainant as modules (with encapsulation), testing samples were created using a diamond saw to cut out sections consisting of approximately two solar cells that were then further cut into approximately 1" × 1" squares, which were subsequently decapsulated by removing the encapsulating glass and binding polymer, and cleaned. *Id.*

In response to Dr. Souri's testimony on extraction, the Hanwha Respondents' expert opining on non-infringement, Dr. John, testified that Dr. Souri's two-step cutting process is flawed because Dr. Souri failed to account for the impact of diamond saw cutting on the surface of the wafer and the cross sections of the wafer. *See* RX-0604C (John RWS) at Q/A 116-18. Additionally, Dr. John also testified that Dr. Souri's method of removing the binding polymer from the testing samples is likewise flawed because Dr. Souri did not confirm that the binding polymer was removed completely from the surface of the wafer. *See* RX-0604C (John RWS) at Q/A 119-21. According to Dr. John, if any residue of the polymer remains on the testing sample, the residue will result ultimately in significant changes to the surface of the sample. *Id.* But Dr. John also admitted that changes caused by diamond saw cutting are well documented, including how

traces of the cutting would be reflected in any altered area. *See* RX-0604C (John RWS) at Q/A 116-18.

Dr. Souri explained that he took care in cutting the products he tested: "What I did use the diamond saw for was to cut the sample, isolate the sample, and that means I cut it along the surfaces that are perpendicular to the substrate surface that I was studying. So it was in no way interfering or in any way affecting the quality of the surface that I was analyzing, the top surface of the substrate. So my sample preparation preserved the integrity of the underlying silicon and the structures on that silicon for me to study." Tr. (Souri) at 278:9-279:15.

With respect to Dr. Souri's method of removing the binding polymer from testing samples, Dr. Souri admitted that he used, *inter alia*, tweezers to pull off binding polymer from the surface of the testing samples and, further, that he did not actually remove all of the binding polymer from the surface of the testing samples. Tr. (Souri) at 215:6-217:10. However, Dr. Souri also explained that he used tweezers to pull off binding polymer from most of the surface of the testing samples "to preserve the underlying surface of the sample" and that he subsequently used etching steps, including "a piranha etching step, which is a well-known semiconductor wafer cleaning step, [that] would ensure that any organics left over on the surface, such as the polymer, would be etched away." *Id.* Dr. Souri further explained that "[t]here's no need to aggressively remove anything. The idea here is to prepare the sample nondestructively for further etching steps, which will take care of anything that may be left over in terms of a binding polymer . . . ." Tr. (Souri) at 217:4-10.

I am not persuaded that the process Dr. Souri used to extract samples materially altered the regions he studied in his infringement analysis.

2. Chemical Etching

Following extraction of testing samples, Dr. Souri testified about chemical etching to enable inspection of the layer-by-layer composition and surface topography of the testing samples using Scanning Electron Microscopy ("SEM"). *See* CX-2411C (Souri WS) at Q/A 38. Dr. Souri further testified that the testing samples were inspected: (a) after decapsulation and cleaning, to observe the metal contacts on the surface of the testing samples; (b) after a "Piranha" etch that removed the silver contacts from the surface of the testing samples and enabled investigation of the insulating/passivating layer; (c) after a subsequent hydrofluoric acid (HF) etch that largely removed the insulating/passivating layer and enabled investigation of the underlying silicon; and (d) after another "Piranha" etch that removed any silver remnants embedded in the silicon and enabled investigation of the silicon surface beneath these remnants. *Id.*

In response to Dr. Souri's testimony on chemical etching, Dr. John testified that Dr. Souri failed to properly account for the impact of the "Piranha" etches and the HF etch on the surface of the testing samples. *See* RX-0604C (John RWS) at Q/A 124-35. Specifically, Dr. John testified that the "Piranha" etch causes an extremely reactive chemical reaction that was not properly considered and that the HF etch depends on factors that were not fully disclosed or fully investigated. *Id.* In addition, Dr. John testified that those skilled in the art would understand that the "Piranha" etch cannot be used to confirm the presence or the removal of nanostructures identified by Dr. Souri, and that the HF etch cannot be used to show the location of the p-n junction with the accuracy referenced by Dr. Souri. *Id.*

Dr. John's criticism of Dr. Souri's employment of the HF etch raises serious concerns about the reliability of the preparation of the testing samples for inspection of their layer-by-layer composition. *See* RX-0604C (John RWS) at Q/A 129-32. Dr. John testified that "Dr. Souri failed

to describe the effects of selective etching the n-type silicon with HNO_3:HF"; "[p]ut another way, this etching process would not automatically only remove n-type silicon." RX-0604C (John RWS) at Q/A 130. Dr. John further testified that "[d]epending on the etching rate and materials present, Dr. Souri's etching method could either fail to remove all of the n-emitter or mistakenly remove some amount of p-doped substrate." *Id.*; *see also* RX-0600C (Lebby RWS) at Q/A 99 (discussing deficiencies in Dr. Souri's use of the selective HF etch in analyzing Complainant's LightSense Biosensor). As a result, Dr. Souri's etching process will not necessarily or reliably reveal the location of the p-n junction. *See* RX-0604C (John RWS) at Q/A 129-32.

Moreover, Dr. Souri also admitted that he did not provide any information about the concentrations of the hydrofluoric acid and the nitric acid that were used in the HF etch, which was performed separately by third-party Covalent Metrology. *See* Tr. (Souri) at 217:19-219:8. Such information would provide insight into whether the HF etch selectively etched the substrate as claimed by Dr. Souri. *See* RX-0604C (John RWS) at Q/A 130. Further, Dr. Souri also admitted that, outside of this investigation, he has not done work involving "texturing silicon wafers used in solar cells" including, in particular, work involving forming nanowires or nanostructures on silicon wafers used in solar cells. *See* Tr. (Souri) at 224:1-20.

On balance, Dr. Souri's testimony about his employment of the HF etch does not account for the criticisms that were raised by Dr. John and Dr. Lebby. In my infringement analysis below, I have taken into account the not insubstantial possibility that Dr. Souri's etching materially altered the samples he examined, making his opinions unreliable.

3. Focus Ion Beam (FIB) Milling

In addition to etching, the testing samples Dr. Souri analyzed were subjected to Focus Ion Beam (FIB) milling to reveal their structure in cross-section. *See* CX-2411C (Souri WS) at Q/A

46. Respondents' expert Dr. John criticized Dr. Souri for failing to consider the impact of FIB milling on the testing samples. *See* RX-0604C (John RWS) at Q/A 136-37.

In contrast to the troubling evidence relating to Dr. Souri's etching processes, the record does not show that Dr. Souri's use of FIB milling had a material impact on the structure of the testing samples. Dr. Souri testified that the use of FBI milling on testing samples does not render them deficient. *See* CX-2411C (Souri WS) at Q/A 46. And Dr. John admitted that FIB milling is an industry standard process. *See* RX-0604C (John RWS) at Q/A 137.

B. Complainant's Sample Testing of Accused Products

In addition to sample preparation, Dr. Souri testified about sample testing. Specifically, Dr. Souri testified about the use of Atomic Force Microscopy ("AFM") to assess the topography of the surface of the testing samples. *See* CX-2411C (Souri WS) at Q/A 41. According to Dr. Souri, AFM directly measures the surface topography and outputs coordinates of the imaged surface that can be visualized using standard techniques for processing surface information. *Id.* In this case, AFM data was analyzed using software written in MATLAB. *Id.* To determine whether "nanostructures" and "nanowires" were present in the testing samples, a MATLAB script was specifically written to apply the parties' proposed constructions of "nanostructures" and "nanowires" and to identify features that conform to the requirements of the constructions. *Id.*

In response to Dr. Souri's testimony, Dr. John opined that Dr. Souri's AFM analysis is flawed because Dr. Souri employed MATLAB software to identify localized regions (or sub-parts) of a much larger micron-scale structure. *See* RX-0604C (John RWS) at Q/A 138. According to Dr. John, Dr. Souri's MATLAB code is not designed to identify "nanowires" or "nanostructures" because the MATLAB code makes measurements that "do not provide data regarding the depth or shape of the surface imperfections in question." *See* RX-0604C (John RWS) at Q/A 140. As

discussed *infra* concerning infringement and technical prong of the domestic industry requirement for the Asserted Patents, I find that Dr. John's testimony is persuasive,[8] and that Dr. Souri's AFM analysis is flawed.

VI. THE '599 PATENT

As noted above, Complainant asserts apparatus claims 15, 23, 24, and 27 of the '599 patent. Complainant argues that the Canadian Solar Accused Products and the Boviet Accused Products infringe apparatus claims 15, 23, 24, and 27 of the '599 patent; and that the Hanwha Accused Products infringe apparatus claims 15, 24, and 27 of the '599 patent. Staff contends Complainant has not proven by a preponderance of the evidence that the Accused Products infringe the asserted claims. *See* SIB at 69-101.

A. Infringement Analysis of the '599 Patent

The disputed '599 patent claim terms are shown in context below with emphasis:

15 [preamble]. A photovoltaic device comprising:

> [a] a crystalline semiconductor substrate comprising:
>
> [i] a bottom p-doped region;
>
> [ii] a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located **at least about 30 nm** from the bottom of the **nanowires** and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region; and
>
> [b] a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate.

23. A device as described in claim 15, wherein the device is

[8] As discussed *infra* concerning infringement and technical prong of the domestic industry requirement for the Asserted Patents, I find that the testimony provided by Canadian Solar Respondents' expert, Dr. Neikirk, and Boviet Respondents' expert, Dr. Kanicki, in this respect, is also persuasive.

> fabricated using a process comprising **metal enhanced etching** in a solution comprising HF and an oxidizer.
>
> 24. A device as described in claim 15, wherein the p-n junction is located **at least about 300 nm** from the bottom of the nanowires.
>
> 27. A device as described in claim 15, wherein the crystalline semiconductor comprises polycrystalline silicon.

JX-0001 ('599 Patent) at claims 15, 23, 24, and 27 (emphasis added).

1. Alleged Infringement by Canadian Solar Accused Products

I find that ASGT has failed to demonstrate Canadian Solar infringed any of the asserted claims of the '599 patent with the Canadian Solar Accused Products. My reasoning follows.

a. Independent Claim 15

For the reasons discussed below, I find that the Canadian Solar Accused Products have not been shown to satisfy claim 15 of the '599 patent.

(i) Claim 15 Preamble – "A photovoltaic device comprising"

The preamble of claim 15 of the '599 patent is not limiting. In the alternative, I find that the Canadian Solar Accused Products meet the preamble of claim 15 of the '599 patent. Complainant's expert Dr. Souri testified that the Canadian Solar Accused Products comprise "a photovoltaic device." *See* CX-2411C (Souri WS) at Q/A 51-52.

Moreover, the Canadian Solar Respondents and their expert Dr. Neikirk did not dispute Dr. Souri's testimony concerning the preamble of claim 15 of the '599 patent. *See* RIB at 52-68; RX-0601C (Neikirk RWS) at Q/A 245-46.

(ii) Claim Limitation 15[a] – "a crystalline semiconductor substrate comprising"

The evidence also shows that the Canadian Solar Accused Products meet claim limitation 15[a] of claim 15 of the '599 patent, which recites "a crystalline semiconductor substrate

comprising." ASGT's expert Dr. Souri testified that the Canadian Solar Accused Products are polycrystalline, which is indicative of polycrystalline silicon. *See* CX-2411C (Souri WS) at Q/A Q/A 64.

Additionally, the Canadian Solar Respondents and their expert Dr. Neikirk did not dispute Dr. Souri's testimony on claim limitation 15[a] of claim 15 of the '599 patent. *See* RIB at 52-68; RX-0601C (Neikirk RWS) at Q/A 245-46.

(iii) Claim Limitation 15[a][i] – "a bottom p-doped region"

The evidence also shows that the Canadian Solar Accused Products meet claim limitation 15[a][i] of claim 15 of the '599 patent, which recites "a bottom p-doped region." ASGT's expert Dr. Souri testified that the Canadian Solar Accused Products have a silicon substrate with two regions – one that is p-doped and another one that is n-doped. *See* CX-2411C (Souri WS) at Q/A 65-66. Dr. Souri presented a cross-sectional SEM image of a Canadian Solar Accused Product that has been etched to remove n-doped silicon and explained that it includes a top insulating layer, a gap where n-doped silicon has been removed, and a p-doped silicon substrate. *Id.*; CX-2420C (Compilation Exhibit re Figures from Souri's Expert Report).

Additionally, the Canadian Solar Respondents and their expert Dr. Neikirk did not dispute Dr. Souri's testimony with respect to claim limitation 15[a][1] of claim 15 of the '599 patent. *See* RIB at 52-68; RX-0601C (Neikirk RWS) at Q/A 245-46.

(iv) Claim Limitation 15[a][ii] – "a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located at least about 30 nm from the bottom of the nanowires and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region"

For the reasons discussed below, the Canadian Solar Accused Products do not meet claim limitation 15[a][ii] of claim 15 of the '599 patent, which recites: "a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located at least about 30 nm from the bottom of the nanowires and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region." Although the Canadian Solar Accused Products comprise n-doped silicon and p-doped silicon that form a p-n junction within the bulk of the substrate, *see, e.g.* SIB at 71, the record evidence shows that there are no "nanowires" in the Canadian Solar Accused Products.

Complainant AGST's expert Dr. Souri directed the preparation an AFM image of the surface of the silicon substrate from a sample a Canadian Solar solar module, reproduced below:

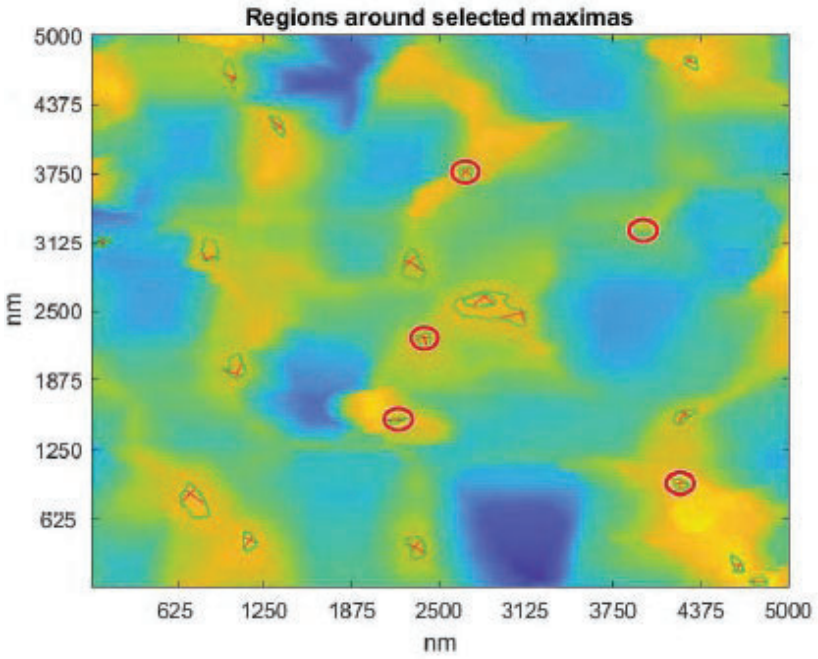


Figure 21: Analysis of AFM image data of the nanostructure on the surface of the silicon substrate within Canadian Solar P4 Products.

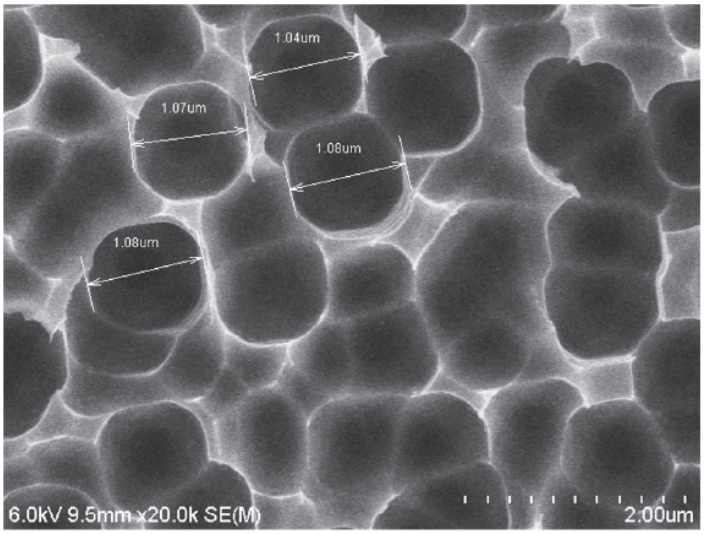
CX-2420C.11 (Compilation Exhibit re Figures from Souri's Expert Report). The AFM image presents a top-down view. The coloring indicates relative heights of surface features with yellow representing taller features and blue indicating lower features. *See* RX-0601C (Neikirk RWS) at Q/A 101.

Dr Souri testified that he used some MATLAB code written for this investigation to identify alleged nanorwires in the AFM image. CX-2411C (Souri WS) at Q/A 41. The software identified localized regions on an undulating surface that, relative to their surroundings, conform to nanoscale dimensions. *See* CX-2411C (Souri WS) at Q/A 74. He marked with an X and drew red ellipses around peaks having dimensions within the parties' proposed constructions for nanowires: *See* RX-0601C (Neikirk RWS) at Q/A 99; CX-2420C.11 (Compilation Exhibit re Figures from Souri's Expert Report); *see also, e.g.*, CX-2411C (Souri WS) at Q/A 68.

Canadian Solar Respondents' expert Dr. Neikirk testified that the features identified by Dr. Souri were not nanowires but rather were sub-micron- and micron-scale craters created to reduce light reflection while minimizing surface recombinations. *See* RX-0601C (Neikirk RWS) at Q/A 4; Tr. (Neikirk) at 592:20-593:16 ("If we look at the structures, they are on the order of 800 nanometers in size. Those are actually quite comparable to the wavelength of light and that means that the way the light's electromagnetic wave is captured is by that structure."); 593:17-594:19 ("So one significant place where recombination happens is at the surface of silicon. And in a nanostructure the surface-to-volume ratio of the nanostructure itself is very large. And that can lead to an opportunity for a lot of recombination."); 594:20-596:9 (With reference to converting nanostructures (approximately 100 nm) into sub-micron-scale structures (approximately 800 nm), "by actually making things bigger, not smaller in this case, the surface-to-volume ratio is better, and the surface recombination relative to how much light was simply being absorbed by those structures was better by getting rid of the nanostructures, eliminating the nanostructures and using submicroscale [(sub-micron scale)] cavities or pits."). Dr. Neikirk also described these sub-micron- scale and micron-scale structures as "pits." Tr. (Neikirk) at 573:4-574:3.

Dr. Neikirk explained the craters or pits are formed by a multi-step process that includes (i) performing a first etching step using a solution containing [redacted]; and (ii) performing a second etching step (called the "post-etching" step) using an [redacted]." RX-0601C (Neikirk RWS) at Q/A 49-50. The "post-etching" step creates sub-micron-scale and micron-scale crater structures with diameters within the range of 800 nm to 1.2 micron. *Id.* at Q/A 50.

The image below is a top-down view of the crater structures in the textured surface of the Canadian Solar Accused Products, with the diameter of some of the craters labeled:



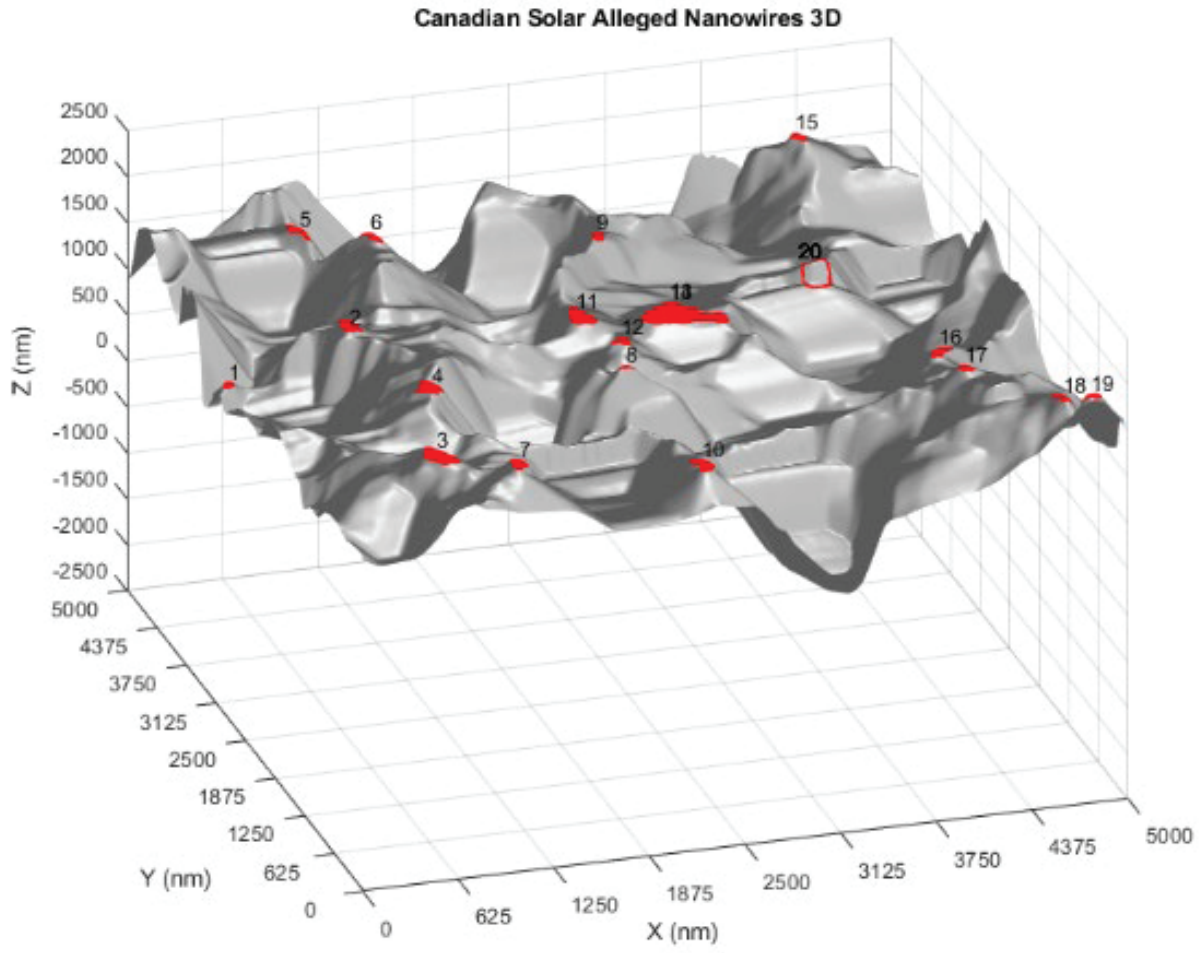
RX-0601C (Neikirk RWS) at Q/A 47; RX-0944C.28. In the image above, the annotations show the diameters of the craters are around 1 micron, which is within the range of 800 nm to 1.2 micron specified by the Canadian Solar Respondents' manufacturing process. *See* RX-0601C (Neikirk RWS) at Q/A 50.

Dr. Neikirk criticized Dr. Souri's methodology because it did not look at the structure as a whole when seeking to identify the constituent limitations of the claims. *See* RX-0601C (Neikirk RWS) at Q/A 88. Dr. Souri focused only on the tips of regions between craters and characterizes those to be nanowires irrespective of the height, diameter, taper, and shape of the object as a whole. *Id*.; *see also id.* at Q/A 90, 99.

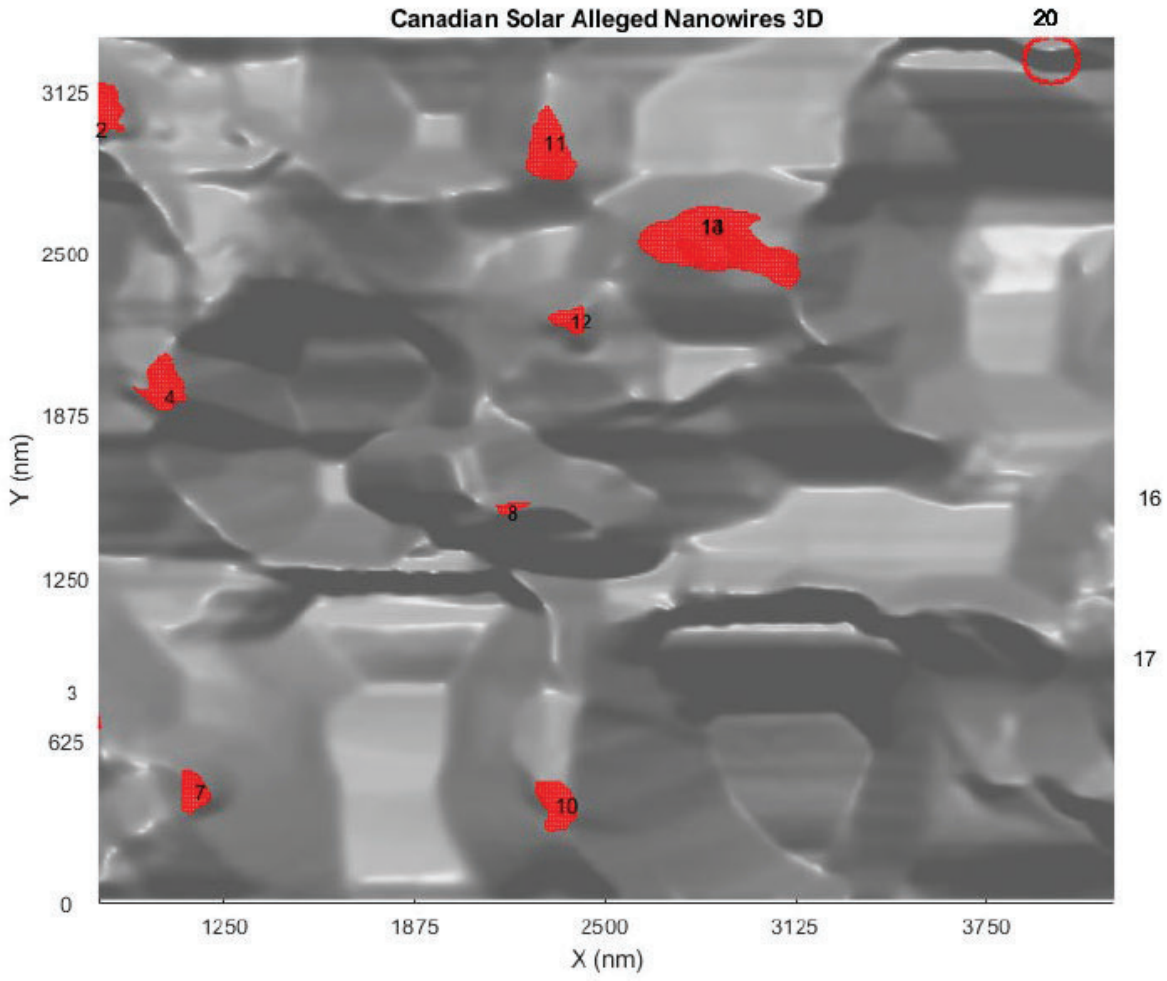
In addition, Dr. Neikirk also provided testimony about his analysis of the MATLAB code used by Dr. Souri to annotate the AFM image. Specifically, Dr. Neikirk testified that the MATLAB code drew a green line at a boundary where the elevation drops 50 nm below the highest point inside the green line, and then made an assessment of elevations above that green-outlined region while ignoring anything below. *See* RX-0601C (Neikirk RWS) at Q/A 106-07. Further,

the MATLAB code used by Dr. Souri drew a red annotation if it identified features in that region at least 200 nm long and having a width less than 200 nm along its length. *Id.*

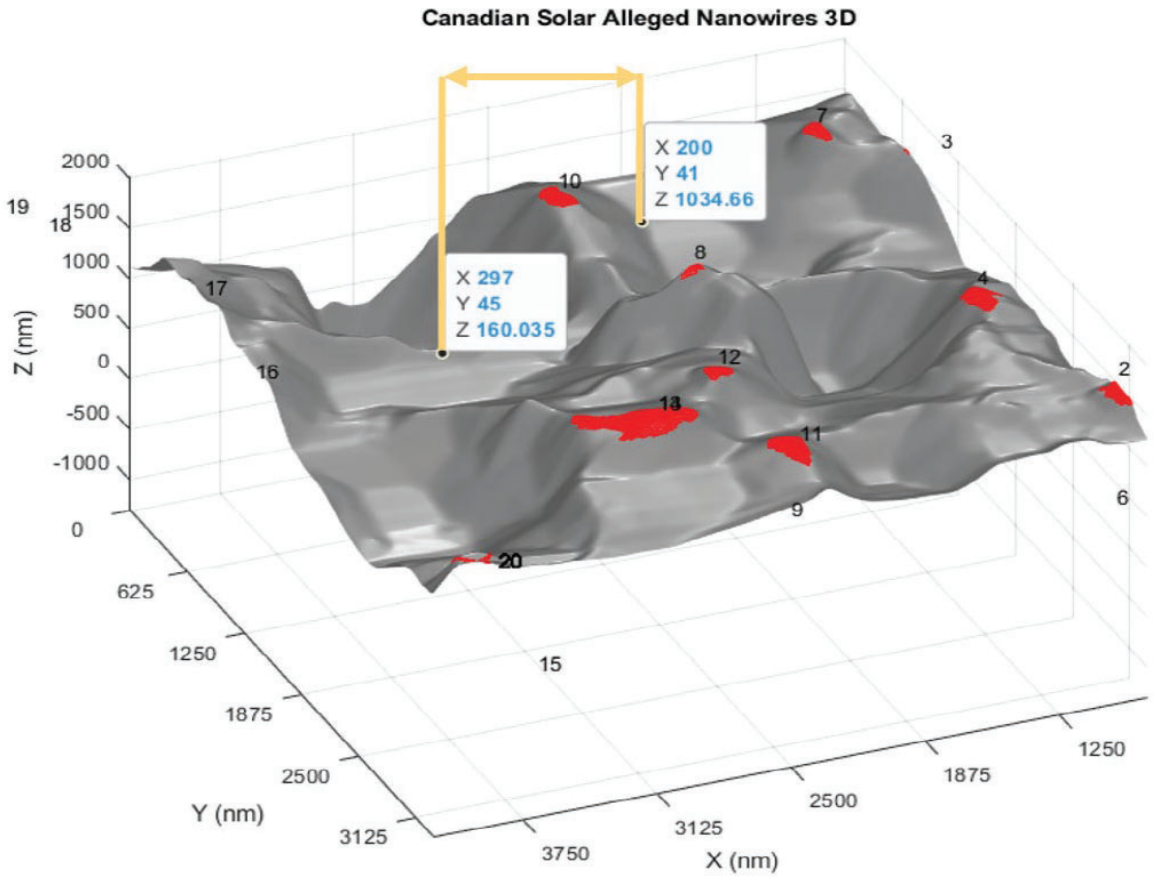
Dr. Neikirk further testified about his independent analysis of the underlying AFM data used by Dr. Souri to generate the AFM image. As part of that independent analysis, Dr. Neikirk created his own 3D images using the underlying AFM data used by Dr. Souri and then highlighted the parts of the images where Dr. Souri had claimed there is a "nanowire" (or a "nanostructure"). *See* RX-0601C (Neikirk RWS) at Q/A 115-20. Unlike Dr. Souri's 2D AFM image, which presents only a top-down view, Dr. Neikirk's 3D AFM image does not obscure the shape of the silicon and shows what the alleged "nanowires" (and "nanostructures") look like in 3D. *Id.* Reproduced below is a screenshot of Dr. Neikirk's 3D AFM image showing Dr. Souri's alleged "nanowires" highlighted in red and numbered 1-20:



RX-0601C (Neikirk RWS) at Q/A 119; RX-0752C (MATLAB 3D Image Neikirk Report 153). Dr. Neikirk offered his opinion that none of Dr. Souri's alleged "nanowires" have the shape of wires, and none are part of larger features or structures having a wire shape. *See* RX-0601C (Neikirk RWS) at Q/A 120. Dr. Neikirk testified about each of the individual alleged "nanowires" and explained that they were merely the edge of a crater, not a nanowire. For example, Dr. Neikirk testified about his analysis of the alleged "nanowire" numbered "10" in the image below (from RX-0823C (MATLAB 3D Image Neikirk Report 209)) that appears as the edge of adjoining craters:



CX-0161C (Neikirk RWS) at Q/A 155; RX-0823C (MATLAB 3D Image Neikirk Report 209). Dr. Neikirk testified that the surface structure on top of which "10" appears continues downward and extends laterally at least over 900 nm between the highlighted points:



CX-0161C (Neikirk RWS) at Q/A 155; RX-0824C (MATLAB 3D Image Neikirk Report 209).

Having reviewed the record evidence, I find that the "nanowires" Dr. Souri identified in the Canadian Solar Acused Products are, at best, the tips of larger, irregularly undulating features, as can be seen in Dr. Neikirk's 3D AFM images above. Dr. Souri admitted as much in his testimony. *See* Tr. (Souri) at 249:3-250:10; CX-2411C (Souri WS) at Q/A 74. I further find no features in the Canadian Solar Accused Products that are generally cylindrical or modestly tapering cylinders, as all parties agree the claim term "nanowire" requires. Additionally, as described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed.

Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Canadian Solar made, used, sold, offered for sale, or imported.

In sum, ASGT has failed to establish that the Canadian Solar Accused Products meet claim limitation 15[a][ii] of claim 15 of the '599 patent.

(v) Claim Limitation 15[b] – "a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate"

Similar to claim limitation 15[a][ii] of claim 15 of the '599 patent, the evidence establishes that the Canadian Solar Accused Products do not meet claim limitation 15[b] of claim 15 of the '599 patent, which recites: "a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate." This claim limitation also requires "nanowires." Thus, for the reasons discussed above with respect to claim limitation 15[a][ii] of claim 15 of the '599 patent, the evidence establishes that the Canadian Solar Accused Products do not meet claim limitation 15[b] of claim 15 of the '599 patent.

In addition, Dr. Neikirk also testified about an additional basis for concluding that this claim limitation is not met. Specifically, Dr. Souri's alleged "nanowires" are the tips of larger features or structures and, as a result, the tips are not in direct physical contact with the substrate, as required by this claim limitation. *See* RX-0601C (Neikirk RWS) at Q/A 238-44. I find this limitation is not met for this additional and independent reason.

b. Dependent Claim 23 – "A device as described in claim 15, wherein the device is fabricated using a process comprising metal enhanced etching in a solution comprising HF and an oxidizer."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 23 of the '599 patent.

(i) "A device as described in claim 15"

For the reasons discussed *supra* part VI.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 23 for at least that reason.

(ii) "wherein the device is fabricated using a process comprising metal enhanced etching in a solution comprising HF and an oxidizer."

The evidence shows that the Canadian Solar Accused Products do not satisfy claim 23 of the '599 patent, which depends from claim 15 (and, thus, includes the limitations of claim 15) and which includes the additional limitation that "the device is fabricated using a process comprising metal enhanced etching in a solution comprising HF and an oxidizer." JX-0001 ('599 Patent) at 12:13-15. Absent any finding of infringement of independent claim 15, there cannot be any finding of infringement of dependent claim 23 of the '599 patent.

In addition, Dr. Neikirk testified about a separate basis for concluding that the Canadian Solar Accused Products do not meet this dependent claim. As discussed in the claim construction section above, metal enhanced etching is, at a minimum, a process in which a metal film is deposited onto the surface of a substrate, and the metallized substrate is then contacted with an etching solution. The evidence shows that the Canadian Solar Respondents expose the surface to [redacted]. *See* RX-0601C (Neikirk RWS) at Q/A 252-53. This one-step process does not practice the claimed two-step process, which requires metal to be deposed onto the surface of the substrate before the metallized substrate is exposed to an etching solution. *Id.*

c. Dependent Claim 24 – "A device as described in claim 15, wherein the p-n junction is located at least about 300nm from the bottom of the nanowires."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 24 of the '599 patent.

For the reasons discussed *supra* part VI.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 24 for at least that reason.

d. Dependent Claim 27 – "A device as described in claim 15, wherein the crystalline semiconductor comprises polycrystalline silicon."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 27 of the '599 patent.

For the reasons discussed *supra* part VI.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 27 for at least that reason.

2. Alleged Infringement by Hanwha Accused Products

I find that ASGT has failed to demonstrate Hanwha infringed any of the asserted claims of the '599 patent with the Hanwha Accused Products. My reasoning follows.

a. Representativeness of the Hanwha Accused Products

ASGT presented evidence analyzing only two Hanwha Accused Products and has failed to show that these two products are representative of all Hanwha Accused Products, whether others of the same model or a different model.

Complainant accuses six Hanwha polycrystalline products of infringing the Asserted Patents: Q.PLUS BFR G4.1, Q.PLUS DUO L G5.2, Q.PLUS G4, Q.PLUS G4.3, Q.PLUS L G4.1

and Q.PLUS L G4.2. CX-2411C (Souri WS) at Q/A 32-34. Hanwha has not stipulated that the surface morphology, features or microstructures of any of its Accused Products are representative of any other Accused Products. Instead, Hanwha has only confirmed that [redacted]. *See* Final Joint Submission regarding Representative and Represented Accused Products at 7 (Dec. 7, 2021) (EDID Doc. ID No. 758111); Tr. (John) at 468:5-469:10 (explaining [redacted]). Complainant may not have appreciated the distinction, but there is one. *See* RX-0604C (John RWS) at Q/A 147-53; Tr. (Schwabedissen) at 417:11-418:3. Nonetheless, Dr. Souri's infringement analysis ignored these other products, and was instead limited to the Hanwha Q.PLUS-L-G4.2 and Hanwha Q.PLUS DUO L-G5.2. *Id.*

[redacted] does not mean that there will be uniformity or consistency in surface morphology across these different products, as Complainant suggests. *See* RX-0604C (John RWS) at Q/A 147-53. To the contrary, Hanwha's models have a variety of different properties that confirm a range of resulting surface topologies across products [redacted]. *Id.* In fact, even within the products Complainant did analyze there will be non-uniformity. *Id.* For example, there is little uniformity across individual polysilicon wafers, which, in turn, will result in variations in surface morphology across these different wafers when textured, [redacted]. Tr. (John) at 468:5-469:10. Complainant has not accounted for this and has thus failed to show representativeness.

Moreover, there are several critical differences in the overall manufacturing processes between different Hanwha Accused Products. Tr. (Schwabedissen) at 413:6-414:2, 417:11-418:3 (testifying Hanwha products have different passivation layers, different [redacted] layers, and

different metallization). Complainant has not addressed any of these differences, and, thus, again failed to establish representativeness. Diffusion processes and deposition of dielectric layers, for example, can have an impact on p-n junction depth. Tr. (Schwabedissen) at 413:6-17; *see also* CX-2485 (Banerjee RWS) at Q/A 59 ("strong oxidizing agents" can impact dopant diffusion and p-n junction depth). And changes in the metallization paste or grid layout for the metallization mesh can have an impact on the screen printing processes resulting in contact formation. Tr. (Schwabedissen) at 417:6-418:3.

For the foregoing reasons, I find Complaiant has not shown infringement by Hanwha based on models for which Complainant did not present detailed evidence. The models lacking detailed evidence are Q.PLUS BFR G4.1, Q.PLUS G4, Q.PLUS G4.3, and Q.PLUS L G4.1. The two models Complainant did analyze, the Hanwha Q.PLUS-L-G4.2 and the Hanwha Q.PLUS DUO L-G5.2, do not demonstrate infringement either, as discussed below.

b. Independent Claim 15

For the reasons discussed below, I find that the Hanwha Accused Products have not been shown to satisfy claim 15 of the '599 patent.

(i) Claim 15 Preamble – "A photovoltaic device comprising"

The preamble of claim 15 of the '599 patent is not limiting. In the alternative, Complainant's expert Dr. Souri provided testimony explaining that the Hanwha Accused Products meet the preamble of claim 15 of the '599 patent. *See* CX-2411C (Souri WS) at Q/A 87. Further, the Hanwha Respondents and their expert Dr. John did not dispute Dr. Souri's testimony in this respect. *See* RIB at 68-79; RX-0604C (John RWS) at Q/A 157.

(ii) Claim Limitation 15[a] – "a crystalline semiconductor substrate comprising"

Complainant's expert Dr. Souri provided testimony that the Hanwha Accused Products meet claim limitation 15[a] of claim 15 of the '599 patent. *See* CX-2411C (Souri WS) at Q/A 87. Also, the Hanwha Respondents and their expert Dr. John did not dispute Dr. Souri's testimony in this respect. *See* RIB at 68-79; RX-0604C (John RWS) at Q/A 157.

(iii) Claim Limitation 15[a][i] – "a bottom p-doped region"

Complainant's expert Dr. Souri provided testimony that the Hanwha Accused Products meet claim limitation 15[a][i] of claim 15 of the '599 patent. *See* CX-2411C (Souri WS) at Q/A 88. Further, Hanwha Respondents and their expert Dr. John did not dispute Dr. Souri's testimony in this respect. *See* RIB at 68-79; RX-0604C (John RWS) at Q/A 157.

(iv) Claim Limitation 15[a][ii] – "a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located at least about 30 nm from the bottom of the nanowires and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region"

For the reasons set forth below, the evidence establishes that the Hanwha Accused Products do not meet claim limitation 15[a][ii] of claim 15 of the '599 patent, specifically with respect to "nanowires" and "wherein the p-n junction is located at least 30 nm from the bottom of the nanowires." The Hanwha Respondents presented testimony from their expert Dr. John that "nanowires" and a p-n junction "located at least 30 nm from the bottom of the nanowires" are missing from the Hanwha Accused Products. *See* RX-0604C (John RWS) at Q/A 165-98.

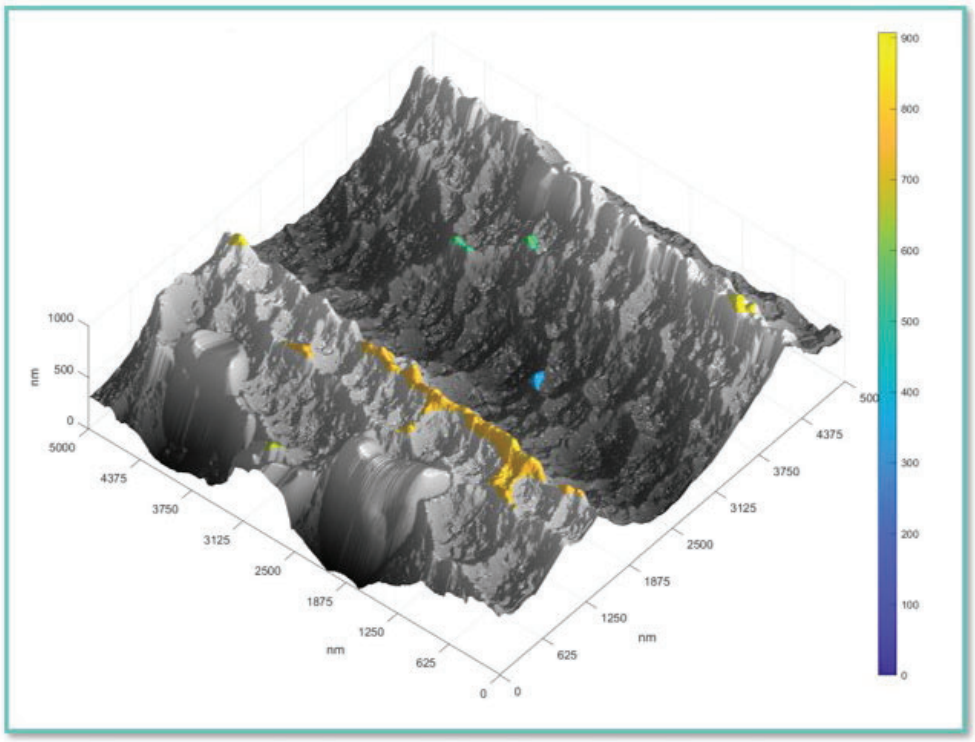
As an initial matter, the evidence shows that Complainant's expert Dr. Souri tested the Hanwha Accused Products according to the same methodology used for the Canadian Solar Accused Products. *See* CX-2411 (Souri WS) at Q/A 38; Tr. (Souri) at 182:16-20 (confirming testing of all of Respondents' Accused Products according to the same methodology); 205:19-206:15 (confirming application of the same methodology including, in particular, the MATLAB code to all of Respondents' Accused Products). Therefore, the above discussion of the deficiencies with Dr. Souri's testing of the Canadian Solar Accused Products applies here.

With respect to "nanowires," the evidence shows that the Hanwha Accused Products do not have "nanowires." Dr. Souri provided testimony identifying "nanowires" in the Hanwha Accused Products only under Complainant's proposed construction, which is incorrect for the reasons discussed *supra* part IV.B.1. *See* CX-2411 (Souri WS) at Q/A 93; Tr. (Souri) at 209:15-210:11.

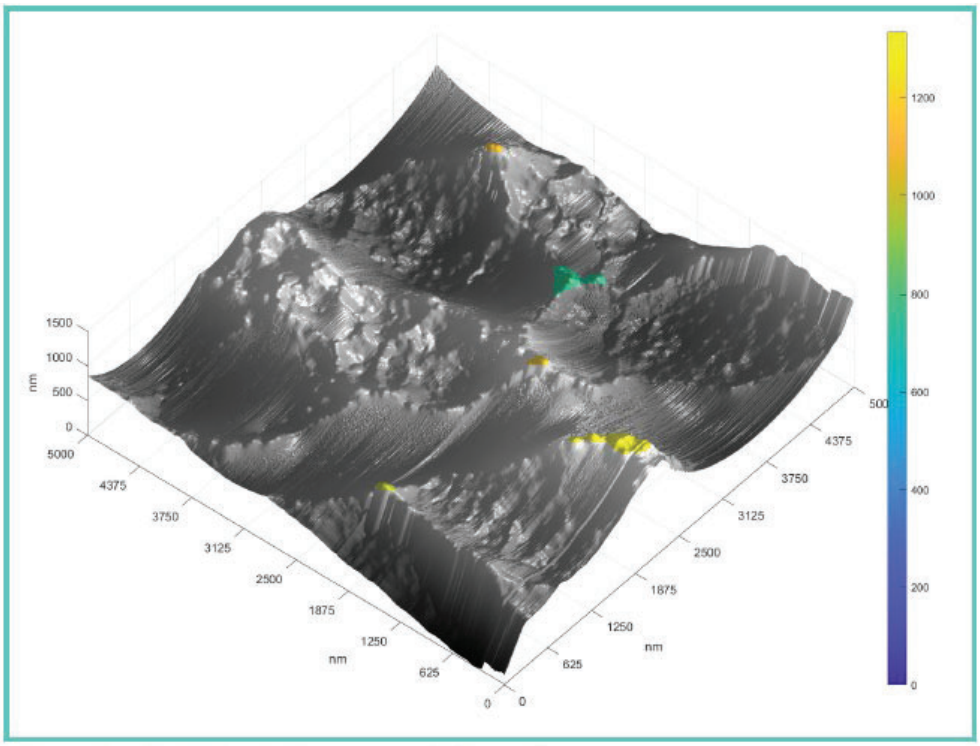
The evidence shows that the Hanwha Accused Products do not have "nanowires" even under Complainant's proposed construction. Dr. John provided testimony that Dr. Souri's analysis of "nanowires" under Complainant's proposed construction is flawed. *See* RX-0604C (John RWS) at Q/A 181-99. Like Dr. Neikirk, Dr. John testified, *inter alia*, that Dr. Souri's MATLAB script and AFM data reflect an incorrect approach to identifying "nanowires." *Id.* Rather than look for structures on the surface of the Hanwha Accused Products and measure them to see whether they fell within the requirements of the claim, Dr. Souri followed a top-down approach that incorrectly identified peaks of larger structures as "nanowires." *Id.*

Also, like Dr. Neikirk, Dr. John testified about his own 3D AFM images produced using Dr. Souri's AFM data to show that the alleged "nanowires" are not, in fact, "nanowires." Reproduced below are two examples of Dr. John's 3D AFM images showing Hanwha's Accused

4.2 Product (RDX-0008.30C: RX-0971C.11 (Compilation re Figures from Dr. Anna S. John's Expert Report)) and 5.2 Product (RDX-0008.31C: RX-0971C.112), wherein the alleged "nanowires" are shown in color against a grayscale background:



Hanwha 4.2: AFM data in 3D with Only Souri maxima shown (Grayscale)



Hanwha 5.2: AFM data in 3D with Only Souri maxima shown (Grayscale)

RX-0604C (John RWS) at Q/A 176-86; RDX-0008.30C (RX-0971C.11 (Compilation re Figures from Dr. Anna S. John's Expert Report): Hanwha 4.2 Product); RDX-0008.31C (RX-0971C.12: Hanwha 5.2 Product). Based on the color scale on the right side of the images, Dr. John testified that the alleged "nanowires" are structures much larger than those incorrectly identified by Dr. Souri. *See* RX-0604C (John RWS) at Q/A 176-86.

With respect to a p-n junction "located at least 30 nm from the bottom of the nanowires," Dr. John provided testimony that Dr. Souri has not presented evidence showing the depth of the p-n junction, much less that "the p-n junction is located at least 30 nm from the bottom of the nanowires," as required by the claim. *See* RX-0604C (John RWS) at Q/A 165-73. Specifically, Dr. John testified that Dr. Souri cannot properly rely upon his use of selective etchant to remove only n-type materials to measure the distance between the bottom of the insulating layer and the

top of the silicon that was not etched away (allegedly corresponding to the distance required to satisfy this claim limitation). *See* RX-0604C (John RWS) at Q/A 129-35. Dr. John further explained that Dr. Souri's "HF" etch would not automatically only remove n-type silicon (as apparently assumed) because, *inter alia*, the presence of materials and the etching rate could remove some amount of the p-doped substrate. *Id.* In Dr. John's opinion, Dr. Souri's "HF" etch actually destroyed the evidence that could be used to evaluate the location of the p-n junction that serves as one point of measurement. *See* RX-0604C (John RWS) at Q/A 168-69.

Further, Dr. John testified that Dr. Souri could have used a reliable technique to identify the p-n junction – a Secondary-Ion Mass Spectrometry (SIMS) analysis. *See* RX-0604C (John RWS) at Q/A 170-73. By performing a SIMS analysis, Dr. Souri could have identified readily the point where the p-dopant concentration and the n-dopant concentration meet, which would have allowed him to reliably estimate the location of the p-n junction. *Id.*

Having reviewed the record evidence, I find that the "nanowires" Dr. Souri identified in the Hanwha Acused Products are, at best, the tips of larger, irregularly undulating features, as can be seen in Dr. John's 3D AFM images above. I further find no features in the Hanwah Accused Products that are generally cylindrical or modestly tapering cylinders, as all parties agree the claim term "nanowire" requires. Additionally, as described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Hanwha made, used, sold, offered for sale, or imported.

In sum, ASGT has failed to establish that the Hanwah Accused Products meet claim limitation 15[a][ii] of claim 15 of the '599 patent.

(v) Claim Limitation 15[b] – "a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate"

Similar to claim limitation 15[a][ii] of claim 15 of the '599 patent, the evidence shows that the Hanwha Accused Products do not meet claim limitation 15[b] of claim 15 of the '599 patent, which also requires, *inter alia*, "nanowires." Thus, for the reasons discussed above with respect to claim limitation 15[a][ii] of claim 15 of the '599 patent, the evidence shows that the Hanwha Accused Products do not meet claim limitation 15[b] of claim 15 of the '599 patent.

c. Dependent Claim 24 – "A device as described in claim 15, wherein the p-n junction is located at least about 300nm from the bottom of the nanowires."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 24 of the '599 patent.

(i) "A device as described in claim 15"

For the reasons discussed *supra* part VI.A.2.b, I find that the Hanwha Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 24 for at least that reason.

(ii) "wherein the p-n junction is located at least about 300nm from the bottom of the nanowires."

In addition, Dr. John testified about a separate basis for finding no infringement. Similar to claim limitation 15[a][ii] of claim 15 of the '599 patent, claim 24 of the '599 patent requires that the "p-n junction is located at least about 300 nm from the bottom of the nanowires." Dr. John testied that Dr. Souri's selective etching cannot accurately determine the location of the p-n junction, as discussed above. I find that Hanwha Accused Products have not been shown to satisfy dependent claim 24 for that additional reason.

d. Dependent Claim 27 – "A device as described in claim 15, wherein the crystalline semiconductor comprises polycrystalline silicon."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 27 of the '599 patent.

For the reasons discussed *supra* part VI.A.2.b, I find that the Hanwha Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 27 for at least that reason.

3. Alleged Infringement by Boviet Accused Products

I find that ASGT has failed to demonstrate Boviet infringed any of the asserted claims of the '599 patent with the Boviet Accused Products. My reasoning follows.

a. Independent Claim 15

For the reasons discussed below, I find that the Boviet Accused Products have not been shown to satisfy claim 15 of the '599 patent.

(i) Claim 15 Preamble – "A photovoltaic device comprising"

The preamble of claim 15 of the '599 patent is not limiting. In the alternative, I find that Boviet Accused Products meet the preamble of claim 15 of the '599 patent. On balance, the weight of the evidence shows that the preamble of claim 15 of the '599 patent is met by the Boviet Accused Products. *Compare* CX-2411C (Souri WS) at Q/A 121 *with* RX-0599C (Kanicki RWS) at Q/A 218.

(ii) Claim Limitation 15[a] – "a crystalline semiconductor substrate comprising"

The evidence shows that the Boviet Accused Products meet claim limitation 15[a] of claim 15 of the '599 patent. Here too, on balance, the weight of the evidence shows that this claim

limitation is met. *Compare* CX-2411C (Souri WS) at Q/A 123 *with* RX-0599C (Kanicki RWS) at Q/A 219.

(iii) Claim Limitation 15[a][i] – "a bottom p-doped region"

The evidence shows that the Boviet Accused Products meet claim limitation 15[a][i] of claim 15 of the '599 patent. Here too, on balance, the weight of the evidence shows that this claim limitation is met. *Compare* CX-2411C (Souri WS) at Q/A 124-25 *with* RX-0599C (Kanicki RWS) at Q/A 220-22.

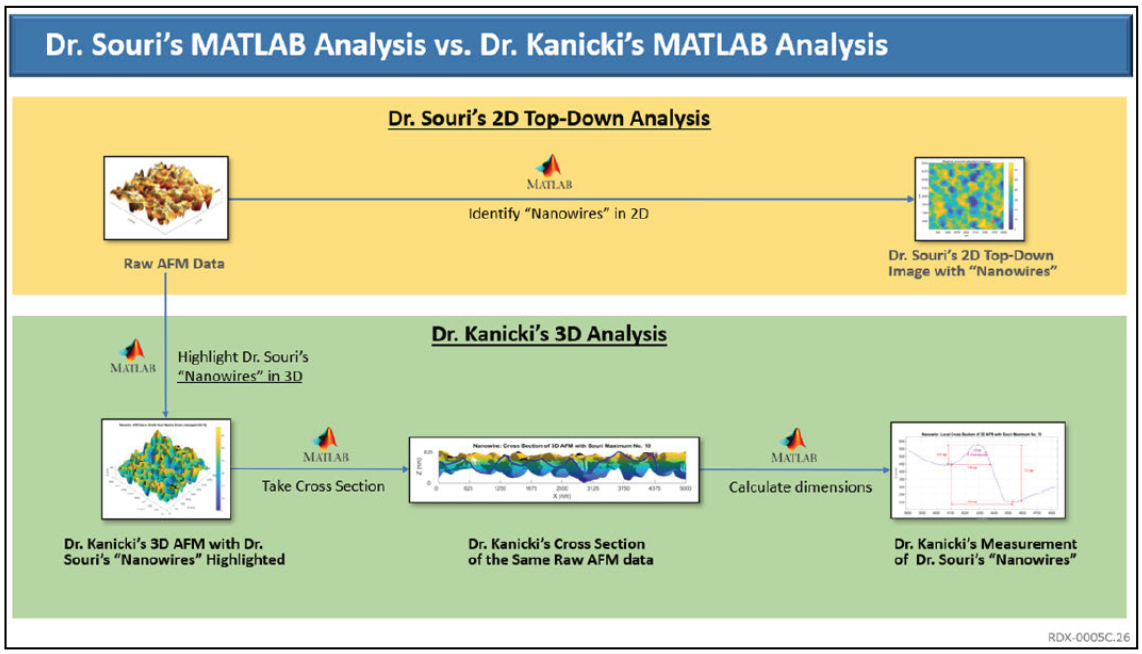
(iv) Claim Limitation 15[a][ii] – "a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located at least about 30 nm from the bottom of the nanowires and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region"

For the reasons set forth below, the evidence establishes that the Boviet Accused Products do not meet claim limitation 15[a][ii] of claim 15 of the '599 patent, specifically with respect to "nanowires" and "wherein the p-n junction is located at least 30 nm from the bottom of the nanowires." The Boviet Respondents presented testimony from their expert Dr. Kanicki that "nanowires" and a p-n junction "located at least 30 nm from the bottom of the nanowires" are missing from the Boviet Accused Products. *See* RX-0599C (Kanicki RWS) at Q/A 67-133, 226-227.

As indicated above, Complainant's expert Dr. Souri tested Respondents' Accused Products according to the same methodology. *See* CX-2411 (Souri WS) at Q/A 38; Tr. (Souri) at 182:16-20, 205:19-206:15. Thus, the above discussion of the deficiencies with Dr. Souri's testing of the Canadian Solar Accused Products and Boviet Accused Products applies here too.

With respect to "nanowires," Dr. Kanicki testified that Dr. Souri's analysis of "nanowires" is flawed. *See* RX-0599C (Kanicki RWS) at Q/A 67-133. Like Dr. Neikirk and Dr. John, Dr. Kanicki testified that Dr. Souri's MATLAB script and AFM data reflect an incorrect approach to identifying "nanowires" *Id.* Rather than look for structures on the surface of the Boviet Accused Products and then measure them to see whether they fall within the requirements of the claim, Dr. Souri followed instead a top-down approach that incorrectly identified peaks of larger structures as "nanowires." *Id.*

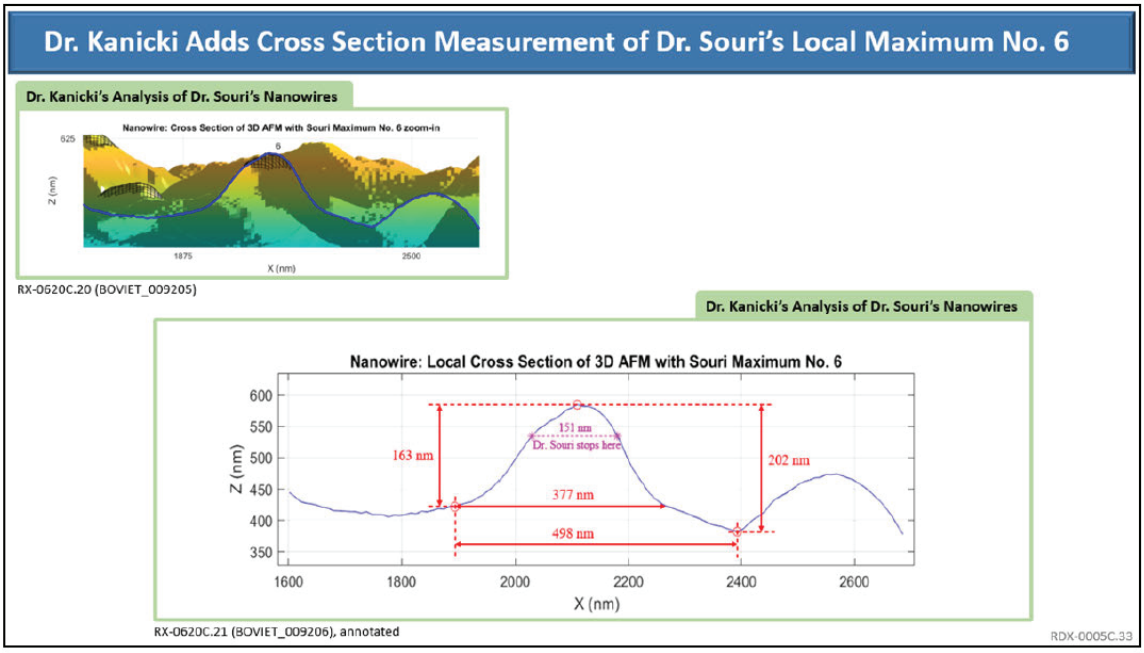
With reference to the demonstrative below (RDX-0005C.26: CX-2420C.27-CX-2420C.28, RX-0620C.2 (MATLAB images), RX-0620C.11, RX-0620C.22) Dr. Kanicki testified about the differences between Dr. Souri's 2D analysis and Dr. Kanicki's 3D analysis:



RDX-0005C.26

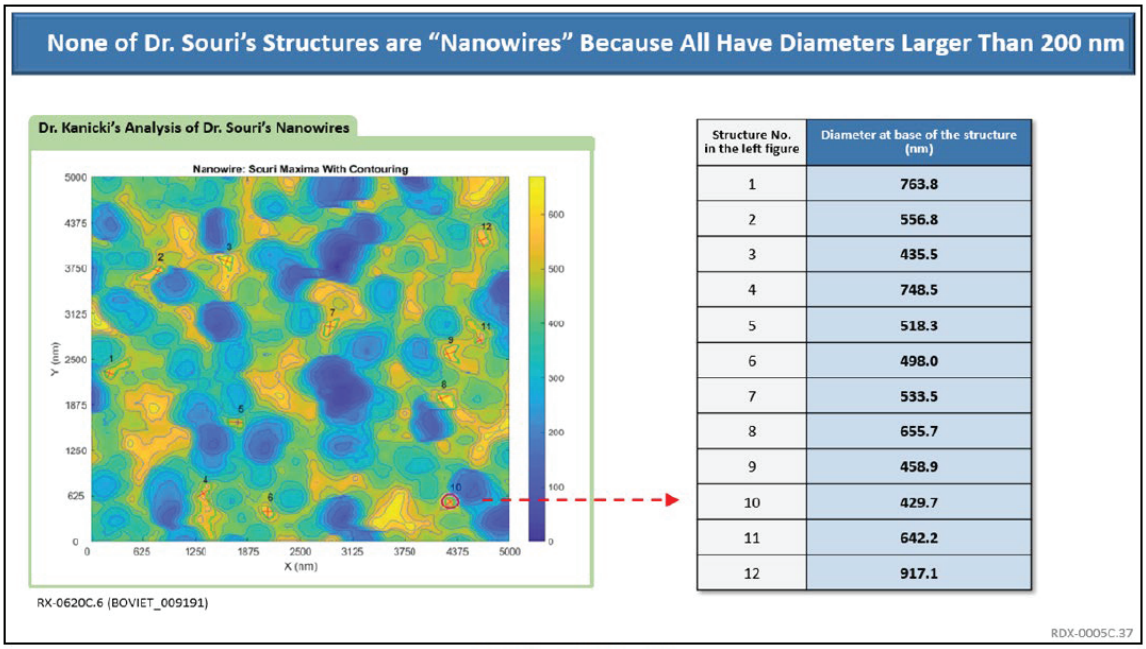
RX-0599C (Kanicki RWS) at Q/A 80; RDX-0005C.26: CX-2420C.27-CX-2420C.28, RX-0620C.2 (MATLAB images), RX-0620C.11, RX-0620C.22. As shown above, Dr. Kanicki testified about his own AFM images produced using Dr. Souri's AFM data to show that the alleged

"nanowires" are not, in fact, "nanowires." *See* RX-0599C (Kanicki RWS) at Q/A 67-133. In addition, Dr. Kanicki testified about making cross-section measurements of Dr. Souri's alleged "nanowires" to further prove that point, as shown in the exemplary demonstrative below (RDX-0005C.33: RX-0620C.20-RX-0620C.21):



RDX-0005C.33

RX-0599C (Kanicki RWS) at Q/A 88; RDX-0005C.33: RX-0620C.20-RX-0620C.21 (MATLAB images). For each of the alleged "nanowires" identified by Dr. Souri, Dr. Kanicki performed a cross-section analysis, and all of the diameter measurements that were taken are greater than 200 nm, as summarized in the demonstrative below (RDX-0005C.37: RX-0620C.6):



Structure No. in the left figure	Diameter at base of the structure (nm)
1	763.8
2	556.8
3	435.5
4	748.5
5	518.3
6	498.0
7	533.5
8	655.7
9	458.9
10	429.7
11	642.2
12	917.1

RDX-0005C.37

RX-0599C (Kanicki RWS) at Q/A 93; RDX-0005C.37: RX-0620C.6).

With respect to a p-n junction "located at least 30 nm from the bottom of the nanowires," Dr. Kanicki testified that Dr. Souri has not presented evidence sufficient to show the location of the p-n junction. *See* RX-0599C (Kanicki RWS) at Q/A 239. Dr. Kanicki testified, *inter alia*, that the p-doped silicon will also be etched during the selective etch process and, as a result, the location of the p-n junction cannot be established as alleged by Dr. Souri. *Id.*

Having reviewed the record evidence, I find that the "nanowires" Dr. Souri identified in the Boviet Acused Products are, at best, the tips of larger, irregularly undulating features, as can be seen in the images above presented by Dr. Kanicki. I further find no features in the Boviet Accused Products that are generally cylindrical or modestly tapering cylinders, as all parties agree the claim term "nanowire" requires. Additionally, as described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not

shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Boviet made, used, sold, offered for sale, or imported. I additionally find ASGT has not demonstrated that there is "a p-n junction at least 30 nm from the bottom of the nanowires" in the Boviet Accused Products, as required by this claim limitation.

(v) Claim Limitation 15[b] – "a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate"

Similar to claim limitation 15[a][ii] of claim 15 of the '599 patent, the evidence shows that the Boviet Accused Products do not meet claim limitation 15[b] of claim 15 of the '599 patent, which also requires, *inter alia*, "nanowires." Therefore, for the reasons stated above with respect to claim limitation 15[a][ii] of claim 15 of the '599 patent, the evidence shows that the Boviet Accused Products do not meet claim limitation 15[b] of claim 15 of the '599 patent.

b. Dependent Claim 23 – "A device as described in claim 15, wherein the device is fabricated using a process comprising metal enhanced etching in a solution comprising HF and an oxidizer."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 23 of the '599 patent.

(i) "A device as described in claim 15"

For the reasons discussed *supra* part VI.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 23 for at least that reason.

(ii) "wherein the device is fabricated using a process comprising metal enhanced etching in a solution comprising HF and an oxidizer."

In addition, Dr. Kanicki also testified about a separate basis for concluding that the Boviet Accused Products do not meet this dependent claim. As discussed above, metal enhanced etching

is, at a minimum, a process in which a metal film is deposited onto the surface of a substrate, and the metallized substrate is then contacted with an etching solution. The evidence shows that the Boviet Respondents do not perform the first step, *i.e.*, deposit a metal film onto the surface of its substrate during the manufacturing process. *See* RX-0599C (Kanicki RWS) at Q/A 245. I find that the Boviet Accused Products do not meet this limitation for at least that reason.

c. Dependent Claim 24 – "A device as described in claim 15, wherein the p-n junction is located at least about 300nm from the bottom of the nanowires."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 24 of the '599 patent.

For the reasons discussed *supra* part VI.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 24 for at least that reason.

d. Dependent Claim 27 – "A device as described in claim 15, wherein the crystalline semiconductor comprises polycrystalline silicon."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 27 of the '599 patent.

For the reasons discussed *supra* part VI.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy claim 15 of the '599 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 27 for at least that reason.

B. Technical Prong of the Domestic Industry Requirement

The technical prong of the domestic industry requirement is satisfied when the complainant in a patent-based section 337 investigation establishes that it is practicing or exploiting the patents at issue. *See* 19 U.S.C. § 1337(a)(2) and (3); *Certain Microsphere Adhesives, Process for Making*

Same and Prods. Containing Same, Including Self-Stick Repositionable Notes, Inv. No. 337-TA-366, Comm'n Op. at 8, USITC Pub. No. 2949 (Jan. 1996). "The test for satisfying the 'technical prong' of the industry requirement is essentially [the] same as that for infringement, *i.e.*, a comparison of domestic products to the asserted claims." *Alloc, Inc. v. Int'l Trade Comm'n*, 342 F.3d 1361, 1375 (Fed. Cir. 2003). To prevail, the patentee must establish by a preponderance of the evidence that the domestic product practices one or more valid claims of the patent. *See id.*; *Spansion*, 629 F.3d at 1349; *Certain Vision-Based Driver Assistance System Cameras and Components Thereof*, Inv. No. 337-TA-907, Comm'n Op. at 36, USITC Pub. No. 4866 (Feb. 2019).

For the reasons discussed below, I find that Complainant's LightSense Biosensor has not been shown to practice claim 15 of the '599 patent.

1. Independent Claim 15

The disputed '599 patent claim terms are shown in context below with emphasis:

15 [preamble]. A photovoltaic device comprising:

> [a] a crystalline semiconductor substrate comprising:
>
> [i] a bottom p-doped region;
>
> [ii] a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located **at least about 30 nm** from the bottom of the **nanowires** and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region; and
>
> [b] a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate.

JX-0001 ('599 Patent) at claim 15 (emphasis added).

a. Claim 15 Preamble – "A photovoltaic device comprising"

The preamble of claim 15 of the '599 patent is not limiting. In the alternative, if the preamble is limiting, then Complainant's LightSense Biosensor does not practice the preamble. The evidence shows that Dr. Souri's analysis of the preamble is conclusory. *See* RX-0600C (Lebby RWS) at Q/A 93. Also, Respondents' expert Dr. Michael Lebby testified that Complainant describes its LightSense Biosensor as a device using the photoelectric effect (*i.e.*, enhancing conductivity with light), rather than the photovoltaic effect (producing electricity from light). *Id.* at Q/A 94.

b. Claim Limitation 15[a] – "a crystalline semiconductor substrate comprising"

The evidence shows that Complainant's LightSense Biosensor practices claim element 15[a] of claim 15 of the '599 patent. Contrary to Dr. Lebby's opinions, Dr. Souri provided sufficient testimony to show that this claim element is more likely than not practiced. *Compare* CX-2411C (Souri WS) at Q/A 140 *with* RX-0600C (Lebby RWS) at Q/A 97.

c. Claim Limitation 15[a][i] – "a bottom p-doped region"

Complainant's LightSense Biosensor practices claim element 15[a][i] of claim 15 of the '599 patent. Contrary to Dr. Lebby's opinions, Dr. Souri provided sufficient testimony to show that this claim element is more likely than not practiced. *Compare* CX-2411C (Souri WS) at Q/A 141 *with* RX-0600C (Lebby RWS) at Q/A 99.

d. Claim Limitation 15[a][ii] – "a top n-doped region adjacent to and in direct physical contact with the p-doped region, wherein the p-doped region and the n-doped region form a p-n junction within the bulk of the crystalline semiconductor substrate, wherein the p-n junction is located at least about 30 nm from the bottom of the nanowires and the top n-doped region contains n-dopant throughout the entirety of the top n-doped region"

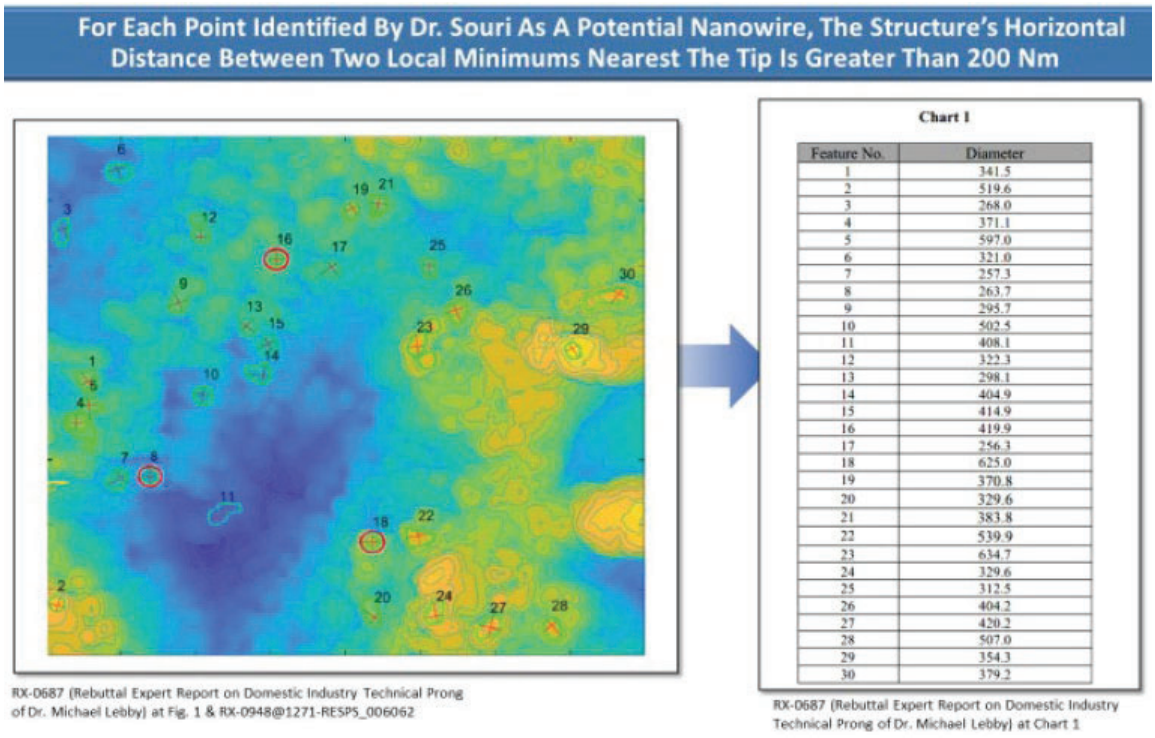
For the reasons discussed below, the evidence shows that Complainant's LightSense Biosensor does not practice claim 15[a][ii] of claim 15 of the '599 patent, which requires, *inter alia*, "nanowires" and a "p-n junction." Respondents' expert Dr. Lebby provided testimony that this limitation is missing from Complainant's LightSense Biosensor. *See* RX-0600C (Lebby RWS) at Q/A 100-132.

The evidence demonstrates that Complainant's expert Dr. Souri tested Complainant's LightSense Biosensor according to the same methodology used for Respondents' Accused Products. *See* CX-2411 (Souri WS) at Q/A 38; Tr. (Souri) at 182:16-20, 205:19-206:15. Thus, the above discussions of the deficiencies with Dr. Souri's testing of the Respondents' Accused Products also apply here.

With respect to the claimed "nanowires," Dr. Lebby testified that Dr. Souri applied a methodology of only looking from the high points or tips of the substrate, down 50 nm, and asking if that small portion of the substrate would fit in a 200 nm diameter cylinder. *See* RX-0600C (Lebby RWS) at Q/A 108.

Also, like Respondents' other witnesses, Dr. Lebby testified about his own AFM images produced using Dr. Souri's AFM data to show that the alleged "nanowires" are not, in fact, "nanowires." *See* RX-0600C (Lebby RWS) at Q/A 107-18. In addition, like Dr. Kanicki, Dr. Lebby also testified about making cross-section measurements of Dr. Souri's alleged "nanowires" to further prove that point. *Id.* For each of the alleged "nanowires" identified by Dr. Souri, Dr.

Lebby performed a cross-section analysis, and all of the diameter measurements that were taken are greater than 200 nm, as summarized in the demonstrative below (RDX-0006C.7: CX-2420C.52):



RX-0600C (Lebby RWS) at Q/A 117; RDX-0006C.7: CX-2420C.52. Given these measurements, Complainant has not demonstrated that the alleged "nanowires" in its LightSense Biosensor are, in fact, "nanowires" as claimed.

With respect to the claimed "p-n junction," Dr. Lebby testified that Dr. Souri used a selective etching technique to remove n-doped silicon that does not confirm that the remaining materials contain p-doped silicon or which part of the remaining materials is p-doped silicon or the boundary between n-doped silicon and p-doped silicon, as identified by Dr. Souri. *See* RX-0600C (Lebby RWS) at Q/A 99. Absent a proper identification of the "p-n junction" and,

moreover, "nanowires," Complainant has not demonstrated that the claimed "p-n junction" is present in its LightSense Biosensor.

e. Claim Limitation 15[b] – "a plurality of n-doped nanowires in direct physical contact with the top n-doped region of the crystalline semiconductor substrate"

For the reasons discussed above with respect to claim limitation 15[a][ii] of claim 15 of the '599 patent, I find that Complainant's LightSense Biosensor does not practice claim limitation 15[b] of claim 15 of the '599 patent, which also requires, *inter alia*, "nanowires."

C. Validity

For the reasons provided below, Respondents have not shown by clear and convincing evidence that the asserted claims of the '599 patent are invalid as anticipated or rendered obvious by any asserted prior art.

1. Invalidity Arguments Based on the Prior Art

Respondents contend several prior art references, alone and in combination, render the asserted claims of the '599 patent invalid. Staff contends "Respondents have not shown clearly and convincingly that the Asserted Claims of the '599 Patent are invalid as anticipated or rendered obvious by any asserted prior art." SIB at 127; *see id.* at 127-36.

A prior art reference anticipates when it discloses or contains all the claimed limitations "arranged or combined in the same way as in the claim." *Wm. Wrigley Jr. Co. v. Cadbury Adams USA LLC*, 683 F.3d 1356, 1361 (Fed. Cir. 2012). However, the reference "need not satisfy an *ipsissimis verbis* test." *In re Gleave*, 560 F.3d 1331, 1334 (Fed. Cir. 2009).

Respondents contend all claims of the '599 patent are anticipated by Guha, and claims 15, 23, and 24 of the '599 patent are anticipated by Fang.

A patent may be found invalid as obvious if "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103(a) (pre-AIA). Because obviousness is determined at the time of invention, rather than the date of litigation, "[t]he great challenge of the obviousness judgment is proceeding without any hint of hindsight." *Star Scientific, Inc. v. R.J. Reynolds Tobacco Co.*, 655 F.3d 1364, 1375 (Fed. Cir. 2011).

The critical inquiry in determining the differences between the claimed invention and the prior art is whether there is an apparent reason to combine the known elements in the fashion claimed by the patent at issue, and a reasonable expectation of success in doing so. *See KSR Int'l Co. v. Teleflex, Inc.*, 550 U.S. 398, 417-418 (2007). Though rare, "in appropriate circumstances, a patent can be obvious in light of a single prior art reference if it would have been obvious to modify that reference to arrive at the patented invention." *Arendi S.A.R.L. v. Apple Inc.*, 832 F.3d 1355, 1361 (Fed. Cir. 2016). Obviousness is a determination of law based on underlying determinations of fact. *Star Scientific*, 655 F.3d at 1374.

Respondents contend dependent claim 27 of the '599 patent is rendered obvious by combinations of Peng and Fang.

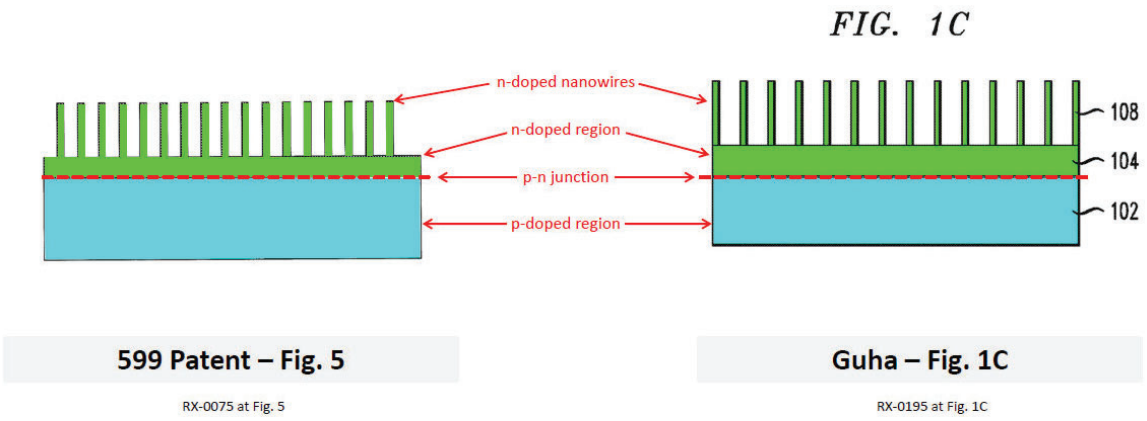
2. Guha (RX-0195)

Respondents assert that U.S. Patent Application Publication No. US2009/021971, entitled "Photovoltaic Devices with Enhanced Efficiencies Using High-Aspect-Ration Nanostructures," ("Guha") (RX-0195) anticipates all of the asserted claims of the '599 patent.[9] The dispute over

[9] There is no dispute that Guha is prior art to the '599 patent. *See* CIB at 149-50; CX-2485C (Banerjee RWS) at Q/A 50-51; RIB at 191-201; RX-0001C (Lebby WS) at Q/A 75-76.

Guha centers on whether it discloses the claim element "a p-n junction within the bulk of the crystalline semiconductor substrate," which is recited in independent claim 15 of the '599 patent. *See* JX-0001 ('599 Patent) at 11:15-16; *see also* CIB at 149-50; CX-2485C (Banerjee RWS) at Q/A 50-51; RIB at 191-201; RX-0001C (Lebby WS) at Q/A 96.

Respondents have not shown by clear and convincing evidence that Guha discloses "a p-n junction within the bulk of the crystalline semiconductor substrate." JX-0001 ('599 Patent) at 11:15:16. Respondents' expert, Dr. Lebby, testified, *inter alia*, that (i) Figure 5 of the '599 patent schematically depicts a solar cell with nanowires where the p-n junction lies within the bulk region; and (ii) Figure 1C of Guha discloses the same device. *See* RX-0001C (Lebby WS) at Q/A 103. Reproduced below is a demonstrative prepared by Dr. Lebby showing Figure 5 of the '599 patent and Figure 1C of Guha:



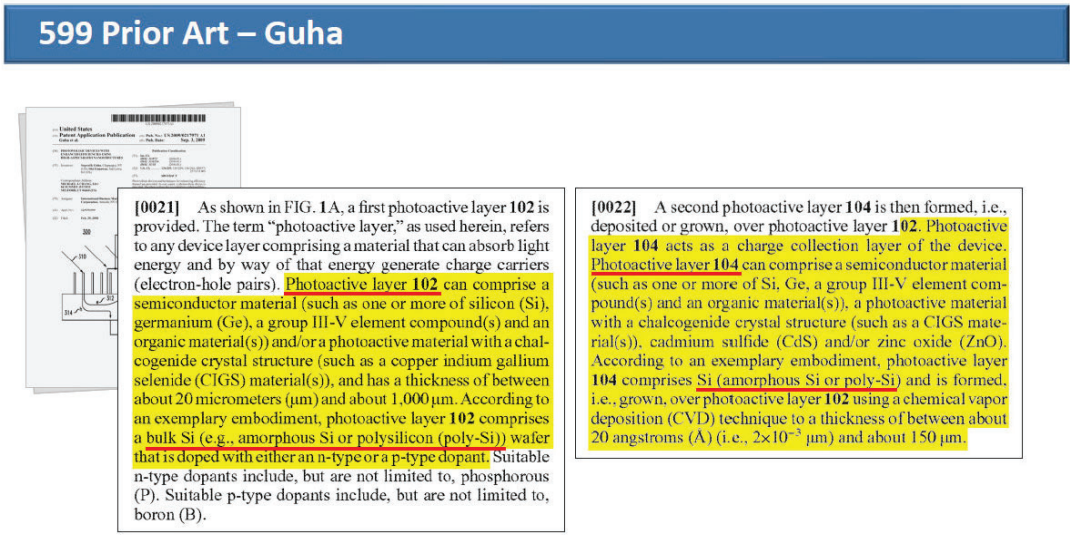
RX-0001C (Lebby WS) at Q/A 103; RDX-0001.25: JX-0001 ('599 Patent) at Figure 5; RX-0195 (Guha), Figure 1C. In the demonstrative above, Dr. Lebby added annotations identifying what he considered in Figure 5 of the '599 patent and Figure 1C of Guha to be "the same vertical nanowires that are n-doped on top of the non-nanotextured region, which is made up of a top n-type doped region and a bottom p-type doped region." *See* RX-0001C (Lebby WS) Q/A 103. According to

Dr. Lebby, "the p-n junction is below the nanowires in both the '599 Patent and Guha devices." *Id.*

While the figures above look strikingly similar when annotated, Respondents have not demonstrated by clear and convincing evidence that Guha discloses a p-n junction "within the bulk" of the substrate. Without Dr. Lebby's annotations, nothing in Figure 1C of Guha identifies a p-n junction within the bulk of the subtrate. Respondents also identify no text of Guha that states that the p-n junction is within the bulk of the substrate. Complainant's expert Dr. Sanjay Banerjee opined that Guha does not disclose a p-n junction "within the bulk" because Guha discloses a p-n junction on top of the bulk, *i.e.*, the photovoltaic layer 102 in Figure 1C of Guha (and which is shown in the demonstrative above). *See* CX-2485C (Banerjee RWS) at Q/A 54.

In particular, Guha specifically uses the term "bulk Si" with reference to photovoltaic layer 120 and the term "Si" with reference to photovoltaic layer 120. *See* RX-0195 (Guha), ¶¶ 21-22. Dr. Banerjee testified that, consistent with industry usage, "bulk Si" refers to bulk silicon, which is the underlying wafer before materials are deposited on it. *See* CX-2485C (Banerjee RWS) at Q/A 53.

In fact, Dr. Lebby himself recognizes that Guha uses different terms - "bulk Si" and "Si" - to identify photovoltaic layer 102 and photovoltaic layer 104, as shown in another demonstrative prepared by Dr. Lebby, which is reproduced below:



RDX-0001.20: RX-0195 (Guha), ¶¶ 21-22. In the demonstrative above, Dr. Lebby himself specifically highlighted and underlined (i) the term "bulk Si," which Guha uses to describe photovoltaic layer 102; and (ii) the term "Si," which Guha uses to describe photovoltaic layer 104. Nonetheless, Dr. Lebby testified that Guha also uses the terms "amorphous Si" and "poly-Si" to describe both photovoltaic layers, which terms are also highlighted and underlined in the demonstrative above. *See* RX-0001C (Lebby) at Q/A 102. However, Guha's use of the terms "amorphous Si" and "poly-Si" does not change the fact that Guha uses the term "bulk Si" to identify only photovoltaic layer 102.

Moreover, the evidence shows that Guha's use of the term "bulk Si" to identify photovoltaic layer 102 (but not photovoltaic layer 104) is consistent with Guha's process for forming the p-n junction, a process that is different from that disclosed in the '599 patent. Specifically, Dr. Banerjee provided testimony explaining that Guha discloses using chemical vapor deposition to form its devices on a bulk silicon wafer and, at no time, discloses any process for forming a p-n junction in the bulk silicon, including the etching process disclosed in the '599 patent. *See* CX-2485C (Banerjee RWS) at Q/A 52. Additionally, Dr. Banerjee testified that

chemical vapor deposition is a high-temperature process that affects how the dopants are present within the surface, which calls into question where the exact p-n junction is within Guha. Tr. (Banerjee) at 933:23-934:24.

Thus, Respondents have not presented clear and convincing evidence that Guha discloses a p-n junction "within the bulk" of the semiconductor substrate. In the absence of that disclosure, Respondents have not met their burden of proving that Guha anticipates the asserted claims of the '599 patent.

3. Fang 2008 (RX-0087)

Respondents assert that a printed publication entitled "Fabrication of Slantingly-Aligned Silicon Nanowire Arrays for Solar Cell Applications" ("Fang 2008") (RX-0087) anticipates asserted claims 15, 23, and 24 of the '599 patent (but not asserted claim 27 of the '599 patent).[10] The dispute over Fang 2008 centers on whether it discloses two claim elements that are recited in claim 15 of the '599 patent: (i) "the p-n junction is located at least 30 nm from the bottom of the nanowires"; and (ii) "the top n-doped region contains n-dopant throughout the entirety of the top n-doped region." JX-0001 ('599 Patent) at 11:17-20; *see also* CIB at 150-52; CX-2485C (Banerjee RWS) at Q/A 61-62; RIB at 202-203; RX-0001C (Lebby WS) at Q/A 166, 174.

Respondents have not shown that Fang 2008 discloses either of the claim elements at issue. Complainant's expert, Dr. Banerjee, provided testimony explaining that Fang 2008 does not disclose sufficient details about its diffusion process for determining the claimed depth of the p-n junction and whether any top n-doped region contains n-dopant throughout the entirety of the top n-doped region. *See* CX-2485C (Banerjee RWS) at Q/A 60-79. In particular, Dr. Banerjee

[10] There is no dispute that Fang 2008 is prior art to the '599 patent. *See* CIB at 150-52; CX-2485C (Banerjee RWS) at Q/A 58-59; RIB at 201-07; RX-0001C (Lebby WS) at Q/A 75-76.

testified that Fang 2008 fails to disclose critical information regarding the phosphorous diffusion process, such as the nature of the phosphorous source used for n-doping, that would allow one of ordinary skill in the art to determine reliably the depth of the p-n junction. *See* CX-2485C (Banerjee RWS) at Q/A 69-72.

In addition, Dr. Banerjee also testified that the silicon samples in Fang 2008 are exposed to three highly oxidizing cleaning solutions prior to phosphorous diffusion, which is significant because these oxidizing agents will oxidize the surface of the silicon to form a silicon oxide layer that can act as a diffusion mask to inhibit the penetration of dopants into the silicon. *See* CX-2485C (Banerjee RWS) at Q/A 75-77. The extent to which this exposure adversely affects the ability of phosphorous dopant to diffuse into the silicon substrate depends on factors that are not specified in Fang 2008. *Id.*; Tr. (Banerjee) at 936:4-18.

Although Respondents' expert, Dr. Lebby, provided extensive testimony in an attempt to demonstrate disclosure of both claim elements at issue, that testimony appears to incorporate too many assumptions about the diffusion process in Fang 2008. Dr. Lebby opines, for example, that one of ordinary skill would have recognized that the dopant diffusion described in Fang 2008 would diffuse dopant into silicon using a common phosphorous-containing gas and that the dopant would convert the top portion of the substrate into n-type silicon to a level that is consistent with a p-n junction depth of 500 nm, which is substantially more than the 30 nm claimed in the '599 patent. *See* RX-0001C (Lebby WS) at Q/A 167.

However, even if the phosphorous source was "a common phosphorous-containing gas," Fang 2008 does not provide any information about, *inter alia*, the concentration of the phosphorous within the gas or the flow rate of the gas, which affect the diffusion of the dopant. *See* CX-2485C (Banerjee RWS) at Q/A 69-70. At most, Fang 2008 discloses a surface concentration of

phosphorous, but that surface concentration creates more questions than answers because it is substantially lower than what one of ordinary skill would expect based on the diffusion temperature disclosed in Fang 2008. *See* CX-2485C (Banerjee RWS) at Q/A 71-72.

Further, Fang 2008 does not disclose that the p-n junction depth is 500 nm, as alleged by Dr. Lebby. Dr. Lebby testified that one of ordinary skill would understand the "depth of the diffusion layer" disclosed in Fang 2008 to be referring to the p-n junction depth. *See* RX-0001C (Lebby WS) at Q/A 164-68. However, Dr. Banerjee testified that the term "diffusion layer" is a vague term and that the depth of the diffusion layer is not synonymous with the p-n junction depth. *See* CX-2485C (Banerjee RWS) at Q/A 66-67. In fact, Dr. Lebby, who is a named author on probably over one hundred scientific publications including papers describing devices that feature a p-n junction, admitted that he did not cite to any of the papers or, moreover, any third-party scientific publications, to support his opinion that the depth of the diffusion layer is synonymous with the p-n junction depth. Tr. (Lebby), 669:2-671:1.

Additionally, the evidence shows that Dr. Lebby has not taken consistent positions with respect to Fang 2008, which calls into question Dr. Lebby's reading of Fang 2008. Previously, Dr. Lebby submitted an invalidity report in this investigation in which he used a simulator to estimate the p-n junction depth of the device disclosed in Fang 2008. *See* CX-2485C (Banerjee RWS) at Q/A 73-74. That analysis does not appear in Dr. Lebby's witness statement, however, possibly because Dr. Banerjee explained in his rebuttal expert report that Dr. Lebby's analysis was flawed, as the analysis was based on an incorrect assumption with respect to the depth of the p-n junction. *Id.* ("By identifying the depth of the p-n junction as the depth as which the phosphorous concentration reaches zero, Dr. Lebby significantly overestimates the depth of the p-n junction."). As explained by Dr. Banerjee, "the fact that Dr. Lebby previously stated in his [expert] report that

he believed the p-n junction is formed where the phosphorous concentration reaches zero [rather than where the phosphorous concentration becomes equal to the background dopant concentration] indicates . . .that his analysis of this element is not credible." *Id.*

Respondents have not presented clear and convincing evidence that Fang 2008 discloses (i) "the p-n junction is located at least 30 nm from the bottom of the nanowires"; and (ii) "the top n-doped region contains n-dopant throughout the entirety of the top n-doped region." JX-0001 ('599 Patent) at 11:17-20. Without these disclosures, Respondents have not met their burden of proving that Fang 2008 anticipates asserted claims 15, 23, and 24 of the '599 patent.

4. Peng 2005 (RX-0175) and Fang 2008 (RX-0087)

In addition to asserting anticipation by Fang 2008, Respondents assert an obviousness combination with Fang 2008: (i) printed publication entitled "Aligned Single Crystalline Si Nanowire Arrays for Photovoltaic Applications" ("Peng 2005") (RX-0175), in combination with (ii) Fang 2008.[11] In support of his opinion that the combination of Peng 2005 and Fang 2008 renders obvious dependent claim 27 of the '599 patent, Dr. Lebby testified that Peng 2005 discloses all of the elements of independent claim 15 of the '599 patent, except for the p-n junction depth. *See* RX-0001C (Lebby WS) at Q/A 196. Thus, Dr. Lebby relies upon Fang 2008 for disclosure of the p-n junction depth. *Id.*

As discussed *supra* part VI.C.3, Fang 2008 does not disclose the p-n junction depth. Because Peng 2005 also fails to disclose the p-n junction depth, a person of skill in the art at the time of the invention would not arrive at the claimed invention when combining those references. *See* CX-2485C (Banerjee RWS) at Q/A 94-96. Without a disclosure of the depth of the p-n

[11] There is no dispute that Peng 2005 is prior art to the '599 patent. *See* CIB at 152-53; CX-2485C (Banerjee RWS) at Q/A 83; RIB at 207-09; RX-0001C (Lebby WS) at Q/A 75-76.

junction, Respondents have not met their burden of proving that the combination of Peng 2005 and Fang 2008 renders obvious dependent claim 27 of the '599 patent.[12]

Accordingly, I determine that Respondents have not presented clear and convincing evidence that the combination of Peng 2005 and Fang 2008 renders obvious dependent claim 27 of the '599 patent.

VII. THE '981 PATENT

A. Infringement Analysis of the '981 Patent

As noted, Complainant asserts process claims 1, 13, 23, and 27 of the '981 patent. Staff contends Complainant has not proven by a preponderance of the evidence that the Accused Products infringe the asserted claims. *See* SIB at 102-11.

The disputed '981 patent claim terms are shown in context below with emphasis:

> 1. A process comprising:
>
> **(a) providing** a substrate having a **nanostructured** material on a surface, the substrate being conductive and the **nanostructured** material being coated with an insulating material,
>
> **(b) removing** the **nanostructured** material and electrically insulating material at least partially from a portion of the surface, and
>
> **(c) depositing** a conductor on the substrate in such a way that the conductor is in electrical contact with the substrate through the portion of the surface where the **nanostructured** material and insulating material has been at least partially removed.
>
> 13. The process of claim 1, wherein the step of removing the **nanostructured** material and insulating material comprises heating or cooling.

[12] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

> 23. The process of claim 1, wherein step (c) comprises screen printing.
>
> 27. A process comprising:
>
> **(a) providing** a substrate having a **nanostructured** material on a surface,
>
> **(b) removing** the **nanostructured** material from a portion of the surface, and
>
> **(c) depositing** an electrical contact in the portion of the surface from which the **nanostructured** material was removed.

JX-0002 ('981 Patent) at claims 1, 13, 23, and 27 (emphasis added).

1. Alleged Infringement by Canadian Solar Accused Products

For the reasons discussed below, I find that Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '981 patent.

a. Independent Claim 1

As recited above, claim 1 of the '981 patent requires, *inter alia*, "nanostructured material," which the parties have agreed means "material made up of nanostructures – *see* parties' proposals for nanostructures." The evidence establishes that "nanostructures" and "nanostructured material" are missing from the Canadian Solar Accused Products.

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Canadian Solar made, used, sold, offered for sale, or imported.

Dr. Souri's methodology for identifying "nanostructures" is the same as that for identifying "nanowires" – a top-down approach that identifies the tips of nano-scale features that are part of much larger micro-scale structures. *See* CX-2411 (Souri WS) at Q/A 155-56. Micro-scale

structures are not nanostructures. Micro means 1×10^{-6}, and nano means 1×10^{-9}. And all parties have agreed that the nanostructures claimed are no more than 200 nm in diameter.

Additionally, even if the features Dr. Souri identified were found to be "nanostructures," the evidence shows that "nanostructured material" is nonetheless missing from the Canadian Solar Accused Products. Dr. Neikirk testified about AFM images showing that there is no "material made up of nanostructures" in the Canadian Solar Accused Products. *See* RX-0601C (Neikirk RWS) at Q/A 87-152.

Additionally, as discussed *supra* part IV.B.3, claim 1 of the '981 patent recites steps that must occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)." The evidence shows that the Canadian Solar Accused Products are not manufactured by a process including step "(b)" (removing nanostructured material and electrically insulating material from a portion of the surface of the substrate) followed by step "(c)" (depositing a conductor on the substrate). Dr. Souri testified that that the Canadian Solar Accused Products are fabricated by a screen-printing process that satisfies steps "(b)" and "(c)." *See* CX-2411C (Souri WS) at Q/A 163. But the weight of the evidence shows otherwise. Specifically, Dr. Neikirk testified that Dr. Souri's reliance upon a "firing step" for meeting step "(b)" is misplaced because the "firing step" is performed after screen printing, which those skilled in the art understand to be a method of depositing a conductor (*i.e.*, step "(c)"). *See* RX-0601C (Neikirk RWS) at Q/A 310-12.

Additionally, Dr. Neikirk also testified that the "firing step" does not necessarily remove silicon material and that Dr. Souri agrees because Dr. Souri understands that removal of silicon material will depend on surface and firing conditions. *Id.*

I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '981 patent.

b. Dependent Claim 13 – "The process of claim 1, wherein the step of removing the nanostructured material and insulating material comprises heating or cooling."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 13 of the '981 patent.

For the same reasons discussed *supra* part VII.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '981 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 13 for at least that reason.

c. Dependent Claim 23 – "The process of claim 1, wherein step (c) comprises screen printing."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 23 of the '981 patent.

For the same reasons discussed *supra* part VII.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '981 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 23 for at least that reason.

d. Independent Claim 27

Like claim 1, claim 27 of the '981 patent requires "nanostructured material" and recites steps that must occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)." For the same reasons set forth above for claim 1, I find that the

Canadian Solar Accused Products have not been shown to satisfy independent claim 27 of the '981 patent.

2. Alleged Infringement by Hanwha Accused Products

As discussed *supra* part VI.A.2.a, Complainant has analyzed only two Hanwha Accused Products and has failed to show that these two products are representative of all Hanwha Accused Products, either of the same model or a different model. I find therefore find Complaiant has not shown infringement by Hanwha based on models for which Complainant did not present detailed evidence. The models lacking detailed evidence are Q.PLUS BFR G4.1, Q.PLUS G4, Q.PLUS G4.3, and Q.PLUS L G4.1. The two models Complainant did analyze, the Hanwha Q.PLUS--L-G4.2 and the Hanwha Q.PLUS DUO L-G5.2, do not demonstrate infringement either, as discussed below.

a. Independent Claim 1

For the reasons discussed below, I find that Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '981 patent.

(i) Claim 1 Preamble – "A process"

Hanwha Respondents do not dispute the preamble. *See* RIB at 124-38.

(ii) Claim Limitation 1(a) – "providing a substrate having a nanostructured material on a surface, the substrate being conductive and the nanostructured material being coated with an insulating material"

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Hanwha made, used, sold, offered for sale, or imported.

The parties agree that "nanostructured material" means "material made up of nanostructures." *See* SIB at 39-40; Joint Claim Construction Chart at 4 (Nov. 12, 2021) (EDIS Doc. ID No. 756513). Accordingly, the fact dispute remaining to be resolved is whether the material in the accused devices is made up of nanostructures. As discussed herein, it is not.

Hanwha Accused Products do not include a "nanostructured material on a surface" of a substrate. Hanwha Accused Products do not meet this limitation because they do not include "nanostructures" or material made up of nanostructures.

First, the texturing process used to fabricate Hanwha Accused Products results in large, micron-scale structures that resemble mountains and valleys; not nanostructures. *See* RX-0604C (John RWS) at Q/A 47; Tr. (John) at 436:1-19 (Hanwha Accused Products include microstructures). These structures are orders of magnitude larger than the claimed nanostructures. *Id.* at Q/A 50. The Hanwha Accused Products are textured using [redacted]. RX-0597C (Schwabedissen RWS) at Q/A 31; RX-0595 ([redacted]). This process results in micron-sized formations that have been known in the art long prior to the filing of the application for the '981 patent as "traditional pyramid texturing." *See* RX-0597C (Schwabedissen RWS) at Q/A 31-48. A person of ordinary skill in the art would not consider the textured surface formed using these processes to be "nanostructures." *See, e.g.*, JX-0003 ('640 Patent) at 1:24-30; JX-0002 ('981 patent) at 1:22-28 (distinguishing between "nanowire arrays" and "traditional pyramids"). None of the Hanwha Accused Products are manufactured using any of the techniques commonly understood to form nanostructures, such as metal enhanced etching or reactive ion etching. *Compare* JX-0002 ('981 Patent) at 7:36-8:15; JX-0001 ('599 Patent) at 6:7-44; JX-0004 ('331 Patent) at 4:4-9, 4:34-62 *with* RX-0595C ([redacted]

[redacted]). Dr. Souri ignored Hanwha's processing documentation in lieu of an infringement analysis based entirely on MATLAB to arrive at his conclusion that the Hanwha Accused Products contain alleged "nanostructures."

Second, the parties agree that "nanostructures" must have a diameter of less than 200 nm and the Hanwha Accused Products do not meet that requirement. Neither Complainant nor its expert, Dr. Souri, has identified any actual "diameters" in Hanwha's products as required by all parties' constructions. *See* RX-0604C (John RWS) at Q/A 52, 267. Dr. Souri identifies a "width of the features," which he equates to a "diameter" regardless of where that width measurement is made. *See* CX-2411C (Souri WS) at Q/A 182, 203, 278, 298, 412, 439. But the diameter of an object—typically, a circle or cylinder—is the length of a straight line passing through the object's center. *See* RX-0604C (John RWS) at Q/A 52. Complainant's expert Dr. Banerjee agrees that the plain meaning of a "diameter" is a line the passing through the *center* of a circle (or near-circular object). Tr. (Banerjee) at 881:25-882:14. Complainant and Dr. Souri have not offered evidence of such a measurement. Instead, Dr. Souri looked for any location along a ridge of a microstructures—*i.e.,* the uppermost 50 nm of these microstructures—where he can identify a width of less than 200 nm, regardless of the width of the remainder of the structure of which the ridge is a part. *Id.* This selected width does not constitute the diameter of any structure.

Third, even Complainant's own evidence, viewed in the proper perspective, confirms that the Hanwha Accused Products do not contain any "nanostructures." Complainant relies on SEM[13] and AFM images generated at the request of its expert, Dr. Souri, to show the alleged presence of

[13] Notably, Dr. Souri agrees with Hanwha's expert, Dr. John, that SEM images are approximations and thus inappropriate for analyzing nanostructures in the first place. *See* Tr. (Souri) at 210:21-211:6; Tr. (John) at 436:24-437:7.

nanostructures. *See* CX-2411C (Souri WS) at Q/A 37; CX-2420C (Compilation Exhibit re Figures from Souri's Expert Report). Dr. Souri's images include annotations created by or on behalf of Dr. Souri. *Id.* Complainant and Dr. Souri argue that these annotations confirm the presence of structures or "features" that meet the dimensions required by the parties' constructions of "nanostructure."[14] CX-2411C (Souri WS) at Q/A 182. Examples of Dr. Souri's images are shown below in what he has labeled Figures 87 and 88 (depicting Hanwha's 4.2 product):

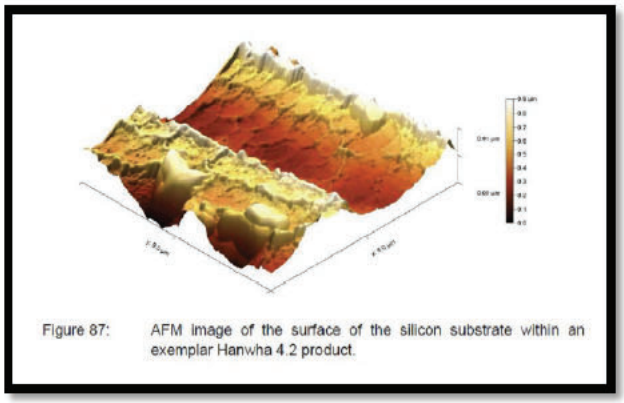


Figure 87: AFM image of the surface of the silicon substrate within an exemplar Hanwha 4.2 product.

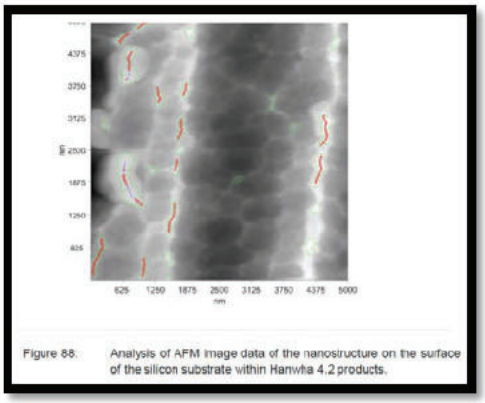


Figure 88: Analysis of AFM image data of the nanostructure on the surface of the silicon substrate within Hanwha 4.2 products.

CX-2420C.87, .88 (Hanwha 4.2).

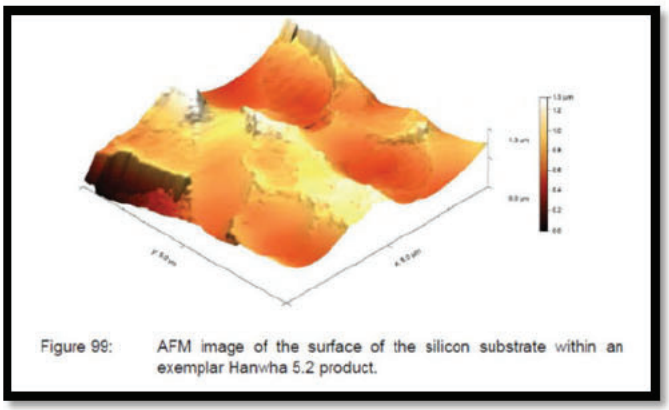


Figure 99: AFM image of the surface of the silicon substrate within an exemplar Hanwha 5.2 product.

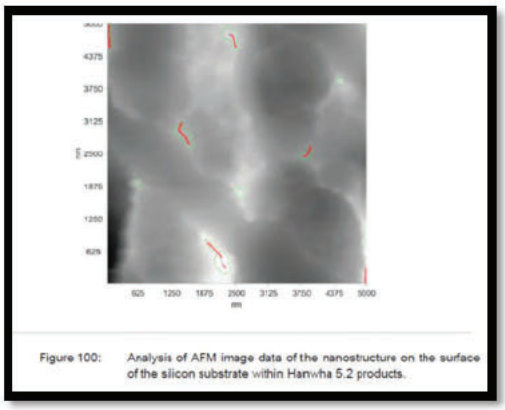


Figure 100: Analysis of AFM image data of the nanostructure on the surface of the silicon substrate within Hanwha 5.2 products.

CX-2420C.99, .100 (Hanwha 5.2).

Figures 87 (CX-2420.87) and 99 (CX-2420.99) above respectively show a color

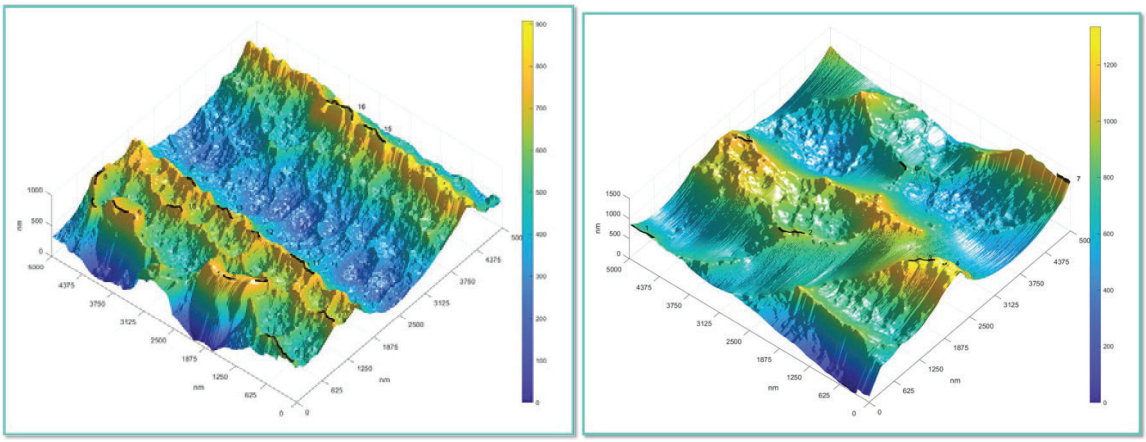
[14] Dr. Souri relies on the same AFM data for his nanostructure analysis for all patents.

perspective-view AFM image of the microstructures in Hanwha's Accused 4.2 and 5.2 Products. Figures 88 (CX-2420.88) and 100 (CX-2420.100) above respectively show a black-and-white top-down view of the same microstructures shown in Figures 87 and 99. Figures 88 and 100 annotate Dr. Souri's AFM images with green shapes and red lines in the middle calling out portions of the larger microstructures of which they are a part. Dr. Souri's MATLAB algorithm identifies these green shapes as planes 50 nm below the peak of the ridgeline of the microstructure, and the red lines indicate a length of 200 nm along the plane formed by the green shapes. *See* CX-2411C (Souri WS) at Q/A 182, 203. Dr. Souri argues that the measurements identified by these green and red annotations confirm the presence of nanostructures that meet the parties' constructions. *Id*.

As seen in exemplary Figures 88 and 100 above, Dr. Souri's MATLAB algorithm merely identifies ***portions*** of Hanwha's micron-scale mountains and valleys that fit certain criteria that Dr. Souri has pre-defined. *See* RX-0604C (John RWS) at Q/A 45-94. This approach fails to account for the overall size of the microstructure—shown in Dr. Souri's Figures 87 and 99 as being microns in height and width—and instead merely looks for a 50 nm portion anywhere on the surface of Hanwha Accused Products that meets a certain width (less than 200 nm)—referred to as a so-called "local maxima." *See* RX-0604C (John RWS) at Q/A 75-79. Dr. Souri's MATLAB program effectively selects a peak of Hanwha's micron-scale structures that is taller than its nearest surroundings, and uses the measurement at that ridgeline, which is part of the micron-scale structure formed on the surface of the accused Hanwha product, to call that portion of the micron-scale structure a "nanostructure." *Id.* at Q/A 79.

Dr. Souri's selective measurement of only portions of the micro-scale structures on the textured surface of Hanwha's products in opining that they contain alleged "nanostructures" is

akin to characterizing the dimensions of an iceberg by measuring only its exposed tip and ignoring the structure below the water line. *See* RX-0604C (John RWS) at Q/A 58-59. Using that approach, a structure of virtually any size could improperly be considered a "nanostructure." *Id.* The three-dimensional color AFM images (generated using the AFM data produced by Complainant) shown below illustrates Complainant's flawed analysis, arbitrarily measuring only the peaks or tips of Hanwha's microstructures and incorrectly identifies them as nanostructures:



RDX-0008.43 (Hanwha 4.2 product); RDX-0008.44 (Hanwha 5.2 product); RX-0604C (John RWS) at Q/A 86. As shown in these images, Dr. Souri's analysis measures only the peaks or tips of micron-sized structures, without any basis for separating these peaks or tips out as "structures" or "features," incorrectly labeling them as "nanostructures." A plain, objective view of the black lines establishes that these are ridges of much larger, micron-sized structures; they are not themselves nanostructures. Dr. Souri's analysis ignores large swaths of the ridgelines in Hanwha Accused Products, identifying only misshapen subsections as nanostructures. *See* RX-0604C (John RWS) at Q/A 84-94. These selective measurements are wholly inconsistent with any party's constructions of "nanostructure" given that ***all*** parties agree that a nanostructure requires ***nano***-scale dimensions.

(iii) Claim Limitation 1(b) – "removing the nanostructured material and electrically insulating material at least partially from a portion of the surface"

Hanwha Accused Products are not fabricated using a step of "removing the nanostructured materials and electrically insulating material." The processing documents for Hanwha Accused Products confirm that Hanwha does not "remov[e]" any material from the surface of its products, let alone remove nanostructures and electrically insulating material as required by the claims. *See* CX-2400C (Schwabedissen Dep. Tr.) at 61:1-24, 71:2-14, 71:17-21; RX-0604C (John RWS) at Q/A 240. Instead, Hanwha [redacted]. *Id.*

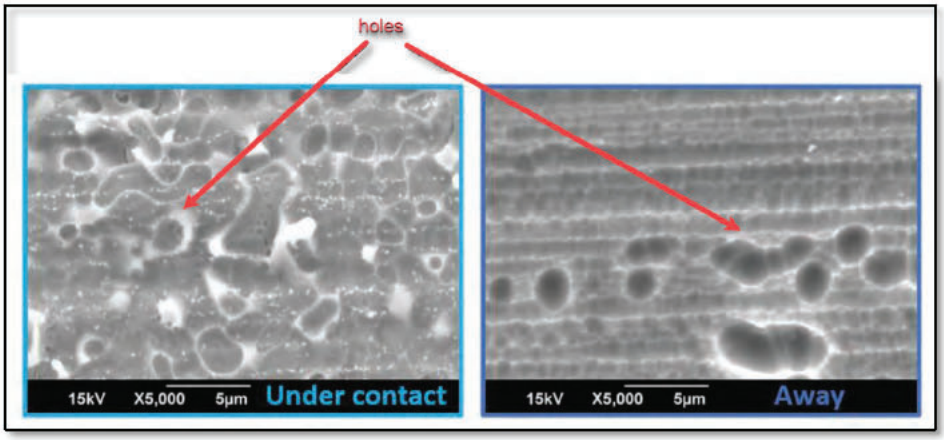
The parties each acknowledge a distinct removal step in the alleged invention of Claim 1:

Complainant	Respondents	Staff
There is no order of events within any of (a), (b), and (c). Furthermore, the events of (b) need not be completed across the entire substrate before the events of (c) begin somewhere on the substrate.	Separate steps that occur in order, such that step (a) is carried out before step (b), and step (b) is carried out before step (c)	separate steps of the claimed process that occur in order such that step "(a)" is carried out before step "(b)", and step "(b)" step is carried out before step "(c)"

As shown above, Complainant does not dispute that a separate "removal" step (b) must occur. Complainant's dispute is that the steps need not take place in order, contending that step (b) need not be "completed across the entire substrate" before the depositing step (c) begins.

Notwithstanding its acknowledgment of a distinct "removal" step, Complainant argues that Hanwha's deposition process—[redacted]—includes the claimed "removing" of nanostructured material and insulating material ([redacted]). In particular, Dr. Souri testified that he performed reverse engineering on Hanwha Accused Products that he contends reveals the

presence of "holes" in the insulator in areas where contacts were [redacted] *See* CX-2411C (Souri WS) at Q/A 186-87. Dr. Souri testified that the presence of these "holes" confirms that nanostructures and [redacted] were originally in that area and then "removed." *See* CX-2420C (Compilation Exhibit re Figures from Souri's Expert Report) at 92. This opinion is incorrect. As an initial matter, the "holes" in Complainant's experiments are present in the insulator in ***both*** regions under the contact and away from the contact:



RDX-0008.37C. Thus, there is no evidence that these holes were necessarily caused by [redacted], since, for example, no [redacted] was done on areas "away" from the contact. *See* RX-0604C (John RWS) at Q/A 252-54. Further, as noted above, Complainant's etching process during sample preparation itself likely caused these voids. *Id.*

In any case, the images Complainant relies upon disclose a top view of Hanwha Accused Products where Hanwha's [redacted] layer completely obscures the n-emitter from view. *See* CX-2420C.92 (describing holes in the "insulator"). Thus, this evidence does not show what Complainant alleges to be nanostructures in the first instance, let alone confirm their removal. Further, Dr. Souri admitted that he did not perform his MATLAB analysis on any of the SEM images where he identifies "holes" or "divots," and, thus, has failed to confirm that there are any

alleged nanostructures in the area shown in these SEM images, let alone that any such alleged nanostructure has been removed as part of the [redacted] process. *See* Tr. (Souri) at 210:16-213:8.

Dr. Souri admitted at the hearing that he did not perform any analysis identifying a particular nanostructure or set of nanostructures under any contact, let alone show complete or partial removal of such alleged nanostructures. *See* Tr. (Souri) at 210:12-213:8. As Dr. Souri conceded, there was "no way" for him to do so, because he only looked at the device ***post-*** fabrication. *Id.* at 212:4-213:8; *see also* RX-0604C (John RWS) at Q/A 241-44 (criticizing Dr. Souri for failing to analyze the surface underneath the contacts). These failures confirm that Dr. Souri's conclusions regarding removal are simply that—conclusions. He offers no evidence to establish removal of any alleged nanostructure, wholly or partially, or a depositing of contact material in the area in which removal has occurred. *See* Tr. (Souri) at 210:12-213:8.

(iv) Claim Limitation 1(c) – "depositing a conductor on the substrate in such a way that the conductor is in electrical contact with the substrate through the portion of the surface where the nanostructured material and insulating material has been at least partially removed"

As discussed above, step 1(c) requires that the nanostructure removal step 1(b) first be performed at least on "the portion of the surface where" the depositing step occurs. As discussed with respect to claim 1(b) above, Hanwha Accused Products are made by [redacted], not with separate "removing" and "depositing" steps. *See* RX-0604C (John RWS) at Q/A 255. Step 1(c) has not been shown to have been met for at least this reason.

b. Dependent Claim 13 – "The process of claim 1, wherein the step of removing the nanostructured material and insulating material comprises heating or cooling."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 13 of the '981 patent.

For the same reasons discussed *supra* part VII.A.2.a, I find that the Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '981 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 13 for at least that reason.

c. Dependent Claim 23 – "The process of claim 1, wherein step (c) comprises screen printing."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 23 of the '981 patent.

For the same reasons discussed *supra* part VII.A.2.a, I find that the Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '981 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 23 for at least that reason.

d. Independent Claim 27

Like claim 1, claim 27 of the '981 patent requires "nanostructured material" and recites steps that must occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)." For the same reasons set forth above for claim 1, I find that the Hanwha Accused Products do not satisfy claim 27 of the '981 patent.

3. Alleged Infringement by Boviet Accused Products

a. Independent Claim 1

I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '981 patent.

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface

Dr. Souri analyzed is representative of products that Boviet made, used, sold, offered for sale, or imported.

As recited above, claim 1 of the '981 patent requires, *inter alia*, "nanostructured material." The parties agree that "nanostructured material" means "material made up of nanostructures." *See* SIB at 39-40; Joint Claim Construction Chart at 4 (Nov. 12, 2021) (EDIS Doc. ID No. 756513). Accordingly, the fact dispute remaining to be resolved is whether the material in the accused devices is made up of nanostructures. As discussed herein, it is not.

The evidence establishes that "nanostructures" and "nanostructured material" are missing from the Boviet Accused Products. Notably, Dr. Souri's methodology for identifying "nanostructures" is the same as that for identifying "nanowires" – a top-down approach that identifies the tips of nano-scale features that are part of much larger micro-scale structures. *See* RX-0599C (Kanicki RWS) at Q/A 134-77. Micro-scale structures are not nanostructures. Micro means 1×10^{-6}, and nano means 1×10^{-9}. And all parties have agreed that the nanostructures claimed are no more than 200 nm in diameter.

Additionally, even if Dr. Souri's alleged "nanostructures" are found to be "nanostructures," the evidence shows that "nanostructured material" is nonetheless missing from the Boviet Accused Products. Dr. Kanicki testified about AFM images showing that there is no "material made up of nanostructures" in the Boviet Accused Products. *See* RX-0599C (Kanicki RWS) at Q/A 148-66. Further, the evidence shows that the scattered "nanostructures" identified by Dr. Souri are not part of any "nanostructured material." *Id.* at Q/A 265-72.

As discussed *supra* part IV.B.3, claim 1 of the '981 patent recites steps that must occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)." The evidence shows that the Boviet Accused Products are not fabricated using the step of

removing nanostructured material and electrically insulating material (*i.e.*, step "(b)"). Unlike Dr. Souri, Dr. Kanicki provided persuasive testimony explaining that Boviet uses a standard screen printing technique that does not include any separate step of removing nanostructured material or electrically insulating material from the surface of the substrate. *See* RX-0599C (Kanicki RWS) at Q/A 299-300. Further, Boviet's screen printing technique is a deposition technique, the opposite of step "(b)" opined by Dr. Souri. *Id.*

Additionally, the evidence shows that even if Boviet's screen printing process could be separated into a first-removing step and a second-depositing step, it does not remove nanostructured material or electrically insulating material. *See* RX-0599C (Kanicki RWS) at Q/A 303. Dr. Kanicki testified that Dr. Souri's reliance on SEM images as evidence of the claimed removal of material is misplaced. *Id.* The evidence shows that Dr. Souri failed to take into proper account the impact of Dr. Souri's sample preparation, which could have been the cause of the removal of material rather than screen printing. *Id.*

Finally, the evidence shows that Dr. Souri actually agrees with Dr. Kanicki that there are screen printing techniques that will never remove silicon nanostructured material. *See* CX-2411C (Souri WS) at Q/A 230; RX-0599C (Kanicki RWS) at Q/A 291-92. Further, whether material will be removed screen printing will depend on the surface and firing conditions. *Id.*

I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '981 patent.

b. Dependent Claim 13 – "The process of claim 1, wherein the step of removing the nanostructured material and insulating material comprises heating or cooling."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 13 of the '981 patent.

For the same reasons discussed *supra* part VII.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '981 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 13 for at least that reason.

c. Dependent Claim 23 – "The process of claim 1, wherein step (c) comprises screen printing."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 23 of the '981 patent.

For the same reasons discussed *supra* part VII.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '981 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 23 for at least that reason.

d. Independent Claim 27

Like claim 1, claim 27 of the '981 patent requires "nanostructured material" and recites steps that must occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)." For the same reasons set forth above for claim 1, I find that the Boviet Accused Products have not been shown to satisfy independent claim 27 of the '981 patent.

B. Technical Prong of the Domestic Industry Requirement

For the reasons discussed below, I find that Complainant's LightSense Biosensor has not been shown to practice claim 27 of the '981 patent.

1. Independent Claim 27

The disputed '981 patent claim terms are shown in context below with emphasis:

> 27. A process comprising:
>
> **(a) providing** a substrate having a **nanostructured** material on a surface,
>
> **(b) removing** the **nanostructured** material from a portion of the surface, and

> **(c) depositing** an electrical contact in the portion of the surface from which the **nanostructured** material was removed.

JX-0002 ('981 Patent) at claim 27 (emphasis added).

As recited above, claim 27 of the '981 patent requires "nanostructured material" and recites steps that must occur in order such that step "(a)" is carried out before step "(b)," and step "(b)" is carried out before step "(c)." Neither of these claim limitations were shown to have been met.

The evidence shows that "nanostructures" and "nanostructured material" are missing from Complainant's LightSense Biosensor. Respondents' expert Dr. Lebby provided testimony about his own AFM images produced using Dr. Souri's AFM data to show that the alleged "nanostructures" identified by Dr. Souri are not, in fact, "nanostructures" (or make up "nanostructured material"). *See* RX-0600C (Lebby RWS) at Q/A 138-48. Dr. Lebby also provided testimony about making cross-section measurements of Dr. Souri's alleged "nanostructures" to further prove that point. *Id.*

Additionally, with respect to the order of steps "(a)," "(b)," and "(c)" in claim 27 of the '981 patent, the evidence shows that Complainant's LightSense Biosensor is not fabricated using step "(b)" (removing nanostructured material from a portion of the surface) followed by step "(c)" (depositing electrical contact in the portion of the surface from which the nanostructured material was removed), as required by the correct claim construction. *See* RX-0600C (Lebby RWS) at Q/A 164.

C. Validity

Respondents contend several prior art references, alone and in combination, render the asserted claims of the '981 patent invalid. *See* RIB at 231-39. Respondents also contend that claims 13, 23, and 27 lack adequate written description and are not enabled. *See* RIB at 240-43.

Staff contends the "asserted claim 27 of the '981 Patent is invalid as anticipated," but Respondents have not shown "any other asserted claim of the '981 Patent is invalid as anticipated or rendered obvious, or invalid for failure to comply with the requirements of 35 U.S.C. § 112." SIB at 136; *see id.* at 136-42.

1. Homyk 2011 (RX-0351)

Respondents contend that U.S. Patent Application Publication No. US2011/0140085 ("Homyk 2011") (RX-0351) anticipates claim 27 of the '981 patent. *See* RIB at 231-34. Homyk 2011 was filed on November 18, 2010, and published June 16, 2011. RX-0351. Because Homyk 2011 was published before the earliest priority date (September 19, 2011) claimed by Complainant, Homyk is prior art under 35 U.S.C. § 102(a).

Independent claim 27 of the '981 patent is reproduced below:

> 27. A process comprising:
>
> **(a) providing** a substrate having a **nanostructured** material on a surface,
>
> **(b) removing** the **nanostructured** material from a portion of the surface, and
>
> **(c) depositing** an electrical contact in the portion of the surface from which the **nanostructured** material was removed.

JX-0002 ('981 Patent) at claim 27 (emphasis added).

Homyk 2011 anticipates claim 27. Specifically, the first step (a) of claim 27 recites "providing a substrate having a nanostructured material on a surface." The "nanostructured material" can be "nanowires," as recited in claim 4 of the '981 patent. JX-0002 ('981 Patent) at 11:58-59; *see also id.* at 2:59-62 ("In certain embodiments, the nanostructured material used in the disclosed processes comprises nanowires, which may comprise a nanowire array."). Homyk 2011 discloses this step because it discloses a process for fabricating semiconductors that include "nanowires" or "nanopillars"—terms that Homyk 2011 uses interchangeably. RX-0351.9 at ¶ 26. Homyk's nanowires are shown, for example, in Figure 1, arranged in an array format on the substrate's surface. RX.0351.2. Homyk 2011 discloses that nanowires have "[h]igh aspect ratio" with "diameters between 50-100 nm" for some applications, and "sub-10 nm diameters" for other applications. *See* RX-0351.8 at ¶ 4; *see also* RX-0001C (Lebby WS) at Q/A 351-57 (discussing other disclosures of the dimensions of nanowires in Homyk 2011). There is no dispute that Homyk 2011 discloses "nanowires" under any of the parties' proposed claim constructions.

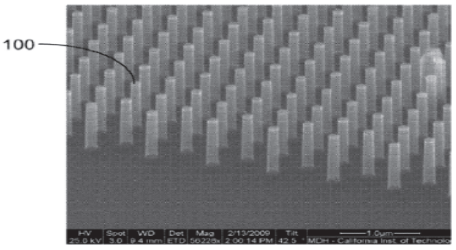


FIG. 1

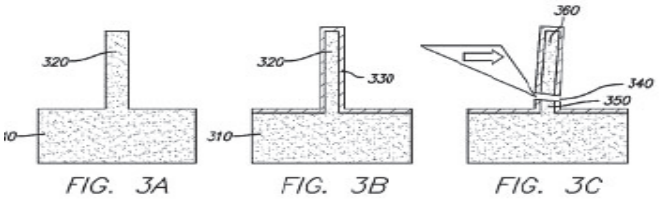


FIG. 3A FIG. 3B FIG. 3C

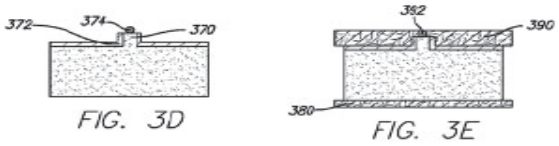


FIG. 3D FIG. 3E

The second step (b) of claim 27 requires "removing the nanostructured material from a portion of the surface." Here, in Figures 3(A)-3(C), Homyk 2011 discloses the removal of a nanowire from a portion of the substrate surface by "mechanically cleaving or mechanically

polishing," in the same way that is taught in the '981 patent. *See* RX-0351.9 at ¶ 34; RX-0001C (Lebby WS) at Q/A 361; JX-0009 ('640 Patent File History) at 23; JX-0002 ('981 Patent) at 2:66-3:2 ("the step of removing nanostructured material and insulating material comprises applying mechanical force to a portion of the surface on which the nanostructured material is located").

Step (c) of claim 27 requires "depositing an electrical contact in the portion of the surface from which the nanostructured material was removed." Homyk 2011 discloses this step and shows it in Figure 3(E) in which a "conductive layer (390)" is deposited in the area where the nanowire was cleaved. *See* RX-0351.4, 10 at ¶ 38, Figure 3E; RX-0001C (Lebby WS) at Q/A 362. This conductive layer 390 forms electrical contact in the portion of the surface where the nanowires were removed. *Id*.

Complainant does not dispute that Homyk 2011 meets the claimed steps, other than to contend that Homyk 2011 does not disclose the "nanostructured material" recited in independent claims 1 and 27 of the '981 patent. Complainant admits that Homyk 2011 discloses cleaving of nanowires but contends that "the features of Homyk 2011's device are not both nanostructures and nanowires." RIB at 155. Complainant's expert Dr. Banerjee opines that under the claim differentiation doctrine, "nanostructured material," as recited in independent claim 1, requires some other nanostructures to be present *in addition* to nanowires recited in dependent claim 4. *See* CX-2485C (Banerjee RWS) at Q/A 167-68. Dr. Banerjee's interpretation of the "nanostructures" of claim 1 is incorrect. Nanowires are a particular type of nanostructures. *See, e.g.*, JX-0002 ('981 Patent) at 5:8-10 ("Since certain alloys of steel and aluminum are less hard than silicon, they are well suited for use as a mechanical object to shear *nanostructures such as nanowires*.") (emphasis added); *see also id.* at 2:59-62, 11:58-59.

First, Dr. Banerjee's testimony (and Complainant's contention) is not persuasive. Dr.

Banerjee has opined that nanowires satisfy the nanostructures requirement of claim 1 of the '331 patent for purposes of his conception and reduction to practice opinions. Tr. (Banerjee) at 880:16-881:19. And Dr. Banerjee (along with Dr. Black) has also admitted that a nanowire is a type of nanostructure. Tr. (Banerjee) at 881:17-19; Tr. (Black) 81:20-82:1. Like the '981 patent, dependent claim 3 of the '331 patent recites that the nanostructured area comprises a nanowire array, and this claim depends on claim 1 requiring "nanostructured area." Thus, the "nanostructured material" in claims 1 and 27 can be a material made up of nanowires. That is exactly what Homyk 2011 discloses.

Second, Complainant's (and, thus, Dr. Banerjee's) claim differentiation argument is a misapplication of the law. While claims 1 and 27 cover nanostructures other than nanowires in addition to nanowires, claim 4 is limited to a particular type of nanostructure, namely, nanowires. Claim differentiation supports claims 1 and 27 being broader than claim 4—for example, encompassing nanostructures that are *either* nanowires (claim 4) *or* porous silicon (claim 3)—but that *does not* mean that the nanostructures of claims 1 and 27 *cannot be* nanowires. Complainant's argument to the contrary has no merit, while also being inconsistent with its argument for conception and reduction to practice of claim 1 of the '331 patent (which relies on alleged nanostructures in Bandgap samples to meet the requirement for "nanostructured material").

Based on the evidence recounted above, I find the Homyk 2011 reference discloses every element of claim 27. Homyk 2011 is clear and convincing evidence that claim 27 of the '981 patent is invalid as anticipated.

2. Chen 2010 (RX-0289) and Tobias 2003 (RX-0331)

Respondents contend that claims 13, 23, and 27 of the '981 patent are rendered obvious by Chen 2010 (RX-0289) in combination with Tobias 2003 (RX-0331),[15] but only under Complainant's proposed claim construction that does not require the claimed steps to be performed in any order. *See* RIB at 235-38; RX-0001C (Lebby WS) at Q/A 397-400.

As discussed *supra* part IV.B.3, the steps denoted by (a), (b), and (c) appearing in asserted claims 1 and 27 of the '981 patent must be performed in the order in which they are recited in the claims (*i.e.*, step (a) is carried out before step (b), and step (b) is carried out before step (c).[16] Therefore, based on my claim construction, the asserted claims of the '981 patent are not rendered obvious by Chen 2010 in combination with Tobias 2003.

3. Homyk 2011 (RX-0351) and Adibi 2009 (RX-0220)

Respondents contend that claim 13 of the '981 patent is rendered obvious by Homyk 2011 (RX-0351) (discussed *supra* part VII.C.1) in combination with U.S. Patent Application Publication No. US2009/0308450 (Adibi 2009) (RX-0220). At the center of the parties' dispute is whether a person of ordinary skill in the art would have had a reason to combine Homyk 2011 with Adibi 2009. *See* RX-0001C (Lebby WS) at Q/A 384-89; CX-2485C (Banerjee RWS) at Q/A 171-72. Even though Dr. Lebby admitted that Homyk 2011 discloses *mechanical cleaving* of the nanowire

[15] Chen 2010 (RX-0289) and Tobias 2003 (RX-0331) are discussed in greater detail with respect to Respondents' allegations that the asserted claim of the '331 patent is anticipated by Chen 2010 (*infra* part IX.C.1) and rendered obvious by the combination of Chen 2010 and Tobias 2003 (*infra* part IX.C.2).

[16] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

and insulating material from the substrate, Dr. Lebby testified that a person of ordinary skill in the art would have been motivated to remove the nanowires and insulating material from the substrate by *heating with a laser*. *See* RX-0001C (Lebby WS) at Q/A 385.

The evidence does not show that a person of ordinary skill in the art would have had a reason to combine Homyk 2011 and Adibi 2009. Specifically, Complainant's expert Dr Banerjee provided persuasive testimony that Homyk 2011 and Adibi 2009 are directed to different applications and that Adibi 2009 does not address any deficiency of Homyk 2011. *See* CX-2485C (Banerjee RWS) at Q/A 173-74. Even if Homyk 2011 and Adibi 2009 were considered to be in the same field of photovoltaic device fabrication, as opined by Dr. Lebby, Dr. Banerjee testified that Adibi 2009 focuses on a method of altering dopant density across features of its surface, which is irrelevant to the goal of forming transistors in Homyk 2011. *Id.* Dr. Lebby provided additional testimony about Adibi 2009 in response, but the testimony is deficient with respect to demonstrating a motivation to combine Homyk 2011 and Adibi 2009. RX-0001C (Lebby WS) at Q/A 388 ("I disagree. Adibi provides an alternative precision technique for cleaving away the nanowire and insulating material in a precise manner. This allows for selective removal of the nanowires only at the locations where the conductor is to be deposited.").

Moreover, Adibi 2009 discloses using a laser beam to form a substantially planar region on the substrate with a result of "melting the peaks of the facets and filling in the valleys between the peaks" of the texturing pyramids on the substrate. *See* CX-2485C (Banerjee RWS) at Q/A 173, 176; RX-0220 (Adibi), ¶ 68. The evidence shows that one of ordinary skill would recognize the texturing pyramids of Adibi 2009 to be a form of microtexturing, rather than nanotexturing.

See CX-2485C (Banerjee RWS) at Q/A 173. In other words, Adibi 2009 is not directed to the same precision fabrication technique of Homyk 2011.[17]

In sum, the evidence does not show that a person of ordinary skill in the art would have had a reason to combine Homyk 2011 and Adibi 2009. Respondents have not demonstrated by clear and convincing evidence that claim 13 of the '981 patent is rendered obvious by the combination of Homyk 2011 and Adibi 2009.

4. Written Description and Enablement

Respondents (and their expert Dr. Lebby) contend that asserted claims 13, 23, and 27 of the '981 patent lack adequate written description support and are non-enabled, because there is allegedly no teaching of removing nanostructures by "cooling." *See* RX-0001C (Lebby WS) at Q/A 426-27; CX-2485C (Banerjee RWS) at Q/A 193-94.

Section 112 of the Patent Act (Pre-AIA) requires that a patent specification "shall contain a written description of the invention . . . in . . . full, clear, concise, and exact terms." 35 U.S.C. § 112, First Paragraph. The written description requirement has several policy objectives. One purpose is to convey to the public what the applicant claims as the invention. *See Regents of the Univ. of Cal. v. Eli Lilly*, 119 F.3d 1559, 1566 (Fed. Cir. 1997), *cert. denied*, 523 U.S. 1089 (1998). Another objective is to "ensure that the inventor had possession, as of the filing date of the application relied on, of the specific subject matter later claimed." *Application of Wertheim*, 541 F.2d 257, 262 (C.C.P.A. 1976); *Billups-Rothenberg, Inc. v. Associated Reg'l & Univ. Pathologists,*

[17] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

Inc., 642 F.3d 1031, 1036 (Fed. Cir. 2011) ("[t]he written description requirement exists to ensure that inventors do not attempt to preempt the future before it has arrived").

When evaluating a written description defense, the Commission conducts "an objective inquiry into the four corners of the specification from the perspective of a person of ordinary skill in the art" to determine whether "the inventor actually invented the invention claimed." *Rivera v. Int'l Trade Comm'n*, 857 F.3d 1315, 1319 (Fed. Cir. 2017) (quoting Ariad, 598 F.3d at 1351). To satisfy the statute, an applicant need not describe "every conceivable and possible future embodiment" of the invention. *Cords Corp. v. Medtronic AVE, Inc.*, 339 F.3d 1352, 1365 (Fed. Cir. 2003). Whether a specification complies with the written description requirement of § 112(a) is a question of fact. *Rivera*, 857 F.3d at 1319. When raising a written description defense, the accused party "must show a lack of written description by clear and convincing evidence." *Id*.

The Patent Act requires that "[t]he full scope of the claimed invention . . . be enabled." *Sitrick v. Dreamworks, LLC*, 516 F.3d 993, 999 (Fed. Cir. 2008); *see also Northpoint Tech. Ltd. v. MDS America Inc.*, 413 F.3d 1301, 1308-10 (Fed. Cir. 2005) (affirming a finding of invalidity for lack of enablement due to the patent's failure to disclose an embodiment with an antenna that met the "directional reception range" limitation of each claim). Namely, "[a] patentee who chooses broad claim language must make sure the broad claims are fully enabled. 'The scope of the claims must be less than or equal to the scope of enablement' to 'ensure[] that the public knowledge is enriched by the patent specification to a degree at least commensurate with the scope of the claims.'" *Sitrick*, 516 F.3d at 999 (quoting *National Recovery Techs., Inc. v. Magnetic Separation Sys., Inc.*, 166 F.3d 1190, 1195-96 (Fed. Cir. 1999)). The enablement requirement is satisfied when one skilled in the art, after reading the specification, could practice the claimed invention without undue experimentation. *AK Steel Corp. v. Sollac & Ugine*, 344 F.3d 1234, 1244 (Fed. Cir.

2003), citing *In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988).

At issue is the term "cooling," which is recited in claim 13 of the '981 patent: "The process of claim 1, wherein the step of removing the nanostructured material and insulating material *comprises heating or cooling*." JX-0002 ('981 Patent) at 12:21-23 (emphasis added). Apparently, Respondents and Dr. Lebby construe claim 13 of the '981 patent to require removal of material by heating or cooling, nothing more.

In contrast, Complainant and its expert, Dr. Banerjee, read claim 13 of the '981 patent in a less restrictive manner, allowing for removal of material by heating or cooling, or processing including heating or cooling. *See* CX-2485C (Banerjee RWS) at Q/A 194 ("[I]t is my understanding that the 'step of removing nanostructure material' in claim 13 need not accomplish the removal only by heating or cooling, but rather just requires that heating or cooling be involved.").

The term "comprising" in claim 13 of the '981 patent permits the removal of material by heating or cooling, or processing involving (including) heating or cooling. JX-0002 ('981 Patent) at 12:21-23. Specifically, the specification discloses, *inter alia*, that "shearing force may be delivered by thermal energy" and that "[a] rapid thermal change in nanostructured material may additionally contribute to base cleavage." *Id.* at 5:55-58. Based on these disclosures including, in particular, the phrase "may additionally contribute to base cleavage," a person of ordinary skill in the art would understand that heating and cooling may be used in conjunction with other methods of removal such as mechanical shear forces. *Id.*; CX-2485C (Banerjee RWS) at Q/A 195.

Additionally, the specification also discloses, *inter alia*, "one way to implement a temperature change between the nanostructures and non-nanostructured (bulk) material is to keep the mechanical object used for cleaving at a temperature more than 20, 30, or 50º C different than

the surface." JX-0002 ('981 Patent) at 5:58-61. A person of ordinary skill in the art would understand that this disclosure is not limited to heating and that "one could achieve this by, for example, cooling the surface of a nanostructured silicon wafer to make the nanostructures more brittle and then mechanically removing the nanostructured material." CX-2485C (Banerjee RWS) at Q/A 196.

With respect to the alleged lack of enablement, the weight of the evidence favors the Complainant's position. *Compare* RX-0001C (Lebby WS) at Q/A 426-44 *with* CX-2485C (Banerjee RWS) at Q/A 193-201. In particular, Dr. Banerjee testified that "a POSITA [person of ordinary skill in the art], reading the '981 patent, would understand that one could create a shearing force by maintaining a difference in temperature between the nanostructured wafer and the mechanical removal tool," and that "it would have been straightforward to create this temperature difference by, for example, heating the mechanical removal tool or cooling the nanostructured wafer by putting it in thermal contact with a cold surface." CX-2485C (Banerjee RWS) at Q/A 201.

Respondents have not shown by clear and convincing evidence that asserted claims 13, 23, and 27 of the '981 patent are invalid for failure to comply with the written description and enablement requirements of 35 U.S.C. § 112.

VIII. THE '640 PATENT

A. Infringement Analysis of the '640 Patent

As noted above, Complainant asserts apparatus claims 1, 4, and 11-13 of the '640 patent. Staff contends Complainant has not shown by a preponderance of the evidence that the Accused Products infringe the asserted claims of the '640 patent. *See* SIB at 114-21.

The disputed '640 patent claim terms are shown in context below with emphasis:

> 1 [Preamble]. An optoelectronic device comprising:
>
> [a] a substrate including a first surface;
>
> [b] a **nanostructured** area including **nanostructures** on the first surface of the substrate, the **nanostructured** area including a first segment in which the **nanostructures** are intact and a second segment in which the **nanostructures** are at least partially broken or removed, the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate;
>
> [c] an electrically insulating layer atop the first surface; and
>
> [d] a conductor atop the electrically insulating layer over the second segment.
>
> 4. The optoelectronic device of claim 1, wherein the conductor makes electrical contact to the substrate through the insulating layer over the second segment.
>
> 11. The optoelectronic device of claim 1, wherein the **nanostructures** comprise silicon.
>
> 12. The optoelectronic device of clam 1, comprising a photovoltaic cell.
>
> 13. The optoelectronic device of claim 11, wherein the **nanostructures** comprise silicon **nanowires**.

JX-0003 ('640 Patent) at claims 1, 4, and 11-13 (emphasis added).

1. Alleged Infringement by Canadian Solar Accused Products

a. Independent Claim 1

For the reasons discussed below, I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '640 patent.

(i) Claim 1 Preamble – "An optoelectronic device comprising"

Canadian Solar Respondents do not dispute the preamble. *See* RIB at 158-66.

(ii) Claim Limitation 1[a] – "a substrate including a first surface"

Canadian Solar Respondents do not dispute this claim limitation. *See* RIB at 158-66.

(iii) Claim Limitation 1[b] – "a nanostructured area including nanostructures on the first surface of the substrate, the nanostructured area including a first segment in which the nanostructures are intact and a second segment in which the nanostructures are at least partially broken or removed, the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate"

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Canadian Solar made, used, sold, offered for sale, or imported.

The process that Canadian Solar uses to texturize its P4 solar cells is explained in detail *supra* part VI.A.1.a. As discussed therein, Canadian Solar's texturing process creates crater structures of micron-scale dimensions through a series of processing steps, including a post-etching isotropic etch using a combination of acids. *See* RX-0601C (Neikirk RWS) at Q/A 42-61. Moreover, as discussed *supra* part VI.A.1.a, the relevant structures on the surface of Canadian Solar's P4 cells are micron-sized, crater structures. *See* RX-0601C (Neikirk RWS) at Q/A 77-86. And the asserted patents and literature in the field supports Dr. Neikirk's testimony that those skilled in the art recognize that an acid-etched texture like Canadian Solar's is composed of crater structures (sometimes referred to as pits or holes), and those craters are the relevant structures in the texture as understood by a person of ordinary skill in the art. *See* RX-0601C (Neikirk RWS) at Q/A 77-86. Indeed, in Canadian Solar's P4 cells, "[i]t's the bowl shape that is -- the structure that's capturing the light" and that "enhances absorption" of the light as opposed to the rims. Tr. (Neikirk) at 592:20-593:16.

Like the ’981 patent, claim limitation 1[b] of the ’640 patent each require “nanostructures.” For the ’640 patent, Dr. Souri performed the same analysis and reported the same results for his nanostructure analysis as he did for the ’981 patent. As explained *supra* part VII.A.1.a, with respect to the ’981 patent, Canadian Solar’s P4 solar cells do not have nanostructures.

Similar to the ’981 patent that requires the nanostructures to be “on a surface” of the substrate, claim limitation 1[b] of the ’640 patent also requires a “nanostructures on the first surface of the substrate ….” For the ’640 patent, Dr. Souri performed the same analysis and reported the same results for his nanostructure analysis as he did for the ’981 patent.

The infringement analysis of “nanostructured area” of claim 1 of the ’640 patent is essentially the same as the analysis with respect to the ’981 patent (*supra* part VII.A.1.a). As recited above, claim 1 of the ’640 patent requires, *inter alia*, “nanostructured area.”

Just as the evidence stablishes that “nanowires” are missing from the Canadian Solar Accused Products (for the reasons set forth *supra* with respect to the ’981 patent), the evidence establishes that “nanostructures” and “nanostructured area” are likewise missing from the Canadian Solar Accused Products. Notably, Dr. Souri calls the tips of micro-scale structures “nanostructures.” *See* CX-2411 (Souri WS) at Q/A 155-56. Dr. Neikirk provided testimony explaining why Dr. Souri’s approach is incorrect. *See* RX-0601C (Neikirk RWS) at Q/A 87-152.

Additionally, even if Dr. Souri’s alleged “nanostructures” were found to be “nanostructures,” the evidence shows that “nanostructured material” is nonetheless missing from the Canadian Solar Accused Products. Claim limitation 1[b] of the ’640 patent requires “a *nanostructured area* … on the first surface of the substrate ….” For similar reasons as the ’981 patent that recites “nanostructured material” that is construed by agreement to mean “material

made up of nanostructures," Canadian Solar's P4 solar cells also do not have a "nanostructured area."

As discussed *supra* part VI.A.1.a, Canadian Solar's P4 texturized silicon is made up of crater structures with micron-scale dimensions. *See* RX-0601C (Neikirk RWS) at Q/A 299-300. It is not made up of nanostructures. *Id*. But even if one considers the ridge features identified by Complainant to be nanostructures (which they are not), the front area of the P4 solar cells is still not made up of nanostructures. *See* RX-0601C (Neikirk RWS) at Q/A 352; *see also*, RX-0601C (Neikirk RWS) at Q/A 278-85. This is confirmed by Dr. Souri's own analysis of the Canadian Solar P4 product, using AFM data fed into the MATLAB software program. For the '640 patent, Dr. Souri performed the same analysis and reported the same results for his "nanostructure" and "nanostructured area" analysis as he did for the '981 patent. The red lines he identified as appearing on the images below - CX-2420C.58 on the left-hand side, and RX-0751C on the right-hand side – are sparse and represent less than 3% of the front area of the P4 solar cell. *See* RX-0601C (Neikirk RWS) at Q/A 280.

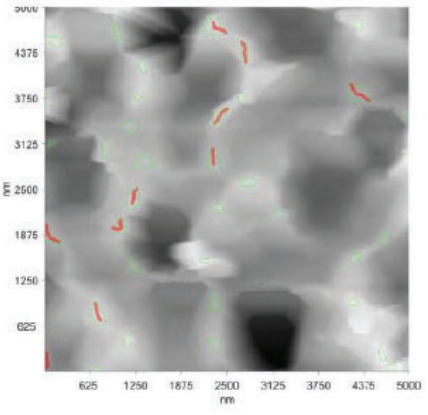
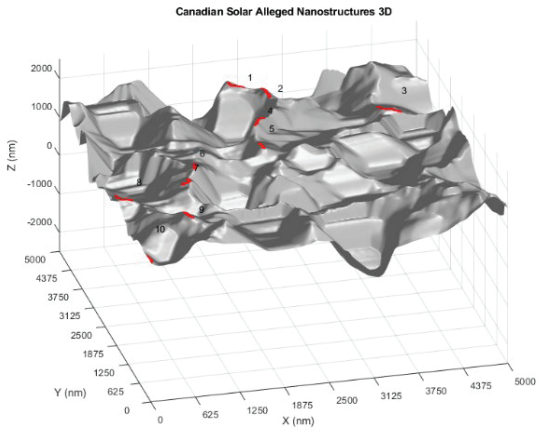


Figure 58: Analysis of AFM image data of the nanostructure on the surface of the silicon substrate within Canadian Solar P4 Products.

CX-2420C.58



RX-0751C

This stands in contrast to the dense array of "nanostructured area" described in the '640 patent.

See RX-0601C (Neikirk RWS) at Q/A 301-04; JX-0003 ('640 Patent) at Figures 6, 7 and 10. The "nanostructured area" in the 640 patent is more than just a sparse sprinkling of nanostructures. *See* JX-0003 ('640 Patent) at Figure 1. Respondents' joint expert Dr. Lebby explained the purpose of nanostructures is to collect as much light as possible, so a reasonable degree of density would be needed. Tr. (Lebby) at 755:21-756:8.

Additionally, claim limitation 1[b] of the '640 patent require a "a first segment in which the nanostructures are intact and a second segment in which the nanostructures are at least partially broken or removed …." "[O]ver the second segment" is where the metal "conductor" is deposited. Similar to the discussion for the '981 patent, Canadian Solar does not have this "first segment" and "second segment" because Canadian Solar P4 cells do not have nanostructures.

But even assuming that the P4 cells have nanostructures, Canadian Solar does not remove the silicon in the area where the metal conductor is to be screen printed. Dr. Souri fails to provide any evidence that the particular process conditions of and metal paste thickness or concentration used in the firing step of Canadian Solar's screen printing process removes any silicon. *See* RX-0601C (Neikirk RWS) at Q/A 354-56. Both Complainant's experts, Dr. Souri and Dr. Banerjee, admitted that whether the firing step removes any silicon depends on the specific parameters of the process and varies with temperature, metal paste thickness, concentration, and many other factors. *See* CX-2411C (Souri WS) at Q/A 163; CX-2485C (Banerjee RWS) at Q/A 183-84.

As discussed above with respect to the "removing" step for the '981 patent, the SEM images relied upon by Dr. Souri do not show that Canadian Solar's P4 solar cell fabrication process does not remove (or break) silicon and thus, to the extent any of the silicon is nanostructures, the nanostructures are not broken or removed. *See* RX-0601C (Neikirk RWS) at Q/A 310-22. Rather, the images merely show that the silver particles are deposited on the surface of the silicon. *Id*.

Thus, even assuming that Canadian Solar's P4 cells have "nanostructures," Canadian Solar's P4 cells do not have a "second segment" with "partially broken or removed" nanostructures.

(iv) Claim Limitation 1[c] – "an electrically insulating layer atop the first surface"

Canadian Solar Respondents do not dispute this claim limitation. *See* RIB at 158-66.

(v) Claim Limitation 1[d] – "a conductor atop the electrically insulating layer over the second segment"

The evidence presented at the Hearing confirmed that in the Canadian Solar P4 products, there is no conductor atop an insulating layer over the second segment. Canadian Solar's expert Dr. Neikirk explained that Canadian Solar forms a [redacted] on top of the silicon of its P4 cells, and a [redacted] on top of the [redacted], but that these layers are eliminated under the conductor during the firing step after screen printing such that the conductor is not on top of (atop) any electrically insulating layer. *See* RX-0601C (Neikirk RWS) at Q/A 357-58. Dr. Neikirk's opinion is supported by the testimony of Canadian Solar's technical employee, Dr. Wang, who developed Canadian Solar's P4 cells, explaining that the insulating layer is eliminated during the firing process. *See* CX-2399C (Wang Dep. Tr.) at 136:25-138:25. That the conductor does not sit on top of an *insulating* layer in Canadian Solar P4 cells is readily apparent because the conductor must be in contact with the silicon in order to have electrical connection. An insulating layer in between Canadian Solar's conductor and silicon would insulate the electrical connection and prevent the collection of electricity, making the cells inoperable.

Complainant's expert Dr. Souri opines that there is an ill-defined layer of a combination of glass frit, silicon nitride, and silicon dioxide under the contact. *See* CX-2411C (Souri WS) at Q/A 262-63. But as Dr. Neikirk testified, this theory is flawed, and the evidence does not support that the Accused Product structure meets the specific arrangement required by the claim. *See* RX-

0601C (Neikirk RWS) at Q/A 363-67. Specifically, the glass frit is introduced by the contact formation process. *Id*. at Q/A 363. It is not present in areas where the metal paste has not been deposited. *Id.* at Q/A 365. The structure of the claim requires the same electrically insulating layer to be atop both the first segment away from the contact and the second segment under the contact. JX-0003 ('640 Patent) at claim 1 ("an electrically insulating layer atop the first surface; and a conductor atop *the* electrically insulating layer over the second segment" (emphasis added)).

Dr. Souri's materials analysis also failed to demonstrate that the conductor is on top of the insulating layer. *See* RX-0601C (Neikirk RWS) at Q/A 360-61, 365-67. For example, as Dr. Neikirk explained, the barely visible nitrogen signal in Dr. Souri's EDS analysis is not indicative of presence of a silicon nitride layer because it does not agree with the atomic mass percent of nitrogen in silicon nitride. *See* RX-0601C (Neikirk RWS) at Q/A 367. And the analysis of oxygen only at best shows "irregularly arranged matter and not a layer." *See* RX-0601C (Neikirk RWS) at Q/A 365. And to the extent that the oxygen signal corresponds to the glass frit, as argued by Dr. Souri, that is not the same insulating layer that is atop the first segment away from the conductor. Thus, Canadian Solar P4 solar cells do not satisfy claim 1 of the '640 patent.

b. Dependent Claim 4 – "The optoelectronic device of claim 1, wherein the conductor makes electrical contact to the substrate through the insulating layer over the second segment."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 4 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 4 for at least that reason.

c. Dependent Claim 11 – "The optoelectronic device of claim 1, wherein the nanostructures comprise silicon."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 11 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 11 for at least that reason.

d. Dependent Claim 12 – "The optoelectronic device of clam 1, comprising a photovoltaic cell."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 12 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 12 for at least that reason.

e. Dependent Claim 13 – "The optoelectronic device of claim 11, wherein the nanostructures comprise silicon nanowires."

I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 13 of the '640 patent.

(i) "The optoelectronic device of claim 11"

For the same reasons discussed *supra* part VIII.A.1.a, I find that the Canadian Solar Accused Products have not been shown to satisfy dependent claim 11 of the '640 patent. The Canadian Solar Accused Products have not been shown to satisfy dependent claim 13 for at least that reason.

(ii) "wherein the nanostructures comprise silicon nanowires."

Claim 13 requires an optoelectronic device wherein the "nanostructures comprise silicon nanowires." For the same reasons discussed with respect to the '599 patent *supra* part VI.A.1.a, Canadian Solar Accused Products do not satisfy claim 13 of the '640 patent.

2. Alleged Infringement by Hanwha Accused Products

As discussed *supra* part VI.A.2.a, Complainant has failed to show that the two products it analyzed are representative of all Hanwha Accused Products, either of the same model or a different model, and that any non-analyzed product infringes the Asserted Patents. I find therefore find Complaiant has not shown infringement by Hanwha based on models for which Complainant did not present detailed evidence. The models lacking detailed evidence are Q.PLUS BFR G4.1, Q.PLUS G4, Q.PLUS G4.3, and Q.PLUS L G4.1. The two models Complainant did analyze, the Hanwha Q.PLUS--L-G4.2 and the Hanwha Q.PLUS DUO L-G5.2, do not demonstrate infringement either, as discussed below.

a. Independent Claim 1

I find that the Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '640 patent.

(i) Claim 1 Preamble – "An optoelectronic device comprising"

Hanwha Respondents do not dispute the preamble. *See* RIB at 166-68.

(ii) Claim Limitation 1[a] – "a substrate including a first surface"

Hanwha Respondents do not dispute this claim limitation. *See* RIB at 166-68.

(iii) Claim Limitation 1[b] – "a nanostructured area including nanostructures on the first surface of the substrate, the nanostructured area including a first segment in which the nanostructures are intact and a second segment in which the nanostructures are at least partially broken or removed, the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate"

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Hanwha made, used, sold, offered for sale, or imported.

Hanwha Accused Products do not include a "nanostructured area." The parties agree that a "nanostructured area" should be construed as "an area made up of nanostructures." Complainant relies on the same evidence to show the existence of "nanostructures" and a "nanostructured area" in Hanwha Accused Products for the '640 patent as it relied on for the '981 patent, and its arguments fail for the same reasons discussed *supra* part VII.A.2.a.

Further, as discussed with respect to the '331 patent (*see infra* part IX.A.2.a), a "nanostructured area" is not simply any area that has at least one nanostructure as there must be a distinction between a nanostructure and a "nanostructured area." Additionally, the "nanostructured area" of claim 1 should logically be understood to refer to a dense area of nanostructures (*e.g.,* a nanowire array), as the patent is directed to "improved techniques for making electrical contacts to nanostructured portions of a surface." JX-0004 ('640 Patent) at 1:36-40, 2:38-39, 10:44-49, Figures 10, 12A-C. Moreover, nanostructures would not serve their intended purpose—antireflection—if spaced microns away. *See* RX-0604C (John RWS) at Q/A

226. These requirements highlight Dr. Souri as having made arbitrary measurements of a portion of a surface structure, rather than any distinct feature or structure, because none of what he measured could be objectively seen to serve any of the purposes disclosed in the patent or otherwise understood to be achieved by nanostructures.

Complainant relies on the same evidence discussed with respect to claim 1 of the '981 patent to show "a second segment in which the nanostructures *are at least partially broken or removed*." As discussed with respect to claim 1 of the '981 patent, Hanwha employs *no* removal step. *See supra* part VII.A.2.a. For the same reasons, Hanwha Accused Products do not satisfy claim 1 of the '640 patent.

Further, as discussed *supra* part VII.A.2.a, Dr. Souri applied AFM to one sample to show the alleged presence of "nanostructures," but did not apply the same AFM or MATLAB analysis to any area below a contact point that he contends shows "removal" or "breaking" of nanostructures. Tr. (Souri) at 210:12-213:8. Instead, Dr. Souri appears to assume that because he identified alleged nanostructures on one sample, they must be present on the second sample, and must have been partially broken or removed. *Id.* This is not supported by evidence. *Id.* In view of the limited number of alleged nanostructures he actually identified in the AFM sample, there is insufficient evidence to establish that any nanostructures are actually removed.

(iv) Claim Limitation 1[c] – "an electrically insulating layer atop the first surface"

Hanwha Respondents do not dispute this claim limitation. *See* RIB at 166-68.

(v) Claim Limitation 1[d] – "a conductor atop the electrically insulating layer over the second segment"

Hanwha Accused products do not have a conductor "atop" the electrically insulating layer. The parties agree that "atop" means "on top of." Thus, the conductor (*i.e.*, metal contacts) must

be "on top of" the electrically insulating layer. But Complainant argues that Hanwha's metal conductor penetrates *through* the insulating layer to the silicon substrate, as evidenced by "holes" in the insulation layer. *See* CX-2420C.163; *see also* CX-2411C (Souri WS) at Q/A 282-84.

A material that has "punctured" another material is not "on top of" it. Thus, even under Complainant's analysis, Hanwha Accused products do not have a conductor "atop" the claimed "second segment."

b. Dependent Claim 4 – "The optoelectronic device of claim 1, wherein the conductor makes electrical contact to the substrate through the insulating layer over the second segment."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 4 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.2.a, I find that the Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 4 for at least that reason.

c. Dependent Claim 11 – "The optoelectronic device of claim 1, wherein the nanostructures comprise silicon."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 11 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.2.a, I find that the Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 11 for at least that reason.

d. Dependent Claim 12 – "The optoelectronic device of clam 1, comprising a photovoltaic cell."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 12 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.2.a, I find that the Hanwha Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 12 for at least that reason.

e. Dependent Claim 13 – "The optoelectronic device of claim 11, wherein the nanostructures comprise silicon nanowires."

I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 13 of the '640 patent.

(i) "The optoelectronic device of claim 11"

For the same reasons discussed *supra* part VIII.A.2.a, I find that the Hanwha Accused Products have not been shown to satisfy dependent claim 11 of the '640 patent. The Hanwha Accused Products have not been shown to satisfy dependent claim 13 for at least that reason.

(ii) "wherein the nanostructures comprise silicon nanowires."

Claim 13 requires an optoelectronic device wherein the "nanostructures comprise silicon nanowires." For the same reasons discussed with respect to the '599 patent *supra* part VI.A.2.b, Hanwha Accused Products do not satisfy claim 13 of the '640 patent.

3. Alleged Infringement by Boviet Accused Products

a. Independent Claim 1

I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '640 patent.

(i) Claim 1 Preamble – "An optoelectronic device comprising"

Boviet Respondents do not dispute the preamble. *See* RIB at 168-72.

(ii) Claim Limitation 1[a] – "a substrate including a first surface"

Boviet Respondents do not dispute this claim limitation. *See* RIB at 168-72.

(iii) Claim Limitation 1[b] – "a nanostructured area including nanostructures on the first surface of the substrate, the nanostructured area including a first segment in which the nanostructures are intact and a second segment in which the nanostructures are at least partially broken or removed, the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate"

The Boviet Accused Products do not satisfy claim limitation 1(b) for several reasons.

First, as described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Boviet made, used, sold, offered for sale, or imported.

Second, as discussed above with respect to the '981 patent, none of the Boviet Accused Products include "nanostructures" nor has Dr. Souri shown that they do. *See* RX-0599C (Kanicki WS) at Q/A 320.

Third, even assuming that Dr. Souri has correctly identified "nanostructures" in the sampled area (he hasn't), such area only has a few purported nanostructures (*i.e.*, red curves) and is not "nanostructured area." *Id.*

The parties agree that "nanostructured area" means "area made up of nonostructures." *See* SIB at 36-39; Joint Claim Construction Chart at 3 (Nov. 12, 2021) (EDIS Doc. ID No. 756513). Accordingly, the fact dispute remaining to be resolved is whether the material in the claimed area of the accused devices is made up of nanostructures. As discussed herein, it is not.

Dr. Kanicki opines that for an area to be made up of nanostructures it requires the area to be mostly comprised of nanostructures. *See* RX-0599C (Kanicki WS) at Q/A 321-25; 330. Boviet Accused Products are certainly not mostly comprised of nanostructures. *Id.* at Q/A 326-27. This is further confirmed by Dr. Souri's testimony during trial. For example, Dr. Souri admitted that there are "micron scale undulations" in the SEM images. Tr. (Souri) at 184:9-16. Even in CX-2420C.28 (Compilation Exhibit re Figures from Souri's Expert Report), based on Dr. Souri's analysis, "the majority of the structures are not identified as nanowires." Tr. (Souri) at 188:15-22, 7-14. By identifying only a few purported nanostructures as meeting the proposed constructions, Dr. Souri appears to agree that the sampling area is not mostly comprised of nanostructures or a "nanostructured area." *Id.* Neither has Dr. Souri shown that the rest of the Boviet Accused Product module has a density of nanostructures at least as dense as the sampled area. *See* RX-0599C (Kanicki WS) at Q/A 326.

Fourth, Complainant and Dr. Souri have failed to show that the Boviet Accused Products include "a substrate," or the "first surface" of the substrate, as required. Moreover, the purported "nanostructures" are formed by Boviet's process of texturing or etching the blank silicon wafer surface. During this process, the structures formed are part of the substrate surface itself. *See* Tr. (Souri) at 293:8-10 ("Q. The flat planar surface is transformed into a textured surface, right? A. That's fine."). While the claim requires "nanostructured material *on* the first surface [of the substrate]," Dr. Souri appears to only identify the alleged nanostructured material as a part of the substrate, but not as something *on* the first surface of the substrate. *See* RX-0599C (Kanicki WS) at Q/A 328-29, 331.

Boviet Accused Products also do not meet "a second segment in which the nanostructures are at least partially broken or removed." Complainant and Dr. Souri have relied on the same

"removal" evidence discussed with respect to claim 1 of the '981 patent to show "a second segment in which the nanostructures *are at least partially broken or removed*." As discussed above with respect to claim 1 of the '981 patent, Boviet uses a standard screen printing deposition technique to deposit metal contacts on its products. As such, there is no step of breaking or removing. For the same reasons discussed above with respect to '981 patent ("removing"), Boviet Accused Products do not meet "a second segment in which the nanostructures are at least partially broken or removed." *See* RX-0599C (Kanicki WS) at Q/A 332.

In addition, Dr. Souri fails to show that the purported "first segment" includes nanostructures that are intact or that the purported "second segment" includes nanostructures that are at least partially broken or removed. *Id.* at Q/A 332-36. For example, Dr. Souri does not correlate the images in which he identifies a "first segment" with CX-2420C.140 (AFM) which is the only place he identifies any purported "nanostructures." *Id.* at Q/A 335-36. In fact, Dr. Souri admits those images and the AFM images were taken from different samples. *See, e.g.,* CX-2411C (Souri WS) at Q/A 38. Unlike his 2D top-down images showing green and red lines to denote nanostructures and nanowires (CX-2420C.140 and CX-2420C.28), Dr. Souri does not include a single annotation on the images to identify where the purported first segment has nanostructures that are intact, or where the purported second segment has nanostructures that are at least partially broken or removed, or what he believes are "divots" versus "indentations" versus "pockmarks" versus "nanostructures." RX-0599C (Kanicki WS) at Q/A 333-37.

Complainant and Dr. Souri have failed to show that Boviet Accused Products satisfy "the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate" because they failed to show that the Accused Products include a "first segment [in which nanostructures are intact]" or a "second segment [in which the nanostructures

are at least partially broken or removed]." *See* RX-0599C (Kanicki WS) at Q/A 340-42. He also fails to identify "a plane defined by the first surface of the substrate." *Id.* While Dr. Souri only purportedly labels "first segment" and "second segment" in CX-2420C.145, he is silent about how the second segment is "laterally displaced" from the first segment and what the area looks like before the second segment is displaced. *Id.*

(iv) Claim Limitation 1[c] – "an electrically insulating layer atop the first surface"

The Accused Products do not have an electrically insulating layer atop the first surface, nor does Dr. Souri show that they do. *See* RX-0599C (Kanicki WS) at Q/A 343-49. The parties agree that "atop" means "on top of." Thus, the electrically insulating layer must be "on top of" the first surface of the substrate. As discussed above, before forming an anti-reflective layer, Boviet's wafers go through an isolation etching process, as part of which, [redacted] is injected into the chamber, forming a thin layer of [redacted] on top of the silicon surface. *See* RX-0635C (SC Etching Process Inspection Sheet). Therefore, the Accused Products do not meet this limitation because the "electrically insulating layer" identified by Dr. Souri is not on top of the first surface of the substrate—there is a silicon dioxide layer in between. *See* RX-0599C (Kanicki WS) at Q/A 349.

(v) Claim Limitation 1[d] – "a conductor atop the electrically insulating layer over the second segment"

Complainant and Dr. Souri have failed to show that Boviet's Accused Products satisfy this limitation because they failed to provide any positional relationship between the purported "conductor" and the "electrically insulating layer," or between the purported "conductor" and a "second segment," and therefore failed to show "a conductor atop the electrically insulating layer over the second segment." *See* RX-0599C (Kanicki WS) at Q/A 350-51.

b. Dependent Claim 4 – "The optoelectronic device of claim 1, wherein the conductor makes electrical contact to the substrate through the insulating layer over the second segment."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 4 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 4 for at least that reason.

c. Dependent Claim 11 – "The optoelectronic device of claim 1, wherein the nanostructures comprise silicon."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 11 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 11 for at least that reason.

d. Dependent Claim 12 – "The optoelectronic device of clam 1, comprising a photovoltaic cell."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 12 of the '640 patent.

For the same reasons discussed *supra* part VIII.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy independent claim 1 of the '640 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 12 for at least that reason.

e. Dependent Claim 13 – "The optoelectronic device of claim 11, wherein the nanostructures comprise silicon nanowires."

I find that the Boviet Accused Products have not been shown to satisfy dependent claim 13 of the '640 patent.

(i) "The optoelectronic device of claim 11"

For the same reasons discussed *supra* part VIII.A.3.a, I find that the Boviet Accused Products have not been shown to satisfy dependent claim 11 of the '640 patent. The Boviet Accused Products have not been shown to satisfy dependent claim 13 for at least that reason.

(ii) "wherein the nanostructures comprise silicon nanowires."

Claim 13 requires an optoelectronic device wherein the "nanostructures comprise silicon nanowires." For the same reasons discussed with respect to the '599 patent *supra* part VI.A.3.a, the Boviet Accused Products do not satisfy claim 13 of the '640 patent.

B. Technical Prong of the Domestic Industry Requirement

For the reasons discussed below, I find that Complainant's LightSense Biosensor has not been shown to practice claim 1 of the '640 patent. There are several independent bases for that determination.

Claim limitation 1[b] requires "a nanostructured area including nanostructures on the first surface of the substrate." The parties have stipulated that a "nanostructured area" is an "[a]rea made up of nanostructures." Like with similar terms in the '981 patent, Dr. Souri's analysis does not show any nanostructures, or an area made up of nanostructures. *See* RX-0600C (Lebby WS) at Q/A 171-72. Likewise, even if such structures existed, they are not identified in relation to a surface, and accordingly not "on the first surface of the substrate." *Id.* at Q/A 173.

Claim limitation 1[b] requires "the nanostructured area including a first segment in which the nanostructures are intact and a second segment in which the nanostructures are at least partially broken or removed." Dr. Souri did not perform any measurements on either area showing that they now or ever contained "nanostructures," and without a before-and-after comparison, there is

no way to tell if anything was "broken or removed." *See* RX-0600C (Lebby WS) at Q/A 174-75.

Claim limitation 1[b] requires "the second segment being laterally displaced from the first segment in a plane defined by the first surface of the substrate." Again, Dr. Souri's inability to consistently identify surfaces or segments on a product makes him unable to show that this claim element is met. *Id.* at Q/A 176.

Claim limitation 1[c] requires "an electrically insulating layer atop the first surface." The analysis supposedly showing a PSG layer is unpersuasive. *See* RX-0600C (Lebby WS) at Q/A 177. Dr. Souri has not shown that the alleged PSG layer is "atop the first surface" because: (1) he has not identified a first surface; and (2) the only cross-sectional view of the alleged Domestic Industry Product claiming to show the first surface has been etched away and there is no way to tell if the alleged PSG sits atop any plausible first surface, other structures, or other materials in intervening layers. *Id.* at Q/A 177.

Claim limitation 1[d] requires "a conductor atop the electrically insulating layer over the second segment." As discussed above, Dr. Souri failed to show such an insulating layer, and moreover, his methodology provides no direct evidence that whatever was placed above that layer is actually a conductor, or where the alleged conductor was located relative any surfaces or segments of the device. *See* RX-0600C (Lebby WS) at Q/A 178.

Each of the deficiencies identified above independently compel a conclusion that ASGT has not satisfied the technical prong of the domestic industry requirement for the '640 patent.

C. Validity

Respondents contend the asserted claims of the '640 patent are invalid as rendered obvious by certain combinations of prior art. *See* RIB at 243-56. Staff contends otherwise. *See* SIB at 143-46.

For the reasons stated below, Respondents have not shown by clear and convincing evidence that the asserted claims of the '640 patent are invalid as rendered obvious by any asserted prior art.

1. Peng 2005 (RX-0175) and Homyk 2011 (RX-0351)

Respondents contend that the asserted claims of the '640 patent are rendered obvious by Peng 2005 (RX-0175) in combination with Homyk 2011 (RX-0351).[18] At the center of the dispute is whether a person of ordinary skill in the art would have been motivated to combine Peng 2005 and Homyk 2011. The weight of the evidence favors the Complainant's position with respect to the requisite motivation to combine. *See* CX-2485C (Banerjee RWS) at Q/A 226-38; RX-0001C (Lebby WS) at Q/A 528-32.

Dr. Lebby testified that Peng 2005 discloses, *inter alia*, a solar cell in which metal contacts were deposited on top of nanowires, which should be coated with a dielectric or insulating layer to reduce surface recombination. *See* RX-0001C (Lebby WS) at Q/A 528. Dr. Lebby further testified that Peng 2005 "points out that contact fabrication need[s] to be improved because the efficiencies of the solar cells were low despite the improved anti-reflection property of the nanowire solar cells." *Id.*; *see also* RX-0001C (Lebby WS) at Q/A 513 ("Peng 2005 . . . teaches that nanowires and the metal electrodes may have high contact resistance contributing to low efficiency of the cell."). According to Dr. Lebby, one of ordinary skill would have been motivated by this suggestion to improve the metal contacts and "would have looked to the solution provided by Homyk 2011 -- cleaving the nanostructures and insulating material in the portion where the contact is to be placed -- to improve the contacts." *See* RX-0001C (Lebby WS) at Q/A 528.

[18] Peng 2005 (RX-0175) was discussed *supra* part VI.C.4, and Homyk 2011 (RX-0351) was discussed *supra* parts VII.C.1 and VII.C.3.

However, Dr. Lebby also admitted that Homyk 2011 discloses mechanical cleaving of nanowires to improve the contact resistance in FETS (Field Effect Transistors), not solar cells. *See* RX-0001C (Lebby WS) at Q/A 529 ("The specific examples in Homyk [2011] [illustrating cleaving of nanowires] are Field Effect Transistors or FET."). Notwithstanding the focus on FET devices in Homyk 2011, Dr. Lebby nonetheless testified that Homyk 2011 is "in the same field of fabricating silicon nanowires as Peng 2005 and discloses that such nanowires are important for both solar cells and microelectronic devices." *See* RX-0001C (Lebby WS) at Q/A 531.

Contrary to Dr. Lebby's testimony, the evidence shows that Peng 2005 and Homyk 2011 are non-analogous art. Dr. Lebby's interpretation of Homyk 2011 applying equally to solar cells is incorrect because, *inter alia*, it is based on an ambiguous passage in Homyk 2011. *See* CX-2485C (Banerjee RWS) at Q/A 232 ("[T]he cited portion of Homyk 2011 is ambiguous: 'Defining high aspect ratio structures with controllable sidewalls in silicon has become increasingly important both in the nanometer and micrometer scale for solar cells, microelectronic devices, and chemical analysis.'"). Dr. Banerjee explained that, while the passage in Homyk 2011 identifies various fields including solar cells, it refers to structures in the nanometer and micrometer scale and "[i]t does not make any specific connection between structures 'in the nanometer . . . scale' and solar cells. *Id.* Dr. Banerjee further explained that "[t]his general statement concerning utility of nano-scale or micro-scale structures to an array of different technologies is also consistent with the idea that some structures are important to some technologies but not to others, without any clear and convincing evidence about which are related to which." *Id.*[19]

[19] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations

Thus, the evidence does not show clearly and convincingly that a person of ordinary skill the art would have been motivated to combine Peng 2005 and Homyk 2011. Without that showing, Respondents have not demonstrated that the asserted claims of the '981 patent are rendered obvious by the combination of Peng 2005 and Homyk 2011.

2. Koynov 2006 (RX-0294) and Tobias 2003 (RX-0331)

Respondents contend that the asserted claims of the '640 patent are rendered obvious by Koynov 2006 (RX-0294) in combination Tobias 2003 (RX-0331),[20] but only under Complainant's proposed claim construction and infringement theory wherein "the screen printing process can be the means by which nanostructures are 'partially broken or removed' as recited in Claim 1 of the 640 Patent." *See* RIB at 251; RX-0001C (Lebby WS) at Q/A 499 ("[W]hen screen printing is used on the nanostructured surface of Koynov 2006, the portion of the silicon nanostructure that is removed using the reactive molten glass frit as part of the firing step of the screen printing process of Tobias 2003 would correspond to the claimed 'second segment in which the nanostructures are 'partially broken or removed' under Complainant's expert's understanding of the claims.").

As discussed *supra* parts VIII.A.1.a, VIII.A.2.a, and VIII.A.3.a, Complainant's infringement theory regarding screen printing (*i.e.*, "the screen printing process can be the means by which nanostructures are 'partially broken or removed' as recited in Claim 1 of the 640 Patent")

must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

[20] Koynov 2006 is a printed publication entitled "Black Multi-Crystalline Silicon Solar Cells," and Tobias 2003 is a printed publication entitled "Crystalline Silicon Solar Cells and Modules." RX-0294 (Koynov 2006); RX-0331 (Tobias 2003).

is incorrect. Therefore, Respondents have not shown that the asserted claims of the '640 patent are rendered obvious by Chen 2010 in combination with Tobias 2003.[21]

3. Chen 2011 (RX-0290) and Tobias 2003 (RX-0311)

Respondents contend that the asserted claims of the '640 patent are rendered obvious by Chen 2011 (RX-0290) in combination with Tobias 2003 (RX-0311),[22] but only under Complainant's proposed claim construction and infringement theory regarding screen printing. *See* RIB at 255-56; RX-0001C (Lebby WS) at Q/A 465 ("Hence, under Complainant's interpretation that the firing step of screen printing removes or breaks silicon, the second segment would correspond to the area in Chen 2011 where the silver is in contact with the nanowires because in those areas, the top portion of the nanowires would have been etched by the glass first, as explained by Tobias [2003]".).

As discussed above, Complainant's proposed claim construction and infringement theory regarding screen printing are incorrect. Therefore, Respondents have not shown that the asserted claims of the '640 patent are rendered obvious by Chen 2011 in combination with Tobias 2003.[23]

IX. THE '331 PATENT

[21] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

[22] Chen 2011 is a printed publication entitled "Electrode-Contact Enhancement in Silicon Nanowire-Array-Textured Solar Cells." RX-0290 (Chen 2011).

[23] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

As noted, Complainant asserts apparatus claim 1 of the ’331 patent. Staff contends Complainant has not proven by a preponderance of the evidence that the Accused Products infringe the asserted claim. *See* SIB at 123-26.

A. Infringement Analysis of the ’331 Patent

The disputed ’331 patent claim terms are shown in context below with emphasis:

> 1 [Preamble]. A silicon **nanostructured** device comprising:
>
> [a] a non-**nanostructured** substrate;
>
> [b] a **nanostructured** area disposed on and contacting a surface of the substrate;
>
> [c] a passivating layer coating the **nanostructured** area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride,
>
> [d] one or more contacts comprising a comb-like pattern of metal directly contacting the **nanostructured** area; and
>
> [e] a p-n junction below the **nanostructured** area.

JX-0004 (’331 Patent) at claim 1 (emphasis added).

1. Alleged Infringement by Canadian Solar Accused Products

a. Independent Claim 1

For the reasons discussed below, I find that the Canadian Solar Accused Products have not been shown to satisfy claim 1 of the ’331 patent.

(i) Claim 1 Preamble – “A silicon nanostructured device comprising”

As was explained with respect to the ‘981 and ‘640 patents *supra* parts VII.A.1.a and VIII.A.1.a, the Canadian Solar Accused Products have not been shown to have nanostructures. Without nanostructures, the Canadian Solar Accused Products are not nanostructured devices.

(ii) Claim Limitation 1[a] – "a non-nanostructured substrate"

Canadian Solar Respondents do not dispute this claim limitation. *See* RIB at 174-78.

(iii) Claim Limitation 1[b] – "a nanostructured area disposed on and contacting a surface of the substrate"

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Canadian Solar made, used, sold, offered for sale, or imported.

As was explained with respect to the '981 and '640 patents *supra* parts VII.A.1.a and VIII.A.1.a, the Canadian Solar Accused Products have not been shown to have a nanostructured area.

(iv) Claim Limitation 1[c] – "a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride"

Canadian Solar Accused Products have not been shown to have a "nanostructured area," so there is no passivating layer coating a nanostructured area in those devices.

(v) Claim Limitation 1[d] – "one or more contacts comprising a comb-like pattern of metal directly contacting the nanostructured area"

Canadian Solar Accused Products have not been shown to have a "nanostructured area," so there is no comb-like pattern of metal directly contacting a nanostructured area.

(vi) Claim Limitation 1[e] – "a p-n junction below the nanostructured area"

Canadian Solar Accused Products have not been shown to have a "nanostructured area," so there is no p-n junction below a nanostructured area.

2. Alleged Infringement by Hanwha Accused Products

As discussed *supra* part VI.A.2.a, Complainant has failed to show that the two products it analyzed are representative of all Hanwha Accused Products. With respect to the '331 patent, the evidence shows the layout of the metal contact grids used in the different Hanwha products may differ. Tr. (Schwabedissen) at 417:11-418:3. Because asserted claim 1 of the '331 patent requires a metal contact formed in a comb-like structure, Complainant has not shown infringement with respect to the non-analyzed products, which are Q.PLUS BFR G4.1, Q.PLUS G4, Q.PLUS G4.3, and Q.PLUS L G4.1. The two models Complainant did analyze, the Hanwha Q.PLUS--L-G4.2 and the Hanwha Q.PLUS DUO L-G5.2, do not demonstrate infringement either, as discussed below.

a. Independent Claim 1

For the reasons discussed below, I find that the Hanwha Accused Products have not been shown to satisfy claim 1 of the '331 patent.

(i) Claim 1 Preamble – "A silicon nanostructured device comprising"

As discussed above (*see supra* part VII.A.2.a), the Hanwha Accused Products have not been shown to include "nanostructures." Accordingly, the Hanwha Accused Products are not "nanostructured" devices.

(ii) Claim Limitation 1[a] – "a non-nanostructured substrate"

Hanwha Accused Products are fabricated on a non-nanostructured substrate. *See* CX-2411C (Souri WS) at Q/A 413-414, 440.

(iii) Claim Limitation 1[b] – "a nanostructured area disposed on and contacting a surface of the substrate"

As described in more detail in my review above of Dr. Souri's sample preparation and

testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Hanwha made, used, sold, offered for sale, or imported.

The parties agree that "nanostructured area" should be construed as an "area made up of nanostructures." *See* SIB at 36-39; Joint Claim Construction Chart at 3 (Nov. 12, 2021) (EDIS Doc. ID No. 756513). As discussed above (*see supra* part VII.A.2.a and VIII.A.2.a), the Hanwah Accused Products have not been shown to include "nanostructures" and therefore have not been shown to have a "nanostructured area" for at least the reasons discussed with respect to the '981 and '640 patents.

Moreover, even if the peaks or tips of Hanwha's microstructures identified by Complainant are assumed to be "nanostructures," Dr. Souri's analysis only identifies about a dozen alleged nanostructures for the Hanwha 4.2 product and half a dozen for the Hanwha 5.2 product. I find this sparse distribution of features does not, as a factual matter, constitue an area made up of nanostructures. *See* RX-0604C (John RWS) at Q/A 223-32; *see also supra* parts VII.A.2.a and VIII.A.2.a (infringement analysis of the '981 and '640 patents). The few structures identified by Dr. Souri are spaced *microns* apart in a non-uniform fashion. *See* RX-0604C (John RWS) at Q/A 226. The handful of ridges (or portions of ridge), each less than 200 nm in diameter, scattered across an area more than 100 times their size is not evidence of an area made up of nanostructures. *See, e.g.*, RX-0604C (John RWS) at Q/A 223-32.

Even if the portions of the textured surface of the Hanwha 4.2 and 5.2 samples that Dr. Souri alleges to be nanostructures amounted to a "nanostructured area," they are not "disposed on and contacting a surface of the substrate," as required by the claim. *See* RX-0604C (John RWS)

at Q/A 228-31. Instead, the portions of the textured surface that Dr. Souri alleges to be nanostructures or the nanostructured area are part of the n-doped portion of the silicon substrate in the Hanwha Accused Products. They are simply the resulting shape of the substrate itself after [redacted]. Thus, the area identified by Complainant is not "disposed on and contacting a surface of the substrate" as required by the claim.

Dr. Souri's infringement analysis also vitiates the requirement of claim 1 that the nanostructured area is "contacting a surface of the substrate." According to Dr. Souri, everything below the handful of 50nm tips he identified constitutes the substrate. *See* CX-2411C (Souri WS) at Q/A 412, 439. But if the "nanostructured area" and "non-nanostructured substrate" are portions of the same structure, made from the same material, there is no surface for the nanostructured area to contact.[24] Tellingly, Dr. Souri himself, when describing his AFM images, states that it is the "silicon surface" itself that is "nanostructured." *See* CX-2420C.224 (Compilation Exhibit re Figures from Souri's Expert Report) (AFM "image illustrating the nanostructured silicon surface" of the Hanwha 4.2 product).

For all of the reasons above, Complainant has not shown that the Hanwha Accused Products have "a nanostructured area disposed on and contacting a surface of the substrate."

(iv) Claim Limitation 1[c] – "a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride"

The Hanwha Accused Products have not been shown to have a "nanostructured area," as

[24] *See Becton, Dickinson and Co. v. Tyco Healthcare Group, LP*, 616 F.3d 1249, 1254 (Fed. Cir. 2010) ("Where a claim lists elements separately, 'the clear implication of the claim language' is that those elements are 'distinct component[s]' of the patented invention.").

discussed above. Therefore, those products have not been shown to have a passivating layer coating a nanostructured area.

(v) Claim Limitation 1[d] – "one or more contacts comprising a comb-like pattern of metal directly contacting the nanostructured area"

The Hanwha Accused Products have not been shown to have a "nanostructured area," as discussed above. Therefore, those products have not been shown to have a comb-like pattern of metal directly contacting the nanostructured area.

Additionally, Dr. Souri conceded during the hearing that he has not actually identified any alleged nanostructure or nanostructured area in direct contact with the metal contacts in the Hanwha Accused Products. Tr. (Souri) at 210:12-211:22. Complainant has thus failed to meet its burden of proving this limitation is met. Indeed, Dr. Souri testified that all of the alleged nanostructures in contact with the metal pattern would have been *removed* by the [redacted] process. Tr. (Souri) at 213:3-8 (Q. Just to be sure, you have not gone and identified a partial nanostructure corresponding to one of these divots in your witness statement, correct? A. I haven't found a nanostructure and then discovered that itself was removed because it's obviously been removed by the [redacted] process."). Thus, according to Dr. Souri's logic, after the [redacted] process, there will be no nanostructured area left in contact with any resulting metal pattern. And if there is no nanostructured area left, then the Hanwha Accused Products cannot have "one or more contacts comprising a comb-like pattern of metal directly contacting the nanostructured area."

(vi) Claim Limitation 1[e] – "a p-n junction below the nanostructured area"

The Hanwha Accused Products have not been shown to have a "nanostructured area," as

discussed above. Therefore, the products have not been shown to have a p-n junction below a nanostructured area.

3. Alleged Infringement by Boviet Accused Products

a. Independent Claim 1

For the reasons discussed below, I find that the Boviet Accused Products have not been shown to satisfy claim 1 of the '331 patent.

(i) Claim 1 Preamble – "A silicon nanostructured device comprising"

As discussed above for the '981 patent *supra* part VII.A.3.a, Complainant and Dr. Souri have failed to show that the Boviet Accused Products include any "nanostructures," and therefore they have failed to show that the Boviet Accused Products are nanostructured devices as stated in the preamble.

(ii) Claim Limitation 1[a] – "a non-nanostructured substrate"

The Boviet Accused Products are fabricated on a non-nanostructured substrate. *See* CX-2411C (Souri WS) at Q/A 386.

(iii) Claim Limitation 1[b] – "a nanostructured area disposed on and contacting a surface of the substrate"

As described in more detail in my review above of Dr. Souri's sample preparation and testing techniques, I find that the etching process employed by Dr. Souri altered the features of the surface he analyzed. Accordingly, I find ASGT has not shown persuasive evidence that the surface Dr. Souri analyzed is representative of products that Boviet made, used, sold, offered for sale, or imported.

As discussed above with respect to the '981 and '640 patents, Complainant and Dr. Souri have failed to show the presence of nanostructures in Boviet Accused Products. As also discussed

above, the Boviet Accused Products do not have a "nanostructured area." The parties agree that "nanostructured area" should be construed as an "area made up of nanostructures." *See* SIB at 36-39; Joint Claim Construction Chart at 3 (Nov. 12, 2021) (EDIS Doc. ID No. 756513). Dr. Souri's AFM analysis shows only a few purported nanostructures within the sampling area. The handful of features Dr. Souri identified, each less than 200 nm in diameter, scattered across an area more than 100 times their size is not evidence of an area made up of nanostructures. Accordingly, the Boviet Accused Products do not meet this limitation.

Dr. Souri also fails to show that the purported nanostructured area is "disposed on and contacting" a purported "surface of the substrate." First, Dr. Souri fails to identify any "substrate" or "surface of the substate" in any of the evidence he relies upon for the '331 patent. *See* RX-0599C (Kanicki RWS) at Q/A 377. Second, since the Boviet Accused Products are textured through etching the surface of the substrate, the features identified by Dr. Souri are part of the substrate itself. If the "nanostructured area" and "non-nanostructured substrate" are portions of the same structure, made from the same material, there is no surface for the nanostructured area to contact.[25] *See* RX-0599C (Kanicki RWS) at Q/A 382-84.

For all of the reasons above, Complainant has not shown that the Boviet Accused Products have "a nanostructured area disposed on and contacting a surface of the substrate."

(iv) Claim Limitation 1[c] – "a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride"

The Boviet Accused Products have not been shown to have a "nanostructured area," as

[25] *See Becton, Dickinson and Co. v. Tyco Healthcare Group, LP*, 616 F.3d 1249, 1254 (Fed. Cir. 2010) ("Where a claim lists elements separately, 'the clear implication of the claim language' is that those elements are 'distinct component[s]' of the patented invention.").

discussed above. Therefore, those products have not been shown to have a passivating layer coating a nanostructured area.

Additionally, Complainant's expert Dr. Souri relied on an SEM cross-section where the top n-doped layer that purportedly once included nanostructures has been removed. As such, Dr. Souri's evidence did not actually show any contact between a passivating layer and a nanostructured area, let alone that a passivating layer is coating a purported nanostructured area. *See* RX-0599C (Kanicki RWS) at Q/A 386-87.

For at least the reasons above, Complainant has not shown that the Boviet Accused Products have a passivating layer coating a nanostructured area.

(v) Claim Limitation 1[d] – "one or more contacts comprising a comb-like pattern of metal directly contacting the nanostructured area"

The Boviet Accused Products have not been shown to have a "nanostructured area," as discussed above. Therefore, those products have not been shown to have a comb-like pattern of metal directly contacting the nanostructured area.

(vi) Claim Limitation 1[e] – "a p-n junction below the nanostructured area"

The Boviet Accused Products have not been shown to have a "nanostructured area," as discussed above. Therefore, the products have not been shown to have a p-n junction below a nanostructured area.

In addition, for satisfaction of this element Complainant's expert Dr. Souri relied on an SEM image of a sample from which n-doped silicon was removed by a selective etch. *See* RX-0599C (Kanicki RWS) at Q/A 394-95. Complainant's evidence on this point is not persuasive for this additional reason.

B. Technical Prong of the Domestic Industry Requirement

For the reasons discussed below, I find that Complainant's LightSense Biosensor (LightSense Biosensor) has not been shown to practice claim 1 of the '331 patent. There are several independent bases for that determination.

First, claim 1 of the '331 patent requires "a nanostructured area disposed on and contacting the surface of the substrate." However, no "nanostructures" have been identified in ASGT's LightSense Biosensor as explained in detail above with respect to the '981 patent *supra* part VII.B. *See* RX-0600C (Lebby WS) at Q/A 181-82.

Additionally, claim 1 requires "a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride." ASGT's LightSense Biosensor does not have such a layer. The evidence shows the PSG layer identified by ASGT is not a passivating layer of silicon dioxide. RX-0600C (Lebby WS) at Q/A 191. Additionally, ASGT's expert Dr. Souri did not testify that the alleged passivating layer is "coating the nanostructured area." *Id*. at Q/A 191-92.

Claim 1 further requires "one or more contacts comprising a comb-like pattern of metal directly contacting the nanostructured area." ASGT's expert Dr. Souri did not identify any portion of the LightSense Biosensor where silver is contacting an alleged nanostructured area. RX-0600C at Q/A 193.

Each of the deficiencies identified above independently compel a conclusion that ASGT has not satisfied the technical prong of the domestic industry requirement for the '331 patent.

C. Validity

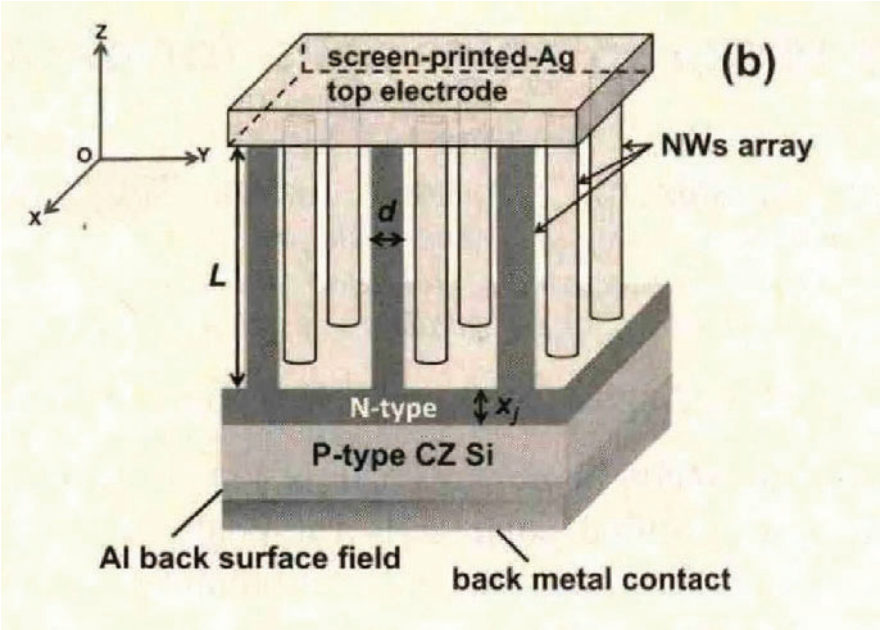
Respondents contend several prior art references, alone and in combination, render asserted claim 1 of the '331 patent invalid. *See* RIB at 209-18, 227-31. Staff contends Respondents have

shown "the Asserted Claim of the '331 Patent is invalid as rendered obvious (but not as anticipated) by the asserted prior art." SIB at 146; *see id.* at 146-54.

1. Chen 2010 (RX-0289)

Respondents have not presented clear and convincing evidence that asserted claim 1 of the '331 patent is anticipated by a printed publication entitled "Silicon Nanowire-Array-Textured Solar Cells for Photovoltaic Application" ("Chen 2010") (RX-0289).[26] The primary dispute over Chen 2010 centers on whether Chen 2010 inherently discloses "contacts comprising a comb-like pattern of metal directly contacting the nanostructured area."

Chen 2010 illustrates the following embodiment:



RX-0289 (Chen 2010) at Fig. 1(b). The figure labels a solid rectangular block on top of a nanowire array as "screen printed Ag top electrode." *Id.* The text of Chen 2010 contains a single sentence

[26] There is no dispute that Chen 2010 is prior art to the '331 patent. *See* CIB at 164-65; CX-2485C (Banerjee RWS) at Q/A 118-19; RIB at 209-15; RX-0001C (Lebby WS) at Q/A 231-32; SIB at 146-49.

about the illustrated electrode, stating that the "screen printed front and back electrode" of several experimental wafers were made using the same process, but that process is never expressly disclosed. *See* RX-0289.16 (Chen 2010).

Respondents' expert Dr. Lebby admitted that Chen 2010 does not expressly show the pattern of its front metal electrodes, but he further testified that a person of ordinary skill in the art would have understood that Chen 2010 "necessarily" forms a comb-like pattern of metal because Chen 2010 discloses that it followed "standard conventional protocols." *See* RX-0289.16 (Chen 2010); RX-0001C (Lebby WS) at Q/A 255 ("[A]s a person of ordinary skill in the art, reading Chen 2010 that says it followed 'standard conventional protocols', I would understand that Chen 2010 necessarily used the standard screen printing process that resulted in a comb-like pattern of metal directly contacting the nanostructured area. The way that the standard screen printing process was done at the time in the solar cell industry for front contacts would produce a comb-like pattern.").

However, the evidence does not demonstrate that the "standard conventional protocols" disclosed in Chen 2010 necessarily resulted in "contacts comprising a comb-like pattern of metal." First, the recitation in Chen 2010 of "standard conventional protocols" referes to the control samples ("CS") in the experiments of Chen *et al*. *See* RX-0289.16 (Chen 2010). The "standard conventional protocols" are identified in contrast to a process that does not include texturing and a process that does not include surface passivation. *Id*. ("In the CSs, the c-Si solar cells were fabricated following the standard conventional protocol in the CS-C (four wafers) but without texturing process in the CS-A (four wafers), and without SiN_x surface passivation layer in CS-B (four wafers)."). There is no indication in Chen 2010 that the "standard conventional protocols" relate at all to screen printing of electrodes. Additionally, the control samples made with "standard

conventional protocols" do not have nanowire arrays. *See* RX-0289.16 ("the control sample (CS) without the Si NW array"). Thus, even if "standard conventional protocols" necessarily produced electrodes in a comb-like pattern, there is no evidence in Chen 2010 of a comb-like pattern of metal "directly contacting the nanostructured area." And finally, Figure 1(b) in Chen 2010 illustrates the screen-printed electrode as a solid rectangular block, not a comb-like pattern. That express disclosure contradicts a conclusion that "standard conventional protocols" in Chen 2010 necessarily result in metal contacts having a comb-like pattern.

In addition, ASGT's expert, Dr. Banerjee, provided testimony that screen printing does not necessarily result in a "comb-like pattern" because there are other patterns, such as a square grid pattern, in the prior art. *See* CX-2485C (Banerjee RWS) at Q/A 125. In fact, Tobias 2003 (RX-0331) (discussed in an obviousness combinations with Chen 2010 and with Oh 2013 (RX-0333) *infra*), shows a square grid pattern. *Id.* Figure 7.8 of Tobias 2003 (RX-0331.22), reproduced below, shows a comb-like pattern on the right side of the figure but also shows a square grid pattern on the left side of the figure:

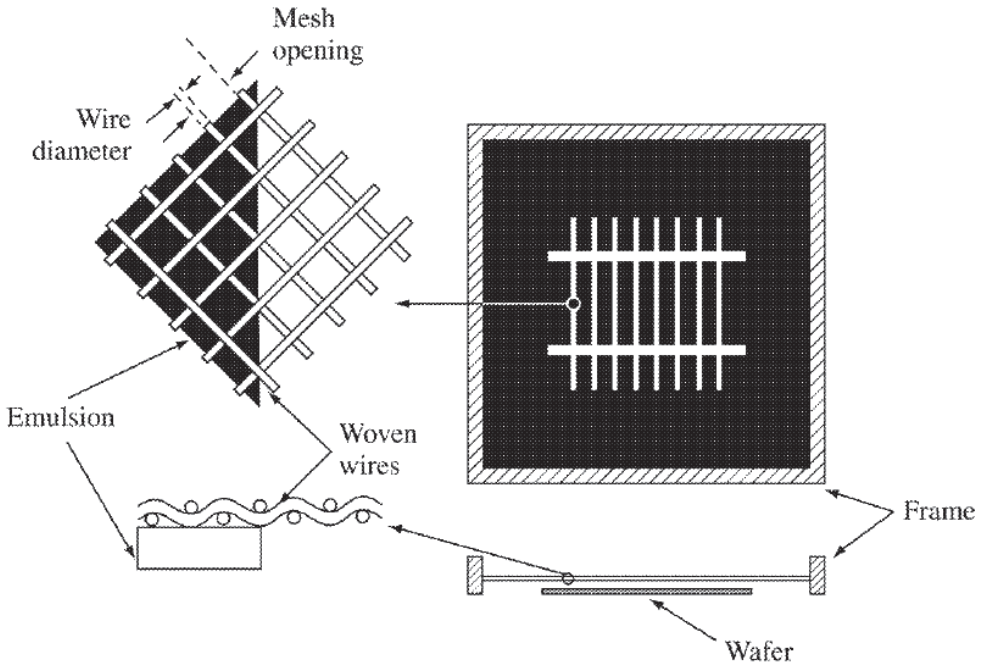


Figure 7.8 A screen for transferring the top contact pattern to a solar cell

RX-0331.22 (Tobias 2003, Figure 7.8). The above figure also appears in Dr. Lebby's witness statement. *See* RX-0001C (Lebby WS) at Q/A 261 (discussing standard screen printing and "comb-like pattern").

In addition, the prior art publication "Optimization of Grid Design for Solar Cells" ("Wen") (CX-1664C) discusses another "square" grid pattern. *See* CX-2485C (Banerjee RWS) at Q/A 126. Reproduced below is Figure 1 of Wen (CX-1664C.2), which shows another "square" grid pattern on the right side of the figure and a "linear" grid pattern on the left side of the figure:

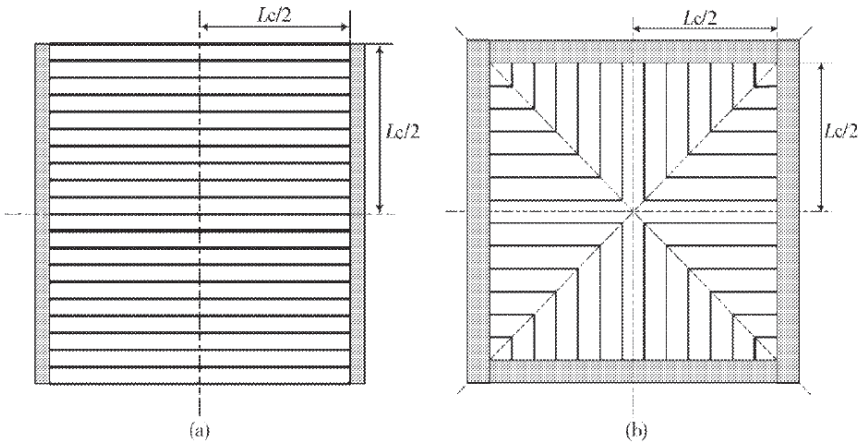


Fig. 1. Two typical top contact grid patterns. (a) Linear grid configuration. (b) Inverted square symmetry grid configuration (square grid for short).

CX-1664C.2 (Wen) at Figure 1.

The weight of the evidence shows screen printing does not necessarily result in a comb-like pattern, contrary to the opinions of Dr. Lebby. *See* CX-2485C (Banerjee RWS) at Q/A 126 ("The presence of these square connected grid patterns in the art the relevant time demonstrates that other screen-printed contact patterns existed, and so Dr Lebby's opinion that screen printing 'necessarily' produces a comb-like pattern of contacts is incorrect.").

Respondents have not shown that Chen 2010 discloses "contacts comprising a comb-like pattern of metal directly contacting the nanostructured area." Anticipation requires a single prior art reference to disclose every single claim limitation "arranged or combined in the same way as in the claim." *Wm. Wrigley Jr. Co. v. Cadbury Adams USA LLC*, 683 F.3d 1356, 1361 (Fed. Cir. 2012). Absent that disclosure, Respondents have not met their burden of proving by clear and convincing evidence that Chen 2010 anticipates the asserted claims of the '331 patent.

2. Chen 2010 (RX-0289) and Tobias 2003 (RX-0331)

For the reasons discussed below, Respondents have shown by clear and convincing evidence that asserted claim 1 of the '331 patent is rendered obvious by the combination of Chen 2010 and a printed publication entitled "Crystalline Silicon Solar Cells and Modules" ("Tobias 2003") (RX-0331).[27]

The record shows Chen 2010 discloses every limitation of claim 1 of the '331 patent except "contacts comprising a comb-like pattern of metal directly contacting the nanostructured area." *See* RX-0001 (Lebby WS) at Q/A 231-84. ASGT's expert Dr. Banerjee did not dispute testimony to that effect. *See* CX-2584C (Banerjee RWS) at Q/A 118-38.

Tobias 2003 expressly discloses a solar cell with screen-printed, comb-like metal contacts atop micron-sized structures. RX-0331.7 (Tobias 2003) (Figure 7.2 (b) illustrates an "industrial cell with screen-printed contacts" having a "metal finger"); *see also id*. at 15 ("square-base pyramids are formed, whose size is adjusted to a few microns"), 32 ("Upright pyramids of 7-µm height can be created"). Tobias 2003 describes using screen printing "to stick a paste containing silver powder to the front face of the wafer in the comblike (fingers plus bus bars) pattern." RX-0331.21 (Tobias 2003). Figure 7.8 of Tobias 2003 (RX-0331.22), reproduced below, shows the comb-like pattern of metal contacts:

[27] The parties agree that Tobias 2003 is prior art to the '331 patent. *See* CIB at 164-65; CX-2485C (Banerjee RWS) at Q/A 127-28; RIB at 216-18; RX-0001C (Lebby WS) at Q/A 258-59; SIB at 149-51.

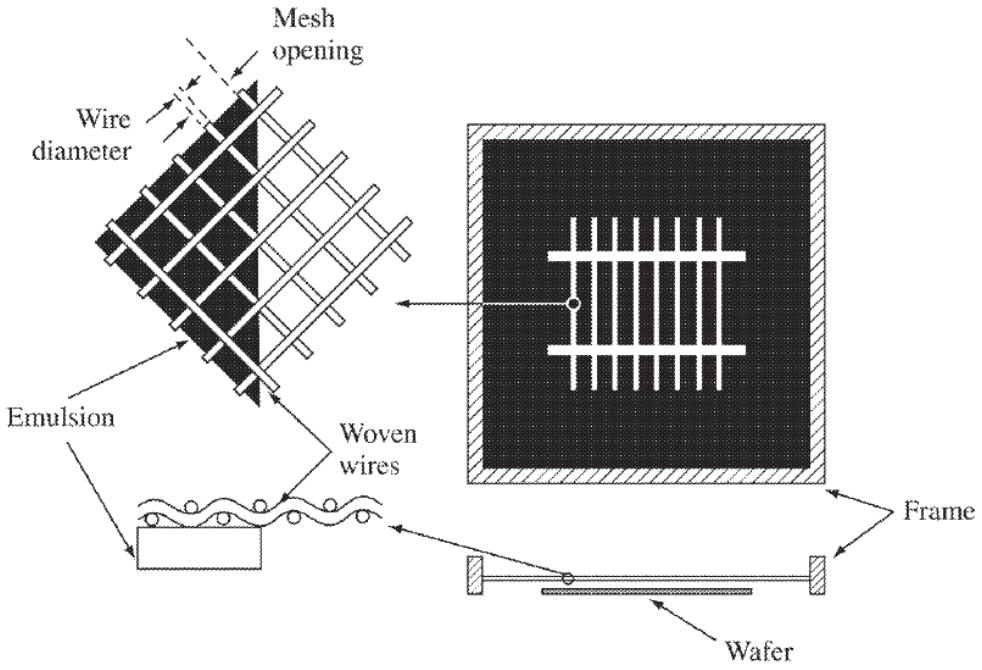


Figure 7.8 A screen for transferring the top contact pattern to a solar cell

RX-0331.22 (Tobias 2003, Figure 7.8).

The primary dispute primary dispute between the parties is whether a person of ordinary skill in the art at the time of the invention would have had a reason to combine Chen 2010 and Tobias 2003. ASGT argues that Tobias 2003 teaches away from using screen printing, and therefore the combination of Chen 2010 and Tobias 2003 would not have occurred to the ordinary artisan. ASGT's argument rests on the following disclosure in Tobias 2003: "In screen printing, the wafer is subjected to considerable pressure. This can pose a problem with a very thing or irregular wafers, such as those obtained by sheet growth silicon, which can break down." RX-0331 (Tobias 2003) at 25. ASGT's expert Dr. Banerjee testified, *inter alia*, that this disclosure teaches that screen printing does not perform well with "irregular" wafers because of their fragility and,

thus, would teach a person of ordinary skill in the art not to combine Chen 2010 with Tobias 2003. *See* CX-2485C (Banerjee RWS) at Q/A 131-33.

The evidence shows that Dr. Banerjee's reading of Tobias 2003 is selective and incomplete. Tobias 2003 provides an overview of manufacturing processes that were "currently implemented at the industrial level, mostly based on screen-printing metallization." RX-0331 (Tobias 2003) at 2. Tobias 2003 teaches that metal contact screen printing "[w]ith more or less minor modifications" was "used by many manufacturers" at the time. *Id*. at 17. In fact, automatic screen printers were available that were "capable of in-line, continuous operation with high throughput." *Id*. at 20. Tobias 2003 describes a variety of design choices that must be balanced when using screen printing technology. *See, e.g., id*. at 11 ("Screen printing drastically affects the design of the emitter"). At the time of Tobias 2003, the reference noted, "[s]ome ways of incorporating selective emitters to screen-printed cells are being considered, SiN_x appearing very well suited for surface passivation. This, however, must be accompanied by a decrease in the finger width so that lower sheet resistances are tolerated." *Id*. at 12. Thus, Tobias 2003 teaches that ordinary artisans would have "considered" screen printing with surface passivation using SiN_x at the time of the invention,[28] and would have known factors to balance when considering screen printing. I find those teachings demonstrate that a person of ordinary skill in the art at the time of the invention would have had motivation to use the screen printing pattern of Tobias 2003 to the screen printed metal contact of Chen 2010.

[28] Like this teaching of Tobias 2003, claim 1 of the '331 patent requires "a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride."

Dr. Lebby provided testimony explaining that Dr. Banerjee misinterpreted the disclosure about screen printing with "irregular" wafers in Tobias 2003 and gave his opinion that nothing in Tobias 2003 suggests an artisan should not use screen printing on nanowires or nanostructures. *See* RX-0001C (Lebby) at Q/A 273, 274, 416. In particular, Dr. Lebby explained that the disclosure about screen printing with "irregular" wafers in Tobias 2013 refers to "very thin wafers that are made by sheet growth of silicon, rather than the conventional wafers disclosed in Chen 2010." *See* RX-0001C (Lebby) at Q/A 416. Moreover, Dr. Banerjee admitted that Tobias 2003 never referred to "irregular" wafers as those containing nanowires, even though nanowires were known, albeit "not discussed in length" at the time of the invention. Tr. (Banerjee) at 909:4-25. In addition, Dr. Lebby testified that Chen 2010 disclosed screen printing on nanowires and nanostructures and, moreover, did not report any difficulty in screen printing on nanowires or nanostructures. *See* RX-0001C (Lebby) at Q/A 273-74.

Additionally, Dr. Lebby testified that there are no secondary consideration factors that support non-obviousness. *See* RX-0001C (Lebby RWS) at Q/A 549-73. Dr. Banerjee did not dispute this testimony. *See* CX-2584 (Banerjee RWS) at Q/A 118-38.[29]

I find that the invention described in claim 1 of the '331 patent would have been obvious to a person of ordinary skill in the art at the time. Chen 2010 describes screen-printed metal contacts atop a device having all of the elements of claim 1 except for "a comb-like pattern" for those contacts. Tobias 2003 teaches screen-printed comb-like metal contacts atop a solar cell and

[29] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

confirms that an ordinary artisan at the time would "consider" using such contacts with SiN_x surface passivation. Combining the teachings of Chen 2010 and Tobias, as suggested in the prior art, an ordinary artisan would have arrived at the claimed invention. Respondents have therefore shown by clear and convincing evidence that asserted claim 1 of the '331 patent is invalid as obvious under 35 U.S.C. § 103.

3. Oh 2013 (RX-0333)

Unlike other prior art at issue, the parties dispute whether U.S. Patent Application Publication No. US2013/0340824 ("Oh 2013") (RX-0333) is prior art to the '331 patent. I address that issue first and follow with a comparison of Oh 2013 to claim 1 of the '331 patent.

a. Whether Oh 2013 is prior art to the '331 patent

The parties dispute whether Oh 2013 is prior art to the '331 patent. *See* CIB at 167-83; RIB at 219-27; SIB at 151; *see also*, *e.g.*, CX-2408C (Banerjee WS) at Q/A 20-25, 36-40; RX-0600C (Lebby RWS) at Q/A 4-8.

Oh 2013 was filed on March 8, 2011, and it was published on December 26, 2013. Oh 2013 was filed before the filing date of the provisional application to which the '331 patent claims priority. Thus, Oh 2013 is presumptively prior art under 35 U.S.C. §§ 102(e) and 102(g). Complainant ASGT contests the prior art status of Oh 2013, arguing that the testimony of Dr. Black establishes claim 1 of the '331 patent was conceived no later than August 2009 and was reduced to practice no later than October 2010 or January 2011, before the filing date of Oh 2013.

As discussed below, ASGT did not present sufficient evidence to corroborate the dates to which Dr. Black testified. Additionally, even if the dates in Dr. Black's testimony were corroborated, the evidence fails to meet the legal standards necessary to prove conception and to prove reduction to practice. Each of these issues is addressed in turn.

(i) Corroboration

Establishing priority cannot be proved by "mere allegation"; it requires "disclosure to others or embodiment of the invention in some clearly perceptible form, such as drawings or model, *with sufficient proof of identity in point of time*." *Mergenthaler v. Scudder*, 11 App. D.C. 264, 278 (D.C. Cir. 1897) (emphasis added). "[T]he case law is unequivocal that an inventor's testimony respecting the facts surrounding a claim of derivation or priority of invention cannot, standing alone, rise to the level of clear and convincing proof." *Price v. Symsek*, 988 F.2d 1187, 1194 (Fed. Cir. 1993).

Dr. Black attempted to corroborate the conception date with an August 29, 2009, email that supposedly attached certain undated drawings showing a comb-like pattern design. *See* CX-2405C (Black WS) at Q/A 64, 66. ASGT's expert Dr. Banerjee relied on the same documents and other emails with supposed attachments in his opinions. *See* CX-2408C (Banerjee WS) at Q/A 26-33. But aside from Dr. Black's testimony, there is no evidence that the drawings in question were in fact attached to the emails on the dates purported.

Dr. Black and Dr. Banerjee cited certain metadata allegedly associated with the documents to date them or otherwise explain them. But Complainant ASGT did not produce during discovery any of the original native format documents from which the metadata could be independently verified. Nor was any native source information introduced at the hearing. The record contains no chain of custody evidence or other indication that the purported email attachments were collected in such a way as to preserve the original metadata without alteration.

For dates allegedly established via metadata, ASGT's expert Dr. Banerjee testified that he relied on a spreadsheet (CX-1272C (ASGT Production Metadata Spreadsheet)) listing dates, filenames, and authors that Complainant ASGT created for purposes of this investigation using

some "e-discovery software." *See* CX-2408C (Banerjee WS) at Q/A 43-46; Tr. (Banerjee) at 882:15-885:3. There is no evidence in the record regarding how this list was created, or how the alleged source material used to generate this list was maintained or used to generate this list. Dr. Banerjee also testified that the notation "101006X" in certain documents refers to a date, but he admitted his understanding is not supported by any evidence beyond information from Dr. Black and ASGT. *See* Tr. (Banerjee) at 885:8-886:24.

Indeed, Dr. Black relied upon hearsay and unnamed sources regarding what the metadata supposedly shows in dating the documents; the unnamed person who performed the metadata analysis did not testify. *See* CX-2405C (Black WS) at Q/A 68 ("*I am informed* that metadata shows this document was created was October 13, 2010…." (emphasis added)); CX-2405C (Black WS) at Q/A 72, 74.

As a named inventor and a party with an interest in the outcome of this litigation (*see* Tr. (Black) at 74:15-23), Dr. Black's testimony must be corroborated. *See Price*, 988 F.2d at 1194. Dr. Black is the only person with personal knowledge who testified about priority. As in *Apator Miitors ApS v. Kamstrup A/S*, 887 F.3d 1293, 1296-97 (Fed. Cir. 2018), it is Dr. Black's testimony alone that connects the emails in question to the attachments in question. It is her testimony alone "that the drawings were created" by August 2009. *See id*. at 1297. Because "the emails and drawings can only provide [necessary] corroboration with help from" Dr. Black's testimony, they are of little corroborative value. *See id*. at 1296 (Fed. Cir. 2018). I find, as a factual matter, that the record evidence does not sufficiently corroborate Dr. Black's priority claim.

(ii) Conception

ASGT asserts that the invention in claim 1 of the '331 patent was conceived no later than August 2009, but, as discussed below, the evidence fails to meet the legal standard for proving

conception by that date.

Conception is the "formation in the mind of the inventor, of a definite and permanent idea of the complete and operative invention, as it is hereafter to be applied in practice." *Hybritech Inc. v. Monoclonal Antibodies Inc*., 802 F.2d 1367, 1376 (Fed. Cir. 1986). Conception "is complete only when the idea is so clearly defined in the inventor's mind that only ordinary skill would be necessary to reduce the invention to practice, without extensive research or experimentation." *Burroughs Wellcome Co. v. Barr Labs., Inc.*, 40 F.3d 1223, 1228 (Fed. Cir. 1994).

The evidence of conception proffered by ASGT does not show the inventors had a "definite and permanent idea of the complete and operative invention" by August 2009. ASGT relies on an email dated August 29, 2009, in which the inventor Dr. Michael Jura states, "I've been thinking a bit more about the top contact (finger) design for the cells in which the submerged contact will be removed." *See* CX-0618C (Email to Jeff Miller re Finger Mask) at 1 (emphasis added). However, the email goes on to say that Dr. Jura was "worried" that thin contacts would "rip off" when the masking tape is removed and he wonders if the fingers of the design "should be thicker." *Id*. The email gives no indication that Dr. Jura believed the prototype he was "thinking" about would be successful if it were built. Respondents' expert Dr. Lebby offered opinions supporting a conclusion that success was not at all apparent in the evidence, noting that removing submerged contacts from a design is not a routine task. *See* RX-0600C (Lebby WS) at Q/A 21-23.

The Jura email, CX-0618C, makes no mention of other elements of the claimed invention, such as a non-nanostructured substrate, a passivating layer, and a p-n junction below a nanostructured area. *See* '331 patent at claim 1. For these elements, ASGT relies on a grant application that has no identified author and lists two Bandgap employees, Dr. Brent Buchine and Mr. Ferris Modawar—who are not named inventors—as having key roles in the project. *See*

CX-0211C (Bandgap Proposal for Solar America) at 14. Dr. Buchine and Mr. Modawar are co-inventors with Dr. Black on the asserted '599 patent, which claims a priority date before the alleged conception of the '331 patent. The '599 patent describes the same buried contact device discussed in the grant application. *See* JX-0001 ('599 Patent) at 3:21-22 and Figure 7. But neither the grant application nor the '599 patent describe a metal contact having a comb-like pattern.

None of the evidence shows an inventor or even an identifiable group of inventors had a definite idea of "the *complete* and operative invention" by August 2009, as is required for ASGT's coneption claim to succeed. *See Hybritech Inc.*, 802 F.2d at 1376 (emphasis added). Thus, even if ASGT had shown the documents in question to be "sufficient proof of identity in point of time," *see Mergenthaler*, 11 App. D.C. at 278, the evidence is insufficient to establish ASGT's conception claim.

(iii) Reduction to practice

ASGT asserts that the invention in claim 1 of the '331 patent was reduced to practice no later than October 2010 or January 2011. To establish actual reduction to practice, ASGT must show (a) the construction of an embodiment that met every element of the claim, and (b) that the embodiment operated for its intended purpose. *Eaton v. Evans*, 204 F.3d 1094, 1097 (Fed. Cir. 2000). ASGT must also show that the inventors recognized or appreciated that the embodiment worked for its intended purposes. *Estee Lauder, Inc. v. L'Oreal S.A.*, 129 F.3d 588, 593 (Fed. Cir. 1997).

ASGT avers that a device constructed in October 2010 or January 2011 practiced all elements of claim 1. ASGT primarily relies upon an undated slide deck which it characterizes as a report of the performance characteristics of a working device built and tested in October 2010. *See* CIB at 173 (citing CX-0582C (101006X Report)). Even if the date of that document were

reliable, however, there is no evidence in that document or elsewhere that the inventors had made a device having (i) a p-n junction below the nanostructured area, or (ii) the claimed passivation layers.[30]

To show the inventors reduced to practice "a p-n junction below the nanostructured area," as required by claim 1 to practice, ASGT cites an email chain involving inventor Dr. Jeff Miller. *See* CX-2408C (Banerjee WS) at Q/A 49-50 discussing CX-1257C.2 (Email from Marcie Black Re Wafer doping). In the chain, Dr. Miller asked a researcher at Georgia Tech to conduct some "development trials" using a "non-standard" recipe for phosphorus diffusion. CX-1257C.2 (Email from Marcie Black Re Wafer doping). Nothing in the message indicates that these development trials or the non-standard recipe for phosphorus diffusion was successful in achieving a p-n junction below the nanostructured area. *See* CX-2408C (Banerjee WS) at Q/A 49-50; RX-0600C (Lebby RWS) at Q/A 36-42. Indeed, as shown by a contemporaneous presentation to the board of the inventors' company, Bandgap, the company was still "figure[ing] out" the doping for its diffusion process even by April 2011. *See* CX-0126C.3 (Bandgap Board Presentations) ("diffusion – we are getting closer to having our doping figure out"); Tr. (Black) at 93:10-94:7. I find, based on the record evidence, that ASGT has not shown a reduction to practice by January 2011 of an invention that has every element of claim 1, including a p-n junction below the nanostructured area.

Additionally, there is no reliable evidence that the inventors actually made a device with

[30] Given my findings that the record does not reliably establish that a device having these two required claim elements was reduced to practice by January 2011, I need not separately address reduction to practice of a device having "a comb-like pattern of metal directly contacting the nanostructured area" as required by claim 1. In any event, I find no reliable evidence of a device having all of the limitations of claim 1, including the comb-like pattern, having been reduced to practice and recognized by the inventors by January 2011.

an aluminum oxide passivating layer by January 2011. ASGT's expert Dr. Banerjee testified about a conversation with Dr. Black in which she told him that in certain documents "atomic layer deposition, or ALD" referred to deposition of aluminum oxide. *See* CX-2408C (Banerjee WS) at Q/A 47 ("Dr. Black confirmed for me that the use of atomic layer deposition, or ALD, for passivating layers referred specifically to the use of ALD to deposit alumina."). But there is no corroboration for that statement by Dr. Black. In contradiction of Dr. Black's interpretation of those initials, other documents proffered by ASGT show that ALD can refer to SiN_x, which is silicon nitride. RX-0972C (Spreadsheets mfg line with screen printing only on backside) (indicating on tab "8. Passivation" that "[n]ano-surface is coated via ALD with a thin layer of SiNx to passivate the surface."); CX-2405C (Black WS) at Q/A 74; RX-0600C (Lebby RWS) at Q/A 47-51. To the extent that silicon nitride was used, the record evidence shows inventors themselves had doubts about its performance relative to other options. In particular, the testing documents indicate that the inventors noted that "SiNx may have slightly worse reflection, causing lower EQE in mid-wavelengths" and that the efficiency actually decreased. *See* CX-1254C.10 (110103X Report); RX-0600C (Lebby RWS) at Q/A 57-59. And in an internal email discussion, the inventor Dr. Jura actually responded negatively to the suggestion by a non-inventor that silicon nitride be used. *See* CX-0610C (Email re Why Silicon Nitride).

Moreover, three of the seven named inventors on the '331 patent did not even start working for Bandgap until after the alleged reduction to practice dates. *See* RX-0600C (Lebby WS) at Q/A 6, 17-18.

I find ASGT has not shown that by January 2011 the inventors reduced to practice and recognized an invention that has every element of claim 1, including the required passivating layer.

Without an actual reduction to practice, ASGT can only rely on its purported conception

date coupled with reasonable diligence toward filing of the application in February 2012. *In re Steed*, 802 F.3d 1311, 1316 (Fed. Cir. 2015). But even assuming that the inventors had conceived of claim 1 by August 2009 (a conclusion I reject above), ASGT's prior invention argument still fails because ASGT adduced no evidence of reasonable diligence for the 2.5 years between the alleged conception and the filing date of a provisional application. *See In re Steed*, 802 F.3d 1311, 1320 (Fed. Cir. 2015) ("evidentiary specificity" is required to prove diligence).

(iv) Conclusion on Priority

"[A]ll of the evidence taken collectively" does not give me "an abiding conviction" that it is "highly probable" that the inventors listed on the '331 patent have a claim to priority that pre-dates the Oh 2013 reference. *Price*, 988 F.2d at 1196. Accordingly, I determine that the Oh 2013 reference is prior art to the invention in claim 1 of the '331 patent.

b. Whether Oh 2013 anticipates claim 1 of the '331 patent

Respondents have not presented clear and convincing evidence that asserted claim 1 of the '331 patent is anticipated by Oh 2013.

There are two main issues with respect to Oh 2013: (i) whether Oh 2013 discloses "nanostructures" and (ii) whether Oh 2013 inherently discloses "comb-like pattern."

Beginning with "nanostructures," Oh 2013 expressly discloses nanostructures in black silicon "pillars, columns, or wires" having "base diameters of 65 to 150 nm, for example." *See* RX-0333 (Oh 2013), Abstract, ¶¶ 44-45. I find that Oh 2013 discloses the "nanostructures" of claim 1 as that term is properly construed. *See supra* part IV.B.2.[31]

[31] ASGT's own expert, Dr. Banerjee, testified that the applicants of Oh 2013 used the term "nanostructure" in a "broader sense" that is consistent with its "customary sense" (as opposed to some specialized sense like that defined by a lexicographer). Tr. (Banerjee) at 925:9-21.

Turning to the "comb-like pattern" of metal contacts required by claim 1, Respondents point to "the same reasons as discussed in Chen 2010 that screen printing necessarily prints a comb-like metal pattern." RIB at 228. But anticipation requires every claim limitation "in a single prior art reference." *Celeritas Techs., Ltd. v. Rockwell Int'l Corp*., 150 F.3d 1354, 1361 (Fed. Cir. 1998). The reference at issue is Oh 2013; arguments about Chen 2010 are irrelevant to the anticipation question.

Respondents next argue that a "front contact grid" disclosed in Oh 2013 would have been understood by a person of ordinary skill in the art to be referring to a comb-like contact pattern and that a cross-section view of the grid in Oh 2013 looks similar to the Figure 4 of the '331 Patent. RIB at 228 (citing RX-1C.65-67 at Q309-15). That argument lacks merit. Oh 2013 states "a front contract grid 570 may be formed such as by opening an array of slits in the passivating oxide on the front or textured surface side of the wafer." I find, as a factual matter, that the grid formed from slits in Oh 2013 is not a comb-like pattern as required by claim 1. *See Advanced Display Sys., Inc. v. Kent State Univ*., 212 F.3d 1272, 1283 (Fed. Cir. 2000) (whether a single reference describes the claimed invention is a question to be resolved by the factfinder).

Respondents have not presented clear and convincing evidence that Oh 2013 discloses every limitation of claim 1 of the '331 patent "arranged or combined in the same way as in the claim." *Wm. Wrigley Jr. Co. v. Cadbury Adams USA LLC*, 683 F.3d 1356, 1361 (Fed. Cir. 2012). Absent that disclosure, Respondents have not met their burden of proving that claim 1 of the '331 patent is invalid as anticipated by Oh 2013.

4. Oh 2013 (RX-0333) and Tobias 2003 (RX-0331)

For the reasons discussed below, Respondents have shown by clear and convincing evidence that asserted claim 1 of the '331 patent is rendered obvious by Oh 2013 in combination with Tobias 2003.

Figure 5 of Oh 2013 discloses a solar cell with nanostructures in a silicon layer 210 atop a non-nanostructured substrate 110:

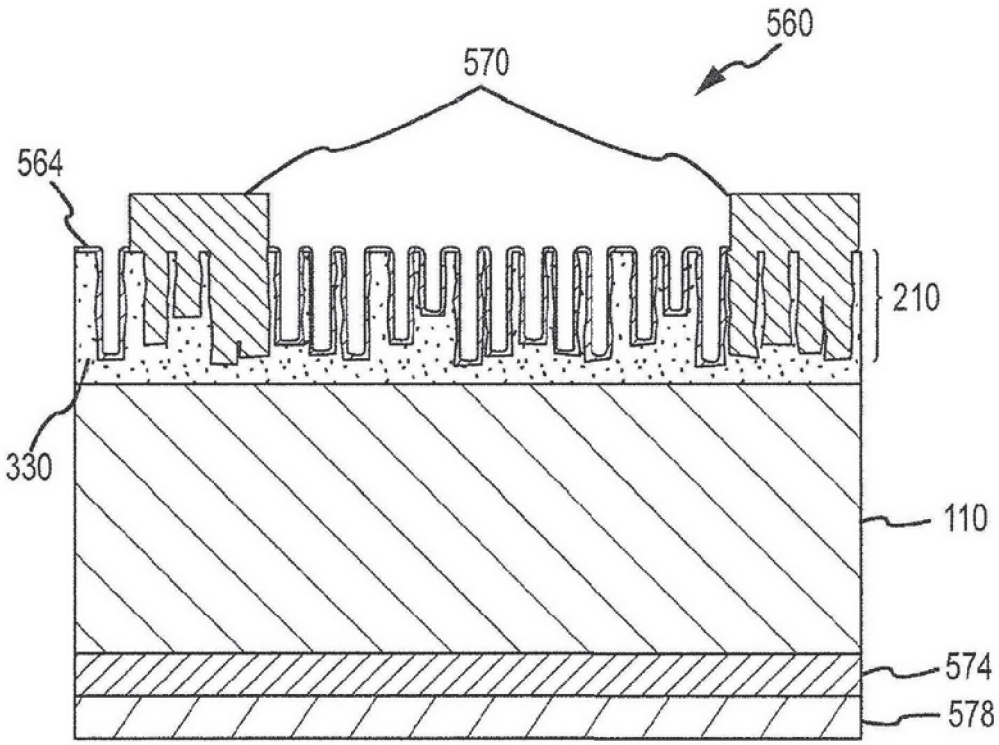


FIG.5

RX-0333 at Fig. 5, ¶¶ 37, 56. The same figure discloses a passivating layer labeled 564. *Id*. at ¶ 56; RX-0001C.67 at Q316. Oh 2013 describes a p-n junction where the n- or p- doped emitter 330 meets an oppositely doped substrate 110, which is shown below the nanostructured area 210

in Figure 5. RX-0333 at Fig. 5, ¶¶ 41, 51, 56. Figure 5 additionally shows metal contacts 570 directly contacting the nanostructured area and states that such contacts may be formed through screen printing. RX-0333 at ¶ 56.

As noted above, Oh 2013 also describes metal contacts 570 "may be formed such as by opening an array of slits in the passivating oxide on the front or textured surface side of the wafer." RX-0333 at ¶ 58. Above I found, as a factual matter, that the grid formed from slits in Oh 2013 is not a comb-like pattern as required by claim 1.

Thus, the record shows Oh 2013 discloses every limitation of claim 1 of the '331 patent except "contacts comprising a comb-like pattern of metal directly contacting the nanostructured area." *See* RX-0001 (Lebby WS) at Q/A 285-325. ASGT's expert Dr. Banerjee did not dispute testimony to that effect. *See* CX-2584C (Banerjee RWS) at Q/A 147-52.

Tobias 2003 expressly discloses a solar cell with screen-printed, comb-like metal contacts atop micron-sized structures. RX-0331.7 (Tobias 2003) (Figure 7.2 (b) illustrates an "industrial cell with screen-printed contacts" having a "metal finger"); *see also id*. at 15 ("square-base pyramids are formed, whose size is adjusted to a few microns"), 32 ("Upright pyramids of 7-µm height can be created"). Tobias 2003 describes using screen printing "to stick a paste containing silver powder to the front face of the wafer in the comblike (fingers plus bus bars) pattern." RX-0331.21 (Tobias 2003). Figure 7.8 of Tobias 2003 (RX-0331.22), reproduced below, shows the comb-like pattern of metal contacts:

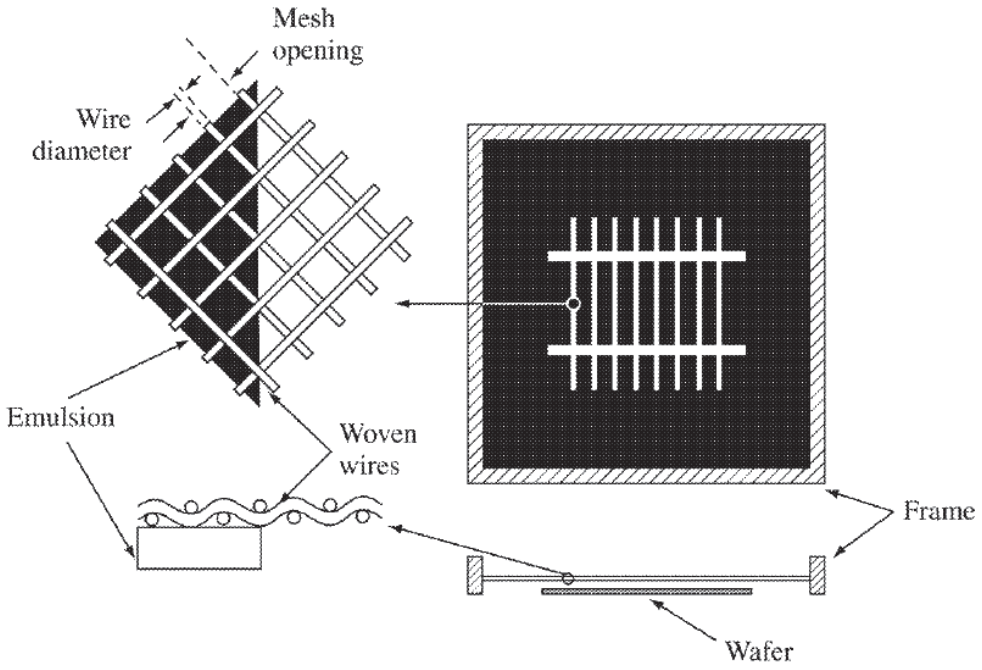


Figure 7.8 A screen for transferring the top contact pattern to a solar cell

RX-0331.22 (Tobias 2003, Figure 7.8).

As noted above in the analysis of the combination of Chen 2010 and Tobias 2003, the Tobias 2003 reference provides an overview of manufacturing processes that were "currently implemented at the industrial level, mostly based on screen-printing metallization." RX-0331 (Tobias 2003) at 2. Tobias 2003 teaches that metal contact screen printing "[w]ith more or less minor modifications" was "used by many manufacturers" at the time. *Id*. at 17. In fact, automatic screen printers were available that were "capable of in-line, continuous operation with high throughput." *Id*. at 20. Tobias 2003 describes a variety of design choices that must be balanced when using screen printing technology. *See, e.g., id*. at 11 ("Screen printing drastically affects the design of the emitter"). At the time of Tobias 2003, the reference noted, "[s]ome ways of incorporating selective emitters to screen-printed cells are being considered, SiN_x appearing very

well suited for surface passivation. This, however, must be accompanied by a decrease in the finger width so that lower sheet resistances are tolerated." *Id*. at 12. Thus, Tobias 2003 teaches that ordinary artisans would have "considered" screen printing with surface passivation using SiN_x at the time of the invention,[32] and would have known factors to balance when considering screen printing. I find those teachings demonstrate that a person of ordinary skill in the art at the time of the invention would have had motivation to use the screen printing pattern of Tobias 2003 to the screen printed metal contact of Oh 2013.

Dr. Lebby provided testimony explaining that Dr. Banerjee misinterpreted the disclosure about screen printing with "irregular" wafers in Tobias 2003 and gave his opinion that nothing in Tobias 2003 suggests an artisan should not use screen printing on nanowires or nanostructures. *See* RX-0001C (Lebby) at Q/A 273, 274, 416. In particular, Dr. Lebby explained that the disclosure about screen printing with "irregular" wafers in Tobias 2013 refers to "very thin wafers that are made by sheet growth of silicon, rather than the conventional wafers disclosed in Chen 2010." *See* RX-0001C (Lebby) at Q/A 416. Moreover, Dr. Banerjee admitted that Tobias 2003 never referred to "irregular" wafers as those containing nanowires, even though nanowires were known, albeit "not discussed in length" at the time of the invention. Tr. (Banerjee) at 909:4-25. In addition, Dr. Lebby testified that Chen 2010 disclosed screen printing on nanowires and nanostructures and, moreover, did not report any difficulty in screen printing on nanowires or nanostructures. *See* RX-0001C (Lebby) at Q/A 273-74.

Additionally, Dr. Lebby testified that there are no secondary consideration factors that

[32] Like this teaching of Tobias 2003, claim 1 of the '331 patent requires "a passivating layer coating the nanostructured area, the passivating layer comprising one of aluminum oxide, silicon dioxide, or silicon nitride."

support non-obviousness. *See* RX-0001C (Lebby RWS) at Q/A 549-73. Dr. Banerjee did not dispute this testimony. *See* CX-2584 (Banerjee RWS) at Q/A 118-38.[33]

I find that the invention described in claim 1 of the '331 patent would have been obvious to a person of ordinary skill in the art at the time. Oh 2013 describes screen-printed metal contacts atop a device having all of the elements of claim 1 except for "a comb-like pattern" for those contacts. Tobias 2003 teaches screen-printed comb-like metal contacts atop a solar cell and confirms that an ordinary artisan at the time would "consider" using such contacts with SiN_x surface passivation. Combining the teachings of Chen 2010 and Tobias, as suggested in the prior art, an ordinary artisan would have arrived at the claimed invention. Respondents have therefore shown by clear and convincing evidence that asserted claim 1 of the '331 patent is invalid as obvious under 35 U.S.C. § 103.

X. INEQUITABLE CONDUCT

Respondents contend that the '331 patent is unenforceable because the inventors committed inequitable conduct at the U.S. Patent and Trademark Office ("Patent Office") when they failed to disclose Oh 2013 (RX-0333) during prosecution of the '331 patent. *See* RIB at 256-60. Staff contends "the evidence does not show that the '331 Patent is unenforceable based on inequitable conduct." SIB at 154; *see id.* at 154-56.

[33] ASGT did not present any evidence of secondary considerations of non-obviousness in its briefs or during the evidentiary hearing. *See* CIB at 32 (citing *TriMed, Inc. v. Stryker Corp.*, 608 F.3d 1333, 1343 (Fed. Cir. 2010) ("We have repeatedly held that evidence of secondary considerations must be considered if present."); *see generally* CIB at 1-264 and CRB at 1-66 (lacking discussion of secondary considerations).

To show inequitable conduct, Respondents must show both intent and materiality, and the showing of intent must be by clear and convincing evidence. *Therasense v. Becton, Dickinson*, 649 F.3d 1276, 1290 (Fed. Cir. 2011).

Respondents assert that, at least as of May 2011, Dr. Marcie Black was provided a confidential copy of Oh 2013 under an NDA with the National Renewable Energy Laboratory ("NREL"), along with other confidential applications. *See id.*; RX-0105C (2011-05-27 Email thread re final Bandgap Engineering NDA); RX-0106C (Wet-Chemical Systems & methods for Producing Black Silicon Substrates); RX-0107C (Forming High-Efficiency Silicon Solar Cells Using Density-Graded Anti-Reflection Surfaces); RX-0108C (Efficient Black Silicon Photovoltaic Devices with Enhanced Blue Response).

Respondents introduced evidence showing that Dr. Black subsequently learned more about the work of the inventors of Oh 2013 at the NREL and actually recognized the import of their work in relationship to the work at her own company Bandgap. *See* RIB at 259; RX-0100C (2011-04-22 Email thread re black silicon); RX-0174C (2009-12-15 Email from Miller to Black); RX-0564C (2010-06-09 Email from Black to Miller & Jura). Further, the evidence shows that Dr. Black sought to license technology from the NREL, including Oh 2013, but elected not to continue to negotiate a license in January 2012, about a month before the provisional application that led to the '331 patent was filed. *See* RIB at 259-60; CX-2405C (Black WS) at Q/A 87, 90-91. No one involved in the prosecution of the '331 patent disclosed Oh 2013 to the examiner.

In rebuttal, Dr. Black stated that she thought that the NREL applications she reviewed "broadly covered the prior art" and were not patentable. CX-2405C (Black WS) at Q/A 91. She could not remember if the inventors had submitted to the Patent Office prior art naming Dr. Howard Branz, who is a co-inventor listed on Oh 2013. *Id*. at Q/A 92. She described her standard

practice when she came across prior art was to "discuss with my prosecution attorneys if the art was relevant to our invention and needed to be included in an IDS." *Id*. at Q/A 83. If she and the attorneys concluded that "the references were relevant to the invention we were trying to patent, then those references would have been included in a disclosure or IDS." *Id*. at Q/A 93.

Respondents apparently did not depose the prosecuting attorneys of the '331 patent to ascertain whether Dr. Black failed to inform them of Oh 2013 or whether they had received a copy of Oh 2013 but did not to submit Oh 2013 to the Patent Office due to negligence or for some other reason.

To meet the clear and convincing evidence standard, Respondents' must show that "the single most reasonable inference able to be drawn from the evidence" is that the inventors intended to deceive the Patent Office. *Therasense*, 649 F.3d at 1290 (quoting Star Scientific Inc. v. R.J. Reynolds Tobacco Co., 537 F.3d 1357, 1365 (Fed. Cir. 2008). The weight of the evidence here does not meet that standard. Although the evidence shows that Dr. Black was aware of Oh 2013 and the similarity of the work of the inventors of Oh 2013 and those at the NREL to her own work at Bandgap, the record would support many possible conclusions as to why Oh 2013 was not disclosed. For example, because Dr. Black generally thought the NREL applications "broadly covered the prior art," she may have considered Oh 2013 to be cumulative of prior art that was disclosed. Additionally, Dr. Black's testimony that she evaluated references for relevance could support a conclusion that the inventors had a subjective belief that Oh 2013 was not relevant to the '331 patent claims. Dr. Black's testimony about her normal practice of submitting relevant prior art could support a conclusion that the inventors provided Oh 2013 to the prosecuting attorney but the attorney failed to submit it to the Patent Office for whatever reason. Further, Dr. Black testified she could not remember whether she included a reference naming Dr. Howard Branz on

an IDS, which leaves open a conclusion that she simply forgot about Oh 2013 during the relevant time. Intentional deception by the inventors is no more likely than any of these other supported conclusions.

Weighing the record evidence as a whole, Respondents have not shown by clear and convincing evidence any specific intent by the inventors listed on the '331 patent to deceive the Patent Office. Without that showing, Respondents have not demonstrated that the '331 patent is unenforceable based on inequitable conduct.

XI. DOMESTIC INDUSTRY (ECONOMIC PRONG)

For a patent-based complaint, a violation of section 337 can be found "only if an industry in the United States, relating to the articles protected by the patent . . . exists or is in the process of being established." 19 U.S.C. § 1337(a)(2). The complainant bears the burden of establishing that the domestic industry requirement is satisfied. *John Mezzalingua Assocs., Inc. v. Int'l Trade Comm'n*, 660 F.3d 1322, 1331 (Fed. Cir. 2011). The domestic industry requirement of section 337 is often described as having an economic prong and a technical prong. *InterDigital Commc'ns, LLC v. Int'l Trade Comm'n*, 707 F.3d 1295, 1298 (Fed. Cir. 2013); *Certain Stringed Musical Instruments and Components Thereof*, Inv. No. 337-TA-586, Comm'n Op. at 12–14, USITC Pub. No. 4120 (Dec. 2009). "The technical prong concerns whether complainant practices at least one claim of the asserted patents. The economic prong concerns domestic activities with respect to the patent or patented article." *Certain Printing and Imaging Devices and Components Thereof*, Inv. No. 337-TA-690, Comm'n Op. at 25, USITC Pub. No. 4289 (Nov. 2011) ("*Certain Printing and Imaging Devices*").

Section 337(a)(3) sets forth the following economic criteria for determining whether the economic prong of the domestic industry requirement is satisfied in such investigations:

> [A]n industry in the United States shall be considered to exist if there is in the United States, with respect to the articles protected by the patent, copyright, trademark, mask work, or design concerned –
>
> (A) significant investment in plant and equipment;
>
> (B) significant employment of labor or capital; or
>
> (C) substantial investment in its exploitation, including engineering, research and development, or licensing.

19 U.S.C. § 1337(a)(3). Given that these criteria are listed in the disjunctive, satisfaction of any one of them will be sufficient to meet the economic prong of the domestic industry requirement. *See Certain Printing and Imaging Devices*, Comm'n Op. at 26.

A. Effect of Invalidity Determinations

Because I find that claim 1 of the '331 patent that Complainant relies upon for its technical prong showing is invalid, *see, e.g., supra* parts IX.C.2 and IX.C.4, I find that the alleged '331 patent LightSense Biosensor is not protected by the '331 patent. *See Certain Child Carriers and Components Thereof, and Products Containing the Same*, Inv. No. 337-TA-1154, Final IDRD (April 7, 2020) (EDIS Doc. ID No. 707158) at 172 ("Because I find the patents are invalid and unenforceable, the patents protect no articles and . . . cannot satisfy the domestic industry requirement"), *not reviewed in pertinent part,* 85 Fed. Reg. 29484 (May. 15, 2020) (EDIS Doc. ID No. 710444). As a result, I find that Complainant cannot satisfy the domestic industry requirement with respect to the '331 patent.

I have further determined that the technical prong of the domestic industry requirement has not been satisfied with respect to the Asserted Patents *supra* parts VI.B, VII.B, VIII.B, and IX.B.

Below I provide findings concerning the economic prong of the domestic industry requirement in the event that the relevant patent claims are not invalid and are practiced by an authorized article.

B. Economic Prong of the Domestic Industry Requirement

Complainant ASGT is relying upon the activities of its licensee ASG to support its' allegations of a domestic industry.

Respondents contend ASGT did not "meet its burden to prove the existence of domestic industry." RIB at 264; *see id.* at 264-79. Staff contends "Complainant has presented evidence demonstrating a domestic industry in existence based on the domestic investments and activities of its licensee, ASG, that are 'significant' under prong (B) and 'substantial' under prong (C) within the meaning of section 337." SIB at 159; *see id.* at 159-65.

Complainant provides the following summary table of expenditures in support of its domestic industry contention:

CIB at 220.

For the reasons that follow, I find that Complainant satisfies the economic prong of the domestic industry requirement.[34]

1. Findings of Fact Relating to the Domestic Industry

The findings of fact below concern the economic prong of the domestic industry requirement.

ASG currently maintains its headquarters in Lowell, Massachusetts. It uses a laboratory at the University of Massachusetts Medical Device Development Center ("Medical Device Development Center") in Lowell, Massachusetts. *See* CX-1173C (ASG Summary NIST Phase I), CX-1199C (Rent Agreement between ASG and UMass, 2017), and CX-2405C (Black WS) at Q/A 170, 177, 179, and 180. ASG also uses the space at the University of Massachusetts Core Research Facilities ("Research Facilities") in Lowell, Massachusetts. Researchers rent the space by the hour in an 11,000 square foot laboratory area which houses highly technical equipment. For example, ASG uses the following equipment within the Research Facilities: (1) CHA Industries electron-beam evaporator to deposit material layers during the fabrication of its biosensor devices, (2) field-emission scanning electron microscope to characterize its biosensor devices, and (3) plasma-enhanced chemical vapor deposition to deposit dielectric materials, such as silicon oxide or silicon nitride. The Medical Device Development Center contains several smaller, more specialized laboratories, and ASG uses two. First, ASG employs the nanofabrication lab for

[34] On May 16, 2022, ASGT filed a "Motion to Strike Argument in Respondents' Post Hearing Brief Under Ground Rule 7.C for Failure to Raise the Issue in Respondents' Pre-Hearing Brief or Pre-Hearing Statement." Motion Docket No. 1271-23. The material ASGT seeks to strike argues against ASGT's assertion that it has met the economic prong of the domestic industry requirement. I have rejected Respondents' arguments on the merits herein, having determined that ASGT satisfied the economic prong of the domestic industry requirement. Accordingly, Motion No. 1271-23 is denied as moot.

"semiconductor processing" activities. Second, ASG employs the materials characterization lab to study and measure nanowire arrays. *See* CX-1166C (ASG Proposal, 2019); CX-1168C (ASG Facilities Summary); CX-1185C (ASG the Research Facilities Invoice, October 2, 2017); CX-1186C (ASG Research Facilities Invoice, December 3, 2018); CX-1187C (ASG Research Facilities Invoice, December 3, 2018); CX-1188C (ASG Facility Invoice, December 3, 2018); and CX-1198C (Research Facilities Service Order, December 11, 2019). ASG's activities at these locations include research, development, testing, and manufacturing nanotextured silicon wafers by ASG's employees. *See e.g.,* CX-2405C (Black WS) at Q/A 170, 177, 179, and 180.

Customers cannot use ASG's single-use LightSense Biosensor silicon chips without the ASG multiple-use LightSense handheld testing system or reader. Tr. (Black) at 103:14-19 ("So our customers will need to buy the silicon chips, but they also need to buy a handheld testing system, and we'll provide them algorithms and software as well to help them interpret the data. But we do need them to buy the handheld testing system because there's really nothing on the market right now that they could use instead of that."); 103:20-104:5; 117:24-118:3. ASGT's expert Dr. Vincent Rotello provided the following high-level overview of ASG's LightSense Biosensor:

> ASG's LightSense™ biosensor is a potentially low-cost, easy-to-use measurement device that is composed of single-use silicon biosensor chips and a handheld reader. The LightSense™ biosensor can be used for the detection and measurement of proteins, nucleic acids, and potentially other biological molecules in solution.
>
> Currently, ASG's LightSense™ biosensor is being developed to detect a certain class of proteins called host cell proteins. Host cell proteins are undesirable by-product contaminants that are produced during the cell-based manufacturing of certain biological therapeutics. ASG's LightSense™ biosensor would be used to determine whether such contaminant is present during manufacturing.

CX-2410C (Rotello WS) at Q/A 25.

Based on the record evidence discussed above, I find that the LightSense handheld chip reader is necessary to exploit the patented technology. The Commission has found investments in articles that do not themselves practice the patent can contribute to the domestic industry where those investments were "central to enabling" exploitation of the article covered by the patented claims. *See, e.g.*, *Certain Magnetic Tape Cartridges and Components Thereof*, Inv. No. 337-TA-1058, Comm'n Op. at 47-57, USITC Pub. No. 4980 (Sept. 2019) (investments in unpatented drives necessary to exploit patented tapes contributed to a domestic industry). Below I analyze ASG's investments that include investments related to the LightSense Biosensor chip as well as the LightSense Biosensor chip reader.

2. Labor and Capital

a. Labor and Capital Investments

I find that Complainant has demonstrated [redacted] in labor and capital expenses with respect to articles protected by the Asserted Patents.

For labor and capital expenses, Complainant's domestic industry investments include salaries and wages for ASG's five employees. Since filing the complaint, ASG has hired two additional employees and is in the process of hiring another. *See* CX-2405C (Black WS) at Q/A 224. From 2017 to 2020, ASG invested $667,519 in domestic labor and capital related to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader.

In the regular course of its business, ASG records costs related to specific projects on its profit and loss statements. These profit and loss statements show that ASG's labor activities primarily relate to engineering, R&D, design, and testing related to the LightSense Biosensor chip and reader. Complainant's economic expert Dr. Bazelon used labor costs recorded on these

documents to confirm the investment proportions attributable to the LightSense Biosensor chip and reader:

CDX-0001C.7: ASG INC. EMPLOYEES DIRECT LABOR CONTRIBUTION TO THE DOMESTIC INDUSTRY PRODUCTS JANUARY 2020-MAY 2021

Employees Dr. Andres Canales and Dr. Nick Bateman both dedicate 100 percent of their time to work related to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader, and Nguyen Le and Celeste Bedard joined those two employees after the complaint was filed in this investigation. *See* CX-1183C (Celeste Bedard Resume), CX-1115 (Nguyen Le Resume), CX-1214C (Celeste Bedard Offer Letter, June 2, 2021), CX-1215C (Nguyen Le Offer Letter, June 25, 2021), CX-1179C (ASG Presentation: Next Generation Biosensors), CX-1219C (ASG Financial Ledger, 2017 to 2021); CX-2405C (Black WS) at Q/A 184.[35] From 2017 to April 2021, ASG incurred various labor expenses including salary and wages, benefits, and outside services/independent contractor services (subcontractor expenses). ASG invested [redacted] in subcontractor-related expenses for activities related to the LightSense Biosensor chip and reader

[35] Although ASG has a Chief Marketing and Sales Officer, Mr. Rever, this role accounts for less than 2 percent of total direct labor hours between May 20, 2019, and December 30, 2019. This role accounts for less than [redacted] percent of total direct labor hours in 2020. Finally, between January 2021 and May 2021, the Chief Marketing and Sales Officer role accounts for less than [redacted] percent of total direct labor hours.

through subcontracting work done with the University of Iowa and subcontracting work with Boston Institute of Biotechnology, LLC. *See* CX-2405C (Black WS) at Q/A 186.

The key documents behind Dr. Bazelon's methodology are ASG's federal income tax returns from 2017 to 2020 (CX-0045C, CX-0047C, CX-0055C, CX-1164C) and its profit and loss statements by customer (CX-1220C (Profit and Loss Statements by Customer 2017-2020)); Tr. (Bazelon) at 365:12-15; CX-2407C (Bazelon WS) at Q/A 78. Dr. Bazelon first determined the total amount of labor and capital investments based on the tax returns, which were reviewed by ASG's accountant and filed with the Internal Revenue Service to generate Rows 1-4 in CDX-0001C.10, reproduced below. He then reviewed ASG's profit and loss statements by customer to determine which investments were related to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader (and which were not) to generate Rows 5-8 in CDX-0001C.10. After subtracting the unrelated investments from the total investments in labor and capital, Dr. Bazelon then applied an allocation ratio (domestic industry investments as a percentage of overall investments) to the difference to derive the investments dedicated to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader. *See* CX-2407C (Bazelon WS) at Q/A 78. Dr. Bazelon testified that his methodology was extremely conservative. Tr. (Bazelon) at 366:19-367:2.

CDX-0001C.10: ASG INC. ALLOCATED DOMESTIC INVESTMENTS IN LABOR & CAPITAL, JANUARY 2017 – APRIL 2021

CDX-000C.10 (Sources: CX-0045C, CX-0048C, CX-0055C, CX-1157, CX-1164C, CX-1219C, CX-1220C.

b. Labor and Capital Investments Are Significant

I find that Complainant's investments of [redacted] in labor and capital expenses with respect to articles protected by the Asserted Patents are qualitatively and quantitatively significant under 19 U.S.C. § 1337(a)(1)(B).

All ASG's activities, including ASG's activities related to the engineering, R&D, design, testing, and manufacture of the ASG LightSense Biosensor chip and the ASG LightSense

Biosensor chip reader, are performed in the United States. *See* CX-1185C (ASG the Research Facilities Invoice, October 2, 2017); CX-1186C (ASG Research Facilities Invoice, December 3, 2018); and CX-1198C (relating to costs for Research Facilities); CX-1199C (Rent Agreement between ASG and UMass); and CX-2405C (Black WS) at Q/A 170. Further, according to Dr. Black, ASG plans to continue making investments in the LightSense Biosensor chip and reader in the United States. *See* CX-2405C (Black WS) at Q/A 227.

As noted above, ASG's labor activities primarily relate to engineering, R&D, design, and testing related to the LightSense Biosensor chip and reader. ASG's domestic industry investments related to the engineering, research, development, and design of the LightSense Biosensor chip and reader are significant when compared to ASG's total investments. ASG's labor and capital investments related to the engineering, research, development, and design of the LightSense Biosensor chip and reader constitute [redacted] percent of ASG's total investments since 2017. The chart below illustrates how that percentage was derived.

CDX-0001.12: ASG INC. SIGNIFICANCE AND SUBSTANTIALITY OF DOMESTIC INVESTMENTS, JANUARY 2017 – APRIL 2021

CX-0037 (ASG 2015 Tax Return), CX-0039 (ASG 2016 Tax Return), CX-0045 (ASG 2017 Tax Return), CX-0047C (ASG 2018 Tax Return) CX-0055 (ASG 2019 Tax Return), CX-1164 (ASG 2020 Tax Return), CX-1194 (ASG Timesheets, May 2019 to December 2019). All these expenses were incurred in the United States.

3. Engineering, Research, and Development

Complainant relies on investments in engineering, research, and development ("ER&D") to show a domestic industry exists with respect to all four Asserted Patents under 19 U.S.C. § 1337(C). The total amount Complainant claims for ER&D from 2017 to 2021 is [redacted]

Under sub-prong (C) of the statute, "the Commission requires that the complainant establish a nexus between the asserted patent and the U.S. investment in its exploitation." *Certain Integrated Circuit Chips & Prod. Containing the Same* ("*Integrated Circuit Chips"*), Inv. No. 337-TA-859, Comm'n Op. at 38, USITC Pub. No. 4849 (Nov. 2018).

a. ER&D Investments in the Domestic Industry Product

Complainant satisfies the economic prong for sub-prong (C) through investments in ER&D in the amount of [redacted] since 2017. The chart below (CDX-0001C.11) illustrates how that amount was derived. *See* CX-2407C (Bazelon WS) at Q/A 106-119. Because all ASG's investments in plant, equipment, labor, and capital are for R&D at the Medical Device Development Center laboratory and the Research Facilities, Dr. Bazelon's analysis of sub-prong (C) combines ASG's sub-prong (A) and (B) investments. *See* CX-2407C (Bazelon WS) at Q/A 106-19.

CDX-0001C.11: ASG INC. ALLOCATED DOMESTIC INVESTMENTS IN R&D JANUARY 2017 – APRIL 2021

CDX-0001C.8; CDX-0001C.10; CX-0045C; CX-0048C; CX-0055C; CX-1164C; CX-1220C; and CX-1219C.

These expenditures bear a nexus to the Asserted Patents because these ER&D activities, are tied to the improvement of various aspects of nanostructures in biosensor chips that are allegedly covered by the claims of the Asserted Patents. *See generally*, CX-1095C (NSF Phase 2B Proposal) (referring throughout to ASG's work on biosensors); *see also* CX-1906 (ASG's Phase 2B presentation to NSF) (referring exclusively to biosensors).

b. ER&D Investments Are Substantial

Where "substantially all of the research and development and engineering for the [domestic industry] was conducted in the United Sates," the industry is "a 'classic case' for the application of subparagraph (C)." *Certain Marine Sonar Imaging Devices, Incl. Downscan & Sidescan Devices, Prods. Containing the Same, & Components Thereof*, Inv. No. 337-TA-921, Comm'n Op. at 65-66 (Jan. 6, 2016) (quoting *InterDigital*, 707 F.3d at 1298-99). As noted above, all ASG's activities, including ASG's activities related to the engineering, R&D, design, testing, and

manufacture of the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader, are performed in the United States. *See* CX-1185C (ASG the Research Facilities Invoice, October 2, 2017); CX-1186C (ASG Research Facilities Invoice, December 3, 2018); and CX-1198C (relating to costs for Research Facilities); CX-1199C (Rent Agreement between ASG and UMass); and CX-2405C (Black WS) at Q/A 170. Further, according to Dr. Black, ASG plans to continue making investments in the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader in the United States. *See* CX-2405C (Black WS) at Q/A 227.

As noted above, ASG's labor activities primarily relate to engineering, R&D, design, and testing related to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader. ASG's domestic industry investments related to the engineering, research, development, and design of the LightSense Biosensor chip and reader are substantial when compared to ASG's total investments. ASG's labor and capital investments related to the engineering, research, development, and design of the LightSense Biosensor chip and reader constitute [redacted] percent of ASG's total investments since 2017. The chart below illustrates how that percentage was derived.

CDX-0001.12: ASG INC. SIGNIFICANCE AND SUBSTANTIALITY OF DOMESTIC INVESTMENTS, JANUARY 2017 – APRIL 2021

CX-0037 (ASG 2015 Tax Return), CX-0039 (ASG 2016 Tax Return), CX-0045 (ASG 2017 Tax Return), CX-0047C (ASG 2018 Tax Return) CX-0055 (ASG 2019 Tax Return), CX-1164 (ASG 2020 Tax Return), CX-1194 (ASG Timesheets, May 2019 to December 2019). All these expenses were incurred in the United States.

Accordingly, I find that Complainant's investment of [redacted] in ER&D related to exploitation of the Asserted Patents is substantial, both qualitatively and quantitatively.

C. Domestic Industry in the Process of Being Established

Complainant contends it has shown "a domestic industry in the process of being established in the United States related to the ASG LightSense Biosensor chip and the ASG LightSense Biosensor chip reader based on its existing efforts to establish a domestic industry and the likelihood that its future efforts will lead to success." CIB at 224.

Because I have determined that Complainant has satisfied the economic prong of the domestic industry requirement, I determine that the question of an industry in the process of being established is moot and I do not address it further.

XII. CONCLUSIONS OF LAW

1. The Commission has subject matter, personal, and *in rem* jurisdiction in this investigation.

2. The importation requirement has been satisfied.

3. Complainant has standing to assert the Asserted Patents.

4. Claims 15, 23, 24, and 27 of the '599 patent have not been shown to be infringed.

5. Claims 1, 13, 23, and 27 of the '981 patent have not been shown to be infringed.

6. Claims 1, 4, and 11-13 of the '640 patent have not been shown to be infringed.

7. Claim 1 of the '331 patent has not been shown to be infringed.

8. Claims 15, 23, 24, and 27 of the '599 patent have not been shown invalid as anticipated by the prior art under 35 U.S.C. § 102(b).

9. Claims 15, 23, 24, and 27 of the ’599 patent have not been shown invalid as obvious in view of the prior art under 35 U.S.C. § 103.

10. Claim 27 of the ’981 patent has been shown invalid as anticipated by the prior art under 35 U.S.C. § 102(b).

11. Claims 1, 13, and 23 of the ’981 patent have not been shown invalid as obvious in view of the prior art under 35 U.S.C. § 103.

12. Claims 1, 13, 23, and 27 of the ’981 patent have not been shown invalid as failing to satisfy the requirements of 35 U.S.C. § 112.

13. Claims 1, 4, and 11-13 of the ’640 patent have not been shown invalid as obvious in view of the prior art under 35 U.S.C. § 103.

14. Claim 1 of the ’331 patent has not been shown invalid as anticipated by the prior art under 35 U.S.C. § 102(b).

15. Claim 1 of the ’331 patent has been shown invalid as obvious in view of the prior art under 35 U.S.C. § 103.

16. Respondents have not demonstrated the ’331 patent is unenforceable based on inequitable conduct.

17. The technical prong of the domestic industry requirement has not been satisfied with respect to the Asserted Patents.

18. The economic prong of the domestic industry requirement has been satisfied with respect to the Asserted Patents if those patents are not invalid and if the ASG LightSense Biosensor chip practices those patents.

XIII. RECOMMENDED DETERMINATION ON REMEDY AND BOND

A. Limited Exclusion Order

The Commission has broad discretion in selecting the form, scope, and extent of the remedy in a section 337 proceeding. *Viscofan, S.A. v. U.S. Int'l Trade Comm'n*, 787 F.2d 544, 548 (Fed. Cir. 1986). A limited exclusion order directed to a respondent's infringing products is among the remedies that the Commission may impose. *See* 19 U.S.C. § 1337(d).

Because I have determined that there has been no violation of section 337, I recommend the Commission not issue a limited exclusion order.

Should the Commission determine that a violation did occur, I recommend entry of a limited exclusion order against the Respondents that would bar importation of infringing articles.

I recommend the inclusion of a certification provision in any exclusion order entered in this investigation. *See* CRB at 64 (certification provision is appropriate); RIB at 293 (certification provision is appropriate). The certification provision will reduce the burden of U.S. Customs in enforcing the exclusion order.

Respondents contend "[a]ny LEO should also include an explicit carve-out for non-infringing products," and "any LEO should be limited to the ***accused polycrystalline products*** and should specifically exclude any of Respondents' non-infringing monocrystalline products." RIB at 293, 295 (emphasis in original).

I do not recommend that the Commission include Respondents' request for a carve out for products supposedly falling outside of the scope of this investigation. The standard language in exclusion orders effectuates the result Respondents seek by excluding only articles that infringe except under license or authority of the patent holder, or with the permission of the patent owner.

See Certain Electric Skin Care Devices, Brushes and Charges Therefor, and Kits Containing the Same, Inv. No. 337-TA-959, Comm'n Op. at 19 (Feb. 13, 2017) (EDIS Doc. ID No. 603444).

B. Cease and Desist Order

Section 337 provides that in addition to, or in lieu of, the issuance of an exclusion order, the Commission may issue a cease and desist order as a remedy for a violation of section 337. 19 U.S.C. § 1337(f)(1). The Commission may issue a cease and desist order when it has personal jurisdiction over the party against whom the order is directed. *Gamut Trading Co. v. U.S. Int'l Trade Comm'n*, 200 F.3d 775, 784 (Fed. Cir. 1999).

Under Commission precedent, "[c]ease and desist orders are generally issued when, with respect to the imported infringing products, respondents maintain commercially significant inventories in the United States or have significant domestic operations that could undercut the remedy provided by an exclusion order." *Certain Air Mattress Systems, Components Thereof, and Methods of Using the Same*, Inv. No. 337-TA-971, Comm'n Op. at 49 (May 17, 2017) (citations and footnote omitted).

Because I find there has been no violation, I do not recommend entry of a cease and desist order. In the alternative, however, I make the following recommendation.

With respect to the Canadian Solar Respondents, the evidence shows that respondent Recurrent Energy SH Proco LLC maintained, on June 1, 2021, and September 1, 2021, [redacted] units of Canadian Solar Accused Products in inventory in the United States. *See* JX-0019 (Stipulation Re Canadian Solar Importation and Inventory). According to calculations performed by Dr. Bazelon, this inventory represents approximately [redacted] megawatts. Given this amount of inventory, a cease and desist order would be appropriate in the event a violation is found.

The evidence shows that the Hanwha Respondents maintained, in August 2021, [redacted] megawatts of inventory of Hanwha Accused Products in the United States. *See* RX-0680C (Hanwha Inventory August 2021); Tr. (Bazelon) at 359:5-7; RX-0598C (Schoettelkotte WS) at Q/A 91. Considering this amount of inventory, a cease and desist order against the Hanwha Respondents is unnecessary and therefore I do not recommend one.

The evidence shows that the Boviet Respondents maintained, on July 31, 2021, [redacted] units of Accused Products (value: [redacted]) and on November 15, 2021, [redacted] units of Boviet Accused Products (value: $[redacted]) in inventory in the United States. *See* JX-0021 (Stipulation Re Boviet Importation and Inventory). According to calculations performed by Dr. Bazelon, the Boviet Respondents held in inventory in the United States on July 31, 2021, and November 15, 2021, [redacted] megawatts of Boviet Accused Products, which is equivalent to less than [redacted]% of one month of Boviet's sales. *See* CX-2407C (Bazelon WS) at Q/A at 198, 202, 203. Considering this amount of inventory (and that the Boviet Respondents stopped producing the Boviet Accused Products in March 2019 and have ceased selling the Boviet Accused Products), a cease and desist order against the Boviet Respondents is unnecessary and therefore I do not recommend one.

C. Bond During Presidential Review

Pursuant to section 337(j)(3), the administrative law judge and the Commission must determine the amount of bond to be required of a respondent during the 60-day Presidential review period following the issuance of permanent relief. The purpose of the bond is to protect the complainant from any injury. 19 U.S.C. § 1337(j)(3); 19 C.F.R. §§ 210.42(a)(1)(ii), 210.50(a)(3).

In this investigation, Complainant does not seek a bond. *See* Joint Outline at 7; CIB at 248-60; CRB at 62-65. Thus, should the Commission determine to enter a remedy, no bond should be entered.

XIV. INITIAL DETERMINATION ON VIOLATION

For the reasons set forth herein, it is my initial determination that no violation of section 337 of the Tariff Act, as amended, has occurred in the importation into the United States and the sale within the United States after importation of certain silicon photovoltaic cells and modules with nanostructures and products containing the same based on infringement of U.S. Patent No. 8,450,599 ("the '599 patent"); U.S. Patent No. 8,852,981 ("the '981 patent"); U.S. Patent No. 9,601,640 ("the '640 patent"); and U.S. Patent No. 9,768,331 ("the '331 patent").

I hereby certify to the Commission this initial determination and the recommended determination. The Secretary shall serve the confidential version of this initial determination upon counsel who are signatories to the Protective Order (Order No. 1) issued in this investigation. A public version will be served at a later date upon all parties of record.

Pursuant to 19 C.F.R. § 210.42(h), this initial determination shall become the determination of the Commission unless a party files a petition for review pursuant to 19 C.F.R. § 210.43(a) or the Commission, pursuant to 19 C.F.R. § 210.44, orders on its own motion a review of the initial determination or certain issues therein.

XV. ORDER

Within seven days of the date of this document, the parties shall jointly submit a single proposed public version with any proposed redactions indicated in red. If the parties submit excessive redactions, they may be required to provide declarations from individuals with personal knowledge, justifying each proposed redaction and specifically explaining why the information sought to be redacted meets the definition for confidential business information set forth in 19 C.F.R. § 201.6(a). To the extent possible, the proposed redactions should be made electronically, in a single PDF file using the "Redact Tool" within Adobe Acrobat. The proposed

redactions should be submitted as "marked" but not yet "applied." The proposed redactions should be submitted via email to Cheney337@usitc.gov and not filed on EDIS.

All pending motions not otherwise disposed of in this order are denied as moot.

SO ORDERED.

Clark S. Cheney
Chief Administrative Law Judge