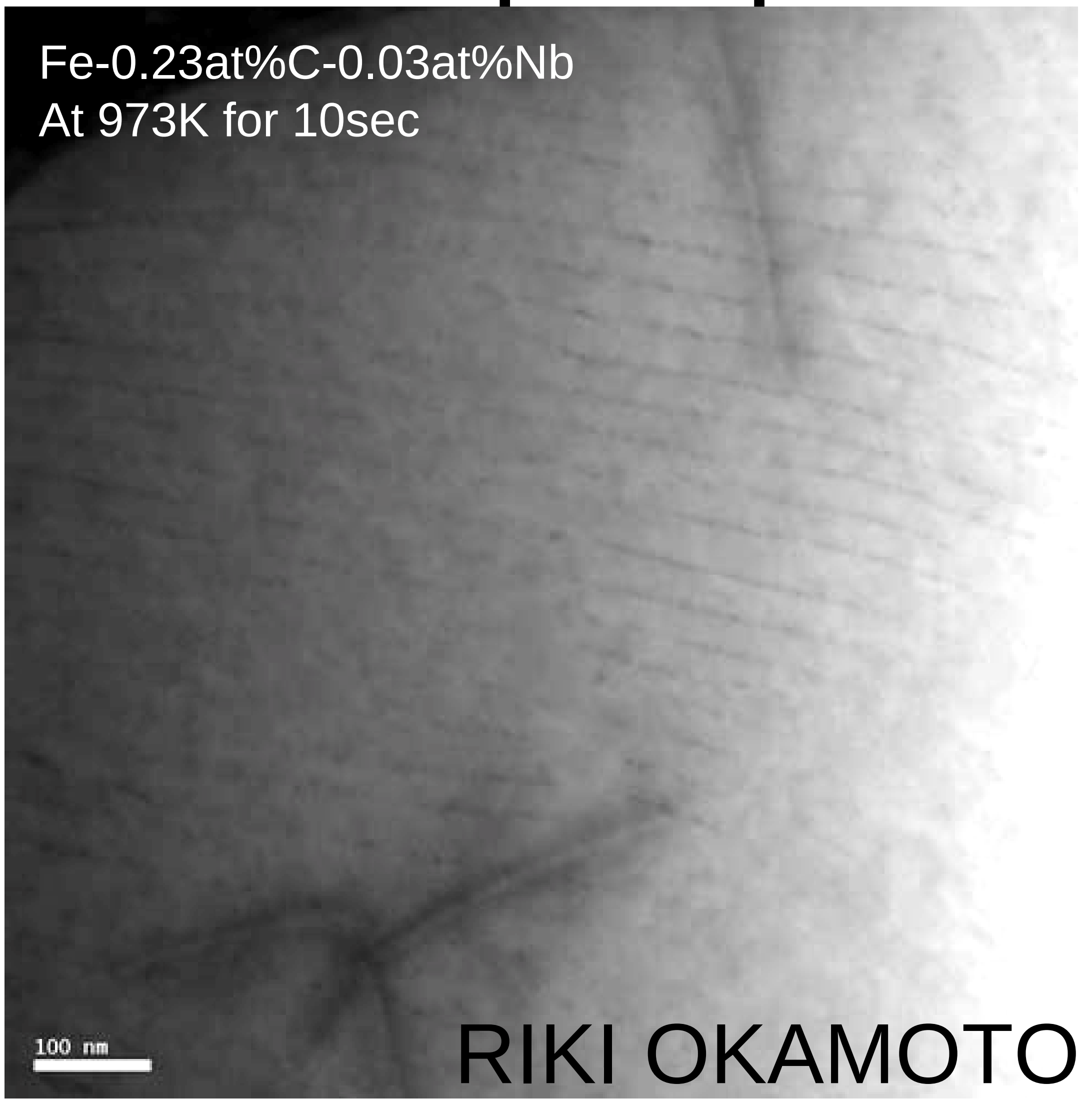
Interface precipitation



RIKI OKAMOTO

KTH VETENSKAP OCH KONST

Basic facts

Interface precipitation (By R.W.K. Honeycombe)
This type of precipitation occurs normally in bands which can be planar or irregularly curved and has been shown to form periodically at the α/γ interface during the phase transformation.

Occurance

Element	V	Nb	Ti	Mo	Cr	W
Alloy Carbide	V(CN)	NbC	TiC	Mo_2C	$Cr_{23}C_6$ Cr_7C_3	W_6C

Microstructure

1. Planar interface precipitation
2. Non-planar interface precipitation
3. Fibrous carbide
4. Dislocated ferrite (Wrinkled ferrite)

} competing microstructure (items 3–4)

Microstructures

Planar interface precipitation

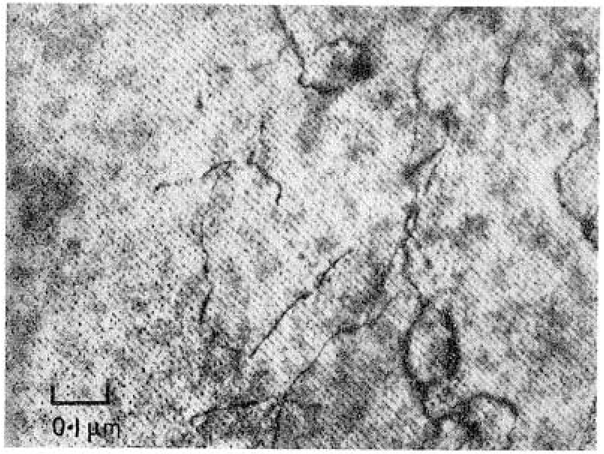
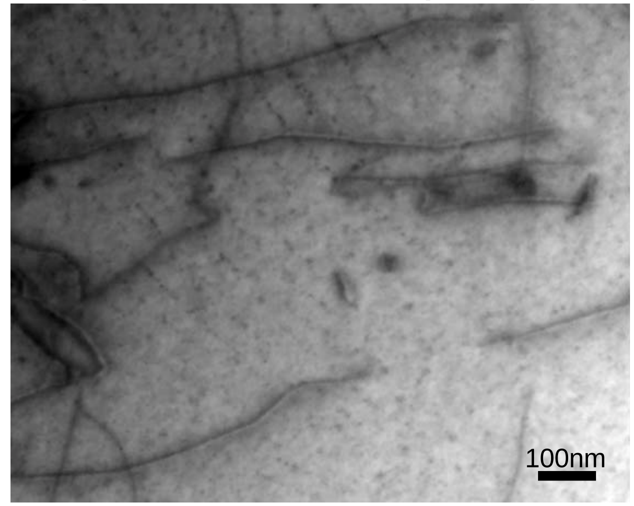


Fig. 1 An iron–0·75%V–0·15%C alloy, isothermally transformed 5 min at (a) 825° C and (b) 725° C. Thin-foil E.M.

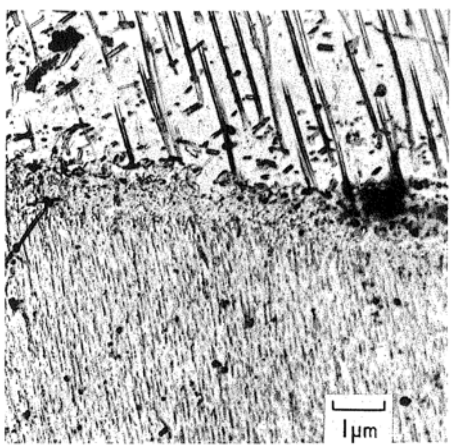
A.D.Batte et.al: Met. Sci. J., 7, (1973), 160.

Non-planar interface precipitation



Present work, Fe-0.23at%C-0.03at%Nb at 923K for 10sec

Fibrous carbide



Coarse fibrous

fine fibrous

Fig. 15—Fe-4Mo-0.2C. Transformation at 850°C then 750°C. Transition from coarse to fine fibrous Mo_2C. Extraction replica EM. Magnification 10,000 times. (Barbacki)[35]

R.W.K.Honeycombe: Metal. Trans. A, 7A, (1976), 915.

Dislocated ferrite

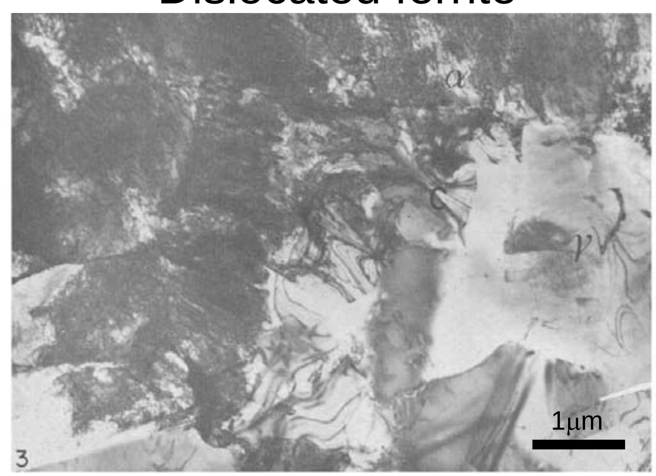


Fig. 3. Dislocated ferrite and cementite, growing into austenite. 1 h at 540°C (x 16,000).

G.R.Purdy: Acta Metall., 26, (1978), 487.

Close correlation with interface precipitation and fibrous carbides

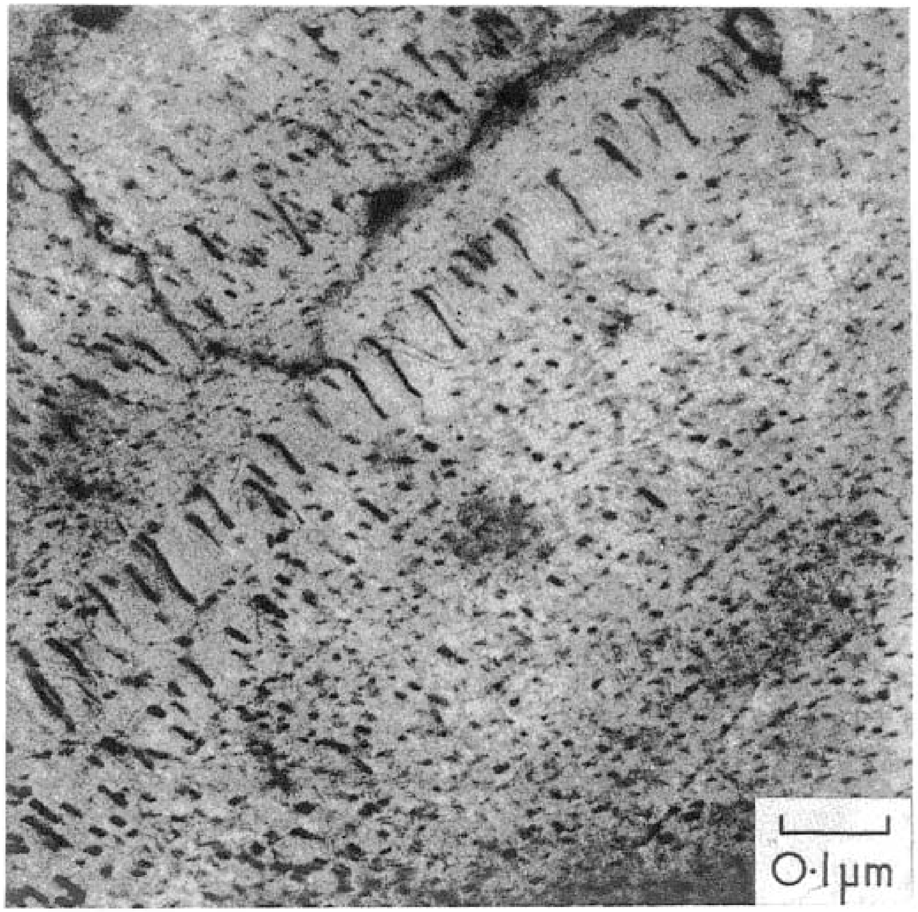


Fig. 17—Transition from interphase to fibrous vanadium carbide growth in an isothermally transformed vanadium steel. Thin foil EM. (Batte)[29]

R.W.K.Honeycombe:
Metal. Trans. A, 7A, (1976), 915.

Close correlation with fibrous carbides and dislocated ferrite

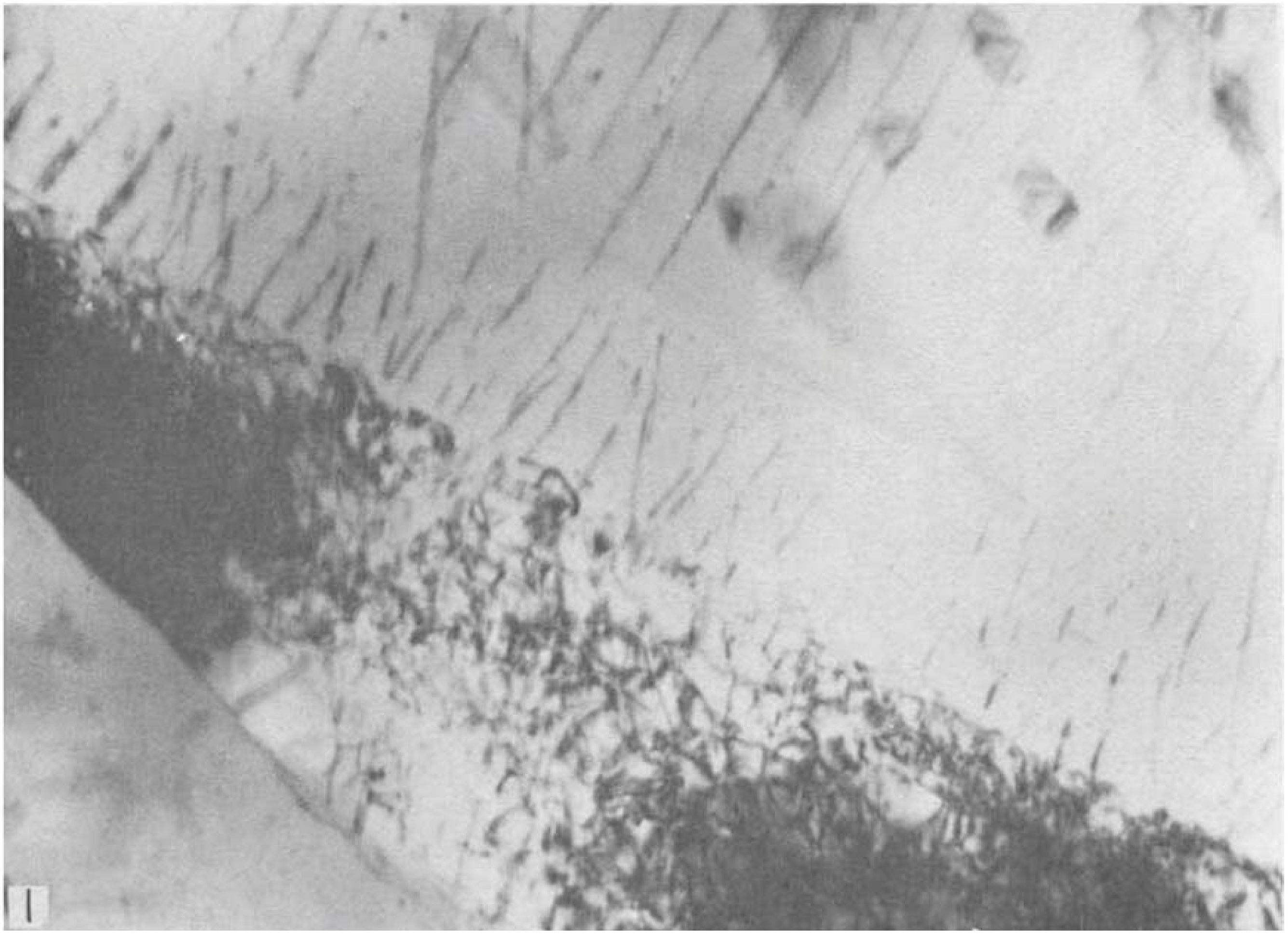


Fig. 1. Fibrous carbides and dislocated ferrite. Observed in a foil transformed for 30 min at 630°C (× 55,000)

G.R.Purdy:
Acta Metall., 26, (1978), 487.

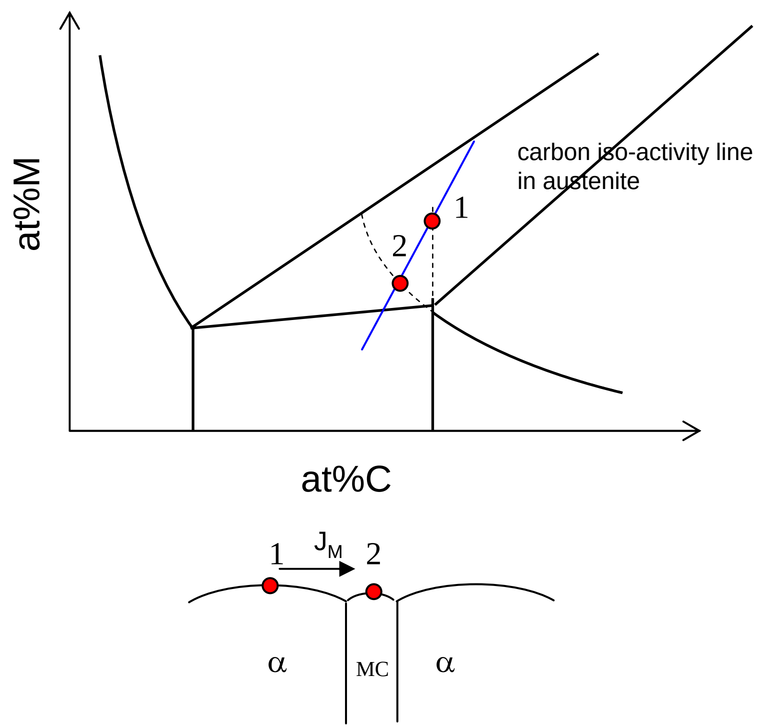
What is the mechanism?

- How does each phenomenon grow?
  - Sub mechanism for each phenomenon
    - Ledge model for planar interface precipitation
      (Lagneborg's mechanism)
    - Eutectoid mechanism for fibrous carbide
    - etc…
- How does competition take place(mixture)?
  - Competitive Carbide Morphologies

Can fibrous carbide be described as an eutectoid formation?

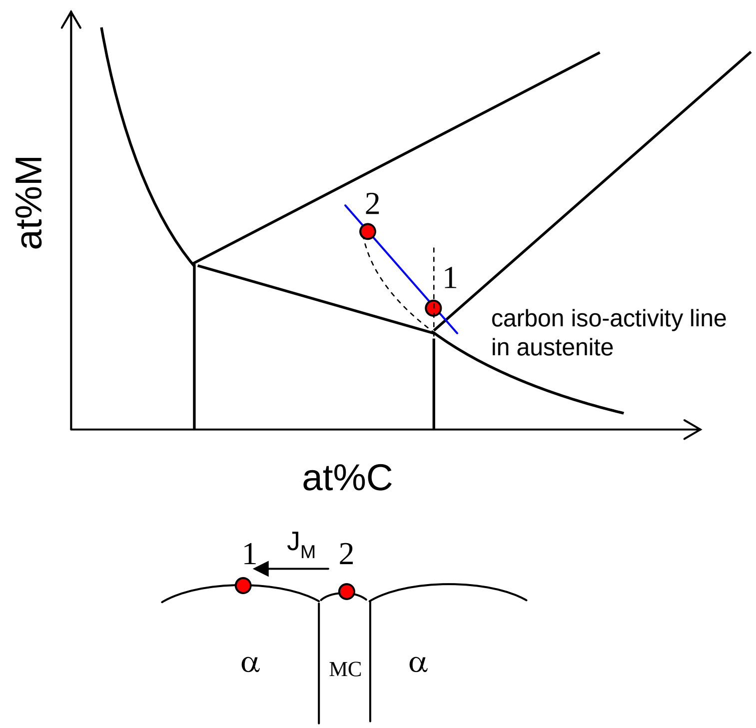
My image of eutectoid by each stabilizer

<u>Austenite stabilizer</u>



Possible

<u>Ferrite stabilizer</u>

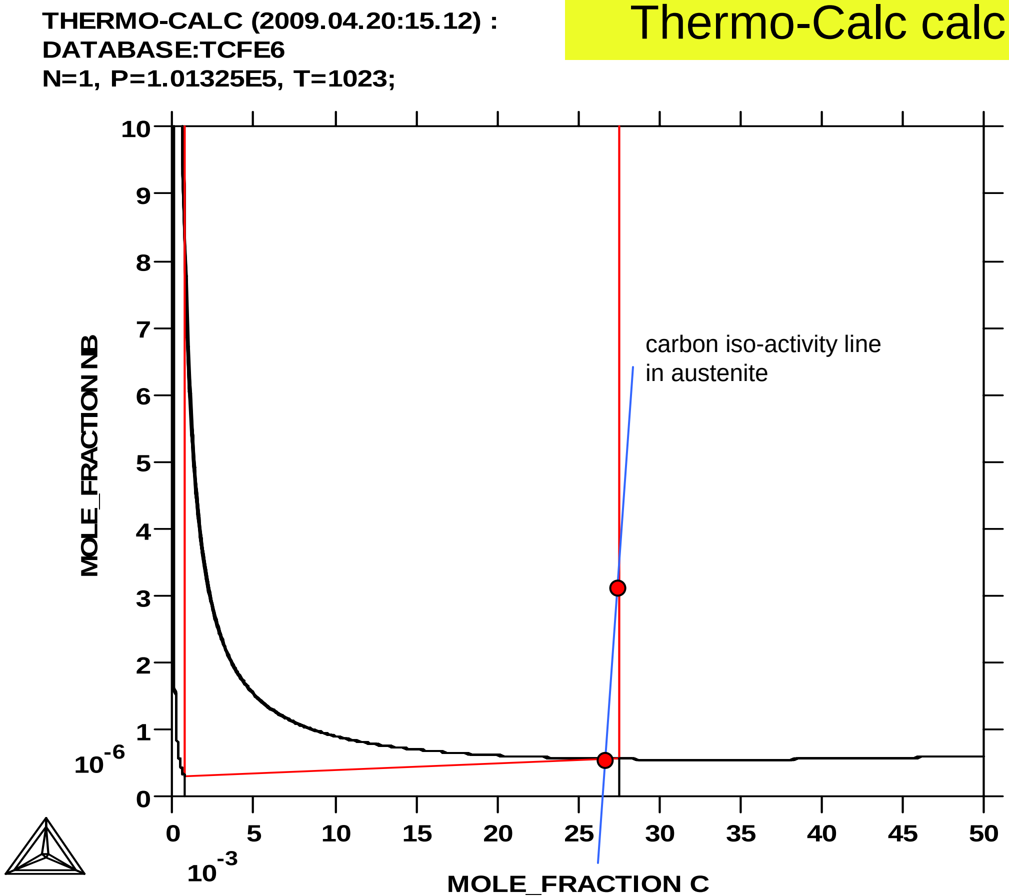


Impossible

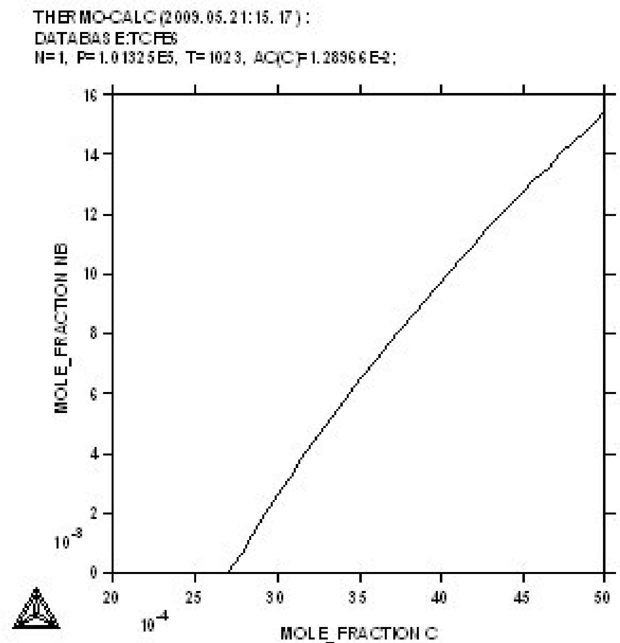
If these image are right, eutectoid can not describe the fibrous carbide, since it has not been observed in system with γ stabilizing elements.

Carbide forming α stabilizer

Thermo-Calc calculation at 750°C



Fe-Nb-C diagram



Carbon iso-activity line

Eutectoid can describe the fibrous carbide by carbide forming α stabilizer at 750°C.

Ledge Model for planar interface precipitation

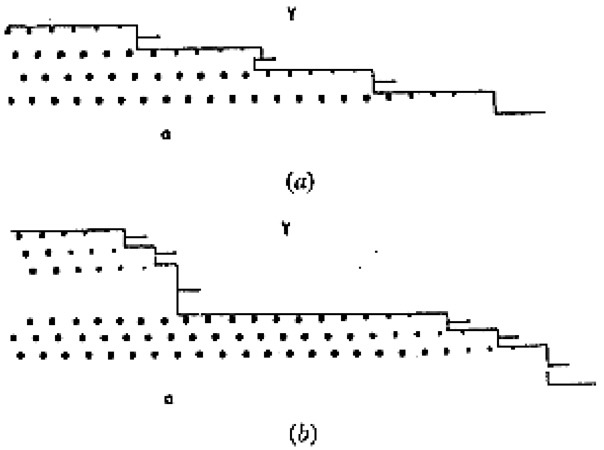
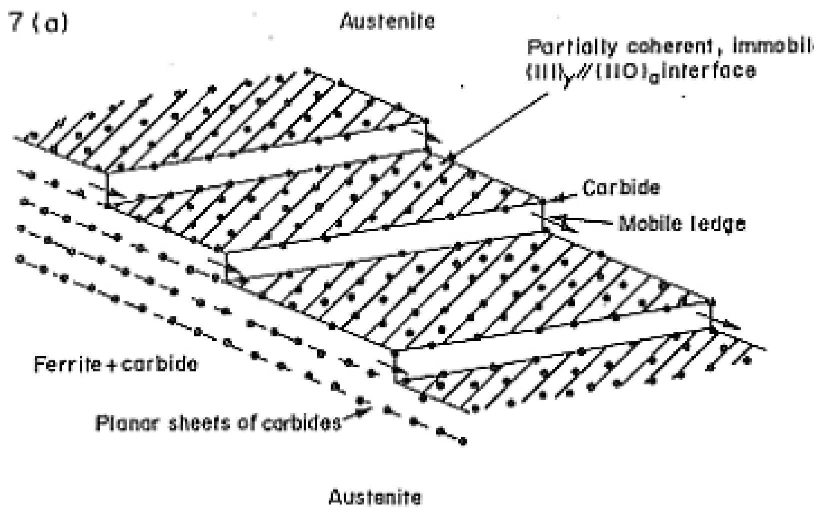


Fig. 1—Schematic representation of the mechanism of nucleation and growth of carbides on the γ/α interface:[8] (a) regular ledge heights, (b) irregular ledge heights.



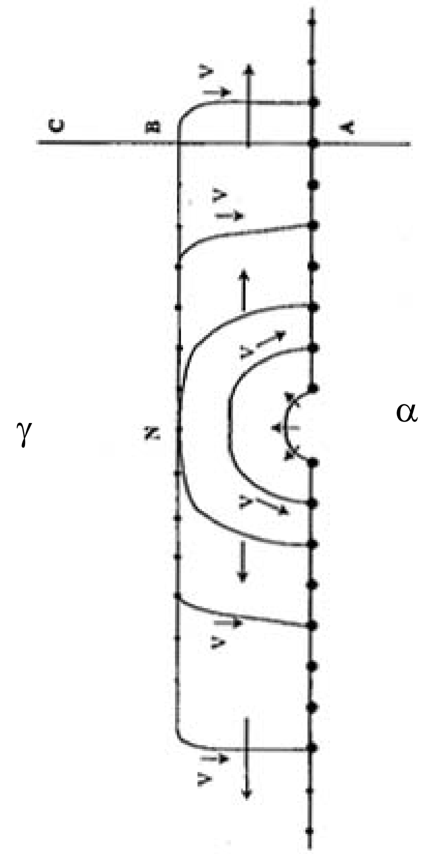
<u>Character of ledge model</u>

Space of precipitation row: regular (sometimes irregular)

Shape of precipitation row: straight (planar)

Precipitation plane: Lowest energy boundary: (011)α

Lagneborg's Mechanism for ledge model (planar interface precipitation)



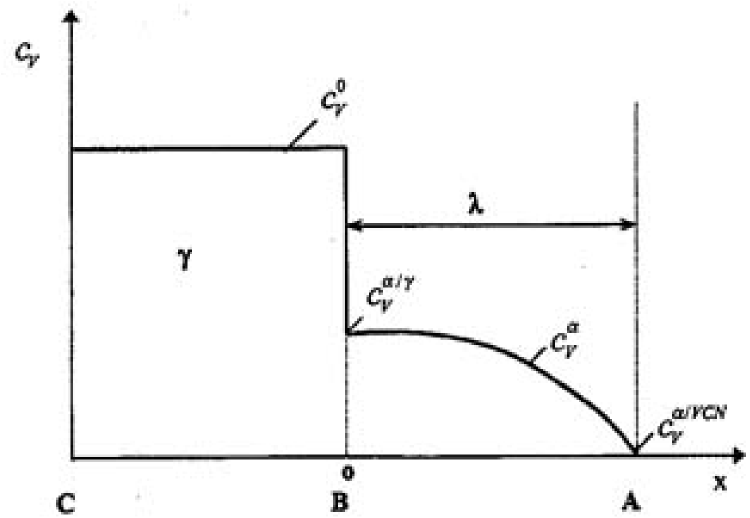


Fig. 9—Top figure shows schematically how the γ/α interface bows out, expands sideways, and eventually reaches material with sufficient V for renewed precipitate nucleation to occur. The transfer of V boundary diffusion to the lower precipitate row is indicated. The lower figure shows the V-content profile in a cross section.

<u>His assumption</u>

$D_M^{\text{semi-coherent}} << D_M^{\text{incoherent}}$

R.Lagneborg:
Metal. Trans. A, 32A, (2001), 39.

Precipitation Plane (our results)

- There is no precipitate on (011)α

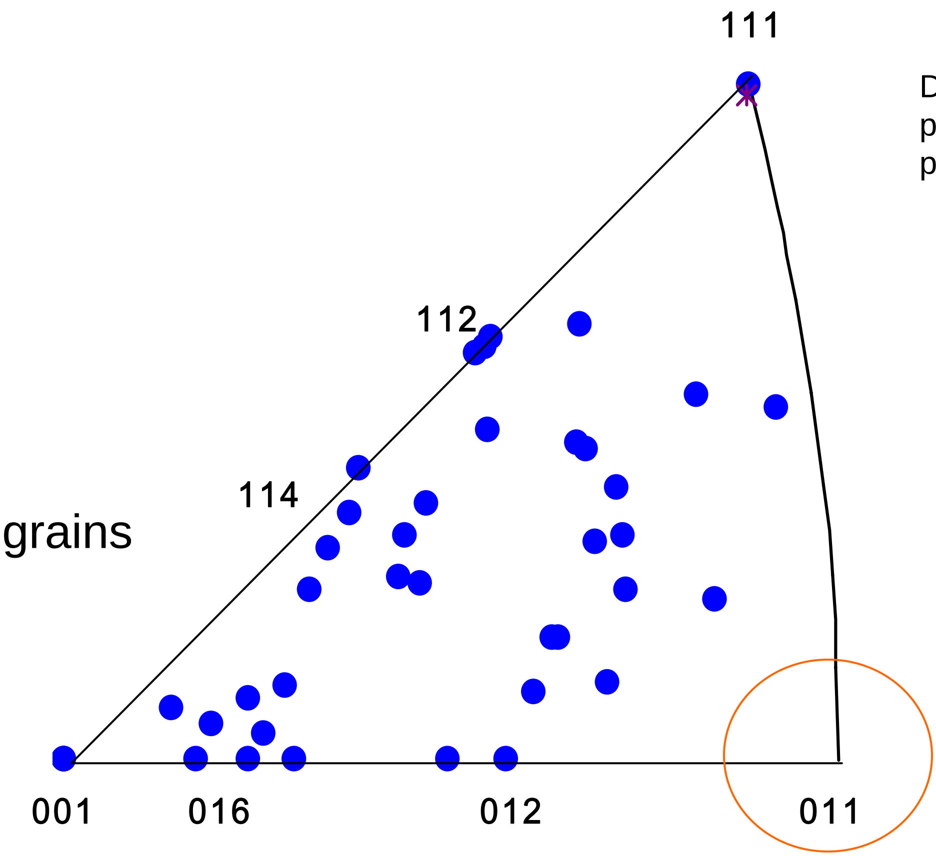
Assumption: The precipitation plane (PP) is perpendicular to the observation plane(OP)

PP ⊥ OP

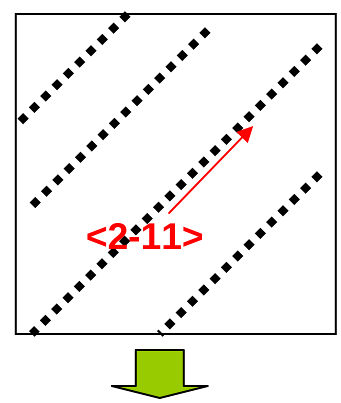
Direction of the precipitation rows(DPR) is perpendicular to the normal to precipitation plane(NPP).

DPR ⊥ NPP

total 56 grains



ex. Observation plane **(1-1-3)**

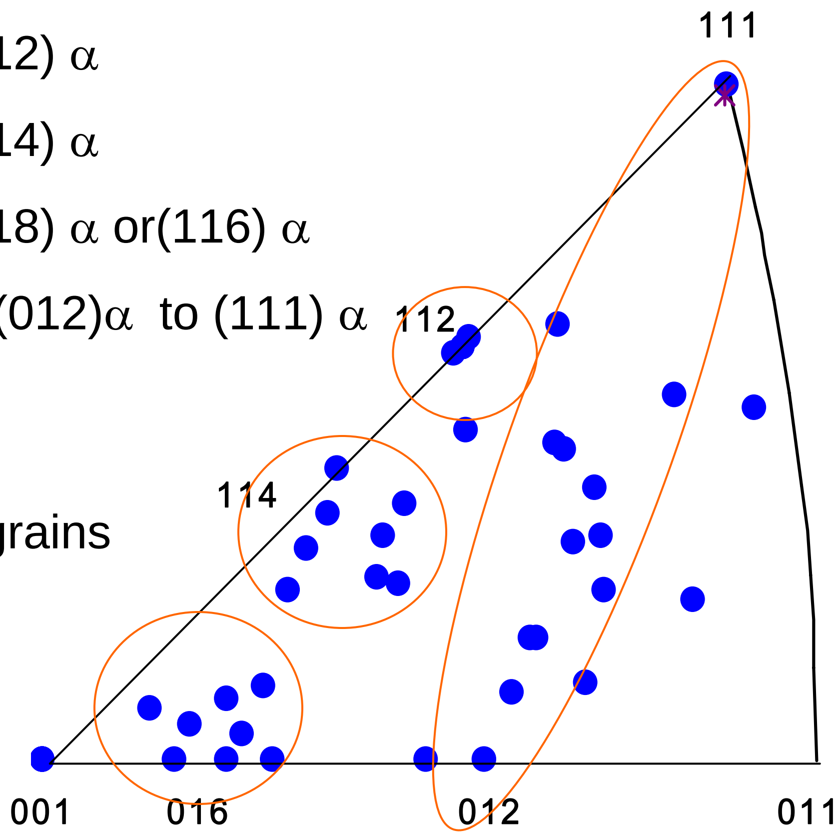


Precipitation plane **(-4-71)**

Precipitation Plane (our results)

- There is no precipitate on (011)α and it is not random.
- around(112) α
- around(114) α
- around(118) α or(116) α
- line from (012)α to (111) α

total 56 grains



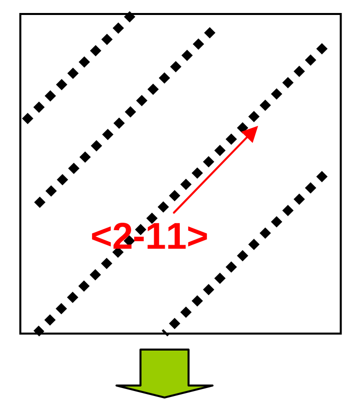
Assumption: The precipitation plane (PP) is perpendicular to the observation plane(OP)

PP $\perp$ OP

Direction of the precipitation rows(DPR) is perpendicular to the normal to precipitation plane(NPP).

DPR $\perp$ NPP

ex. Observation plane **(1-1-3)**



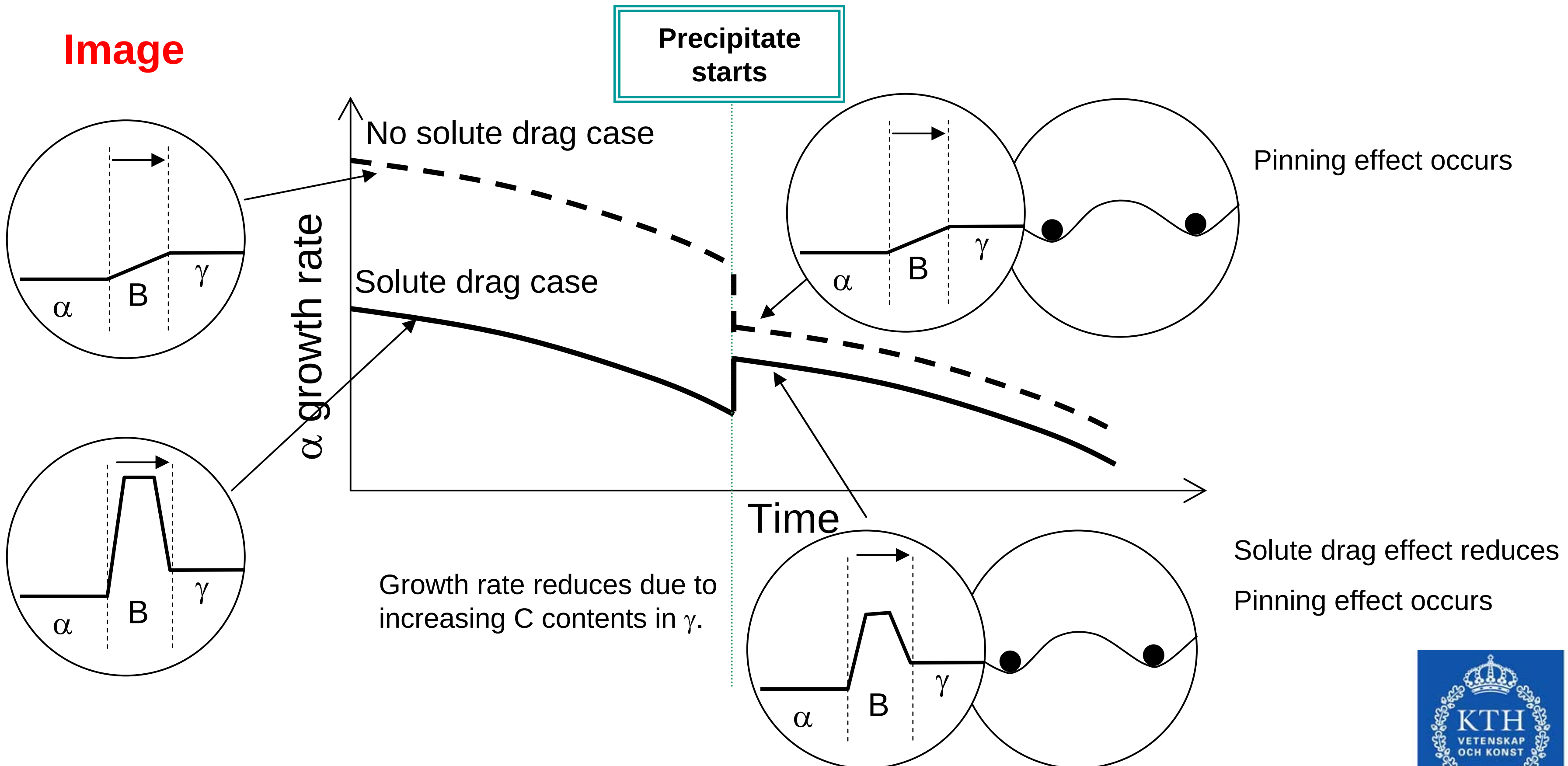
Precipitation plane **(-4-71)**

Our all results disagree “Ledge model”.
Precipitations aren’t on lowest energy boundaries.

Solute drag effect

If there is a solute drag effect, the formation of carbides will increase the α growth rate .

Image



Questions for discussion

- What is the mechanism?
  - How does each phenomenon grow?
    - Is eutectoid transformation reasonable for fibrous carbide?
    - Are there sub-models for interface precipitation instead of ledge model?
    - Are there sub-mechanisms for other phenomena?
  - does competition take place (mixture)?
  - Is there a solute drag effect?

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