C- Mats and their Applications

Materials and Electrochemical Research (MER) Corporation

Tucson, Arizona

Dr. R. O. LOUTFY

MER HISTORY

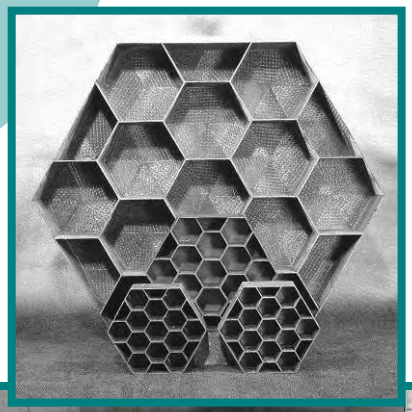
- MER is a private Arizona Corporation started in 1985 by Drs. R.O.Loutfy and J.C.Withers.
- 1986, MER joint ventured with Montedison and sold interest in mid 1988.
- 1999, 2004, 2005 MER joint ventured with Mitsubishi and formed three spin-off companies to commercialize Nanocarbon materials
- MER has received
  - Six R&D 100 Awards
  - National Tibbetts awards in 1998 and 2001
  - Arizona Innovation Network award as "Innovator Company of the Year" and "Innovator of the Year" for fullerene production.

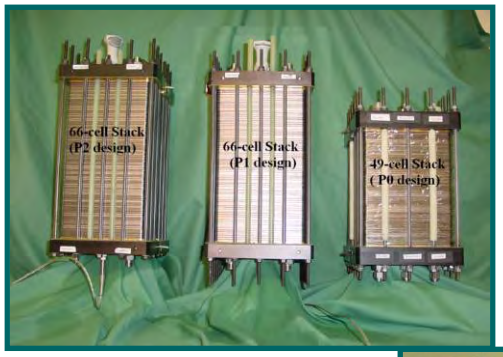
Dr. J.C.Withers

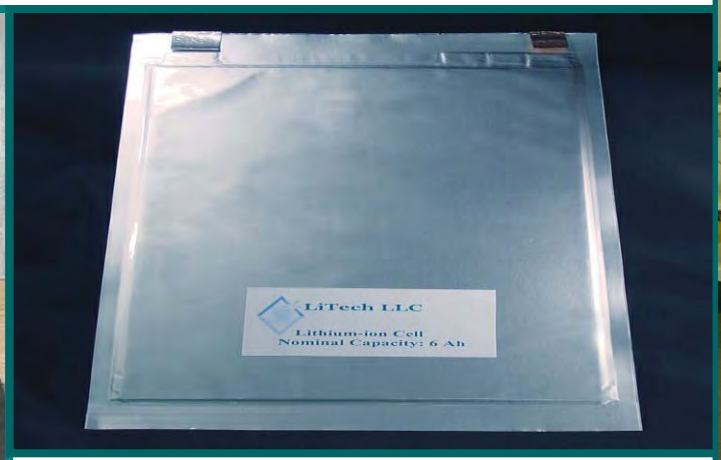
Dr. R.O.Loutfy

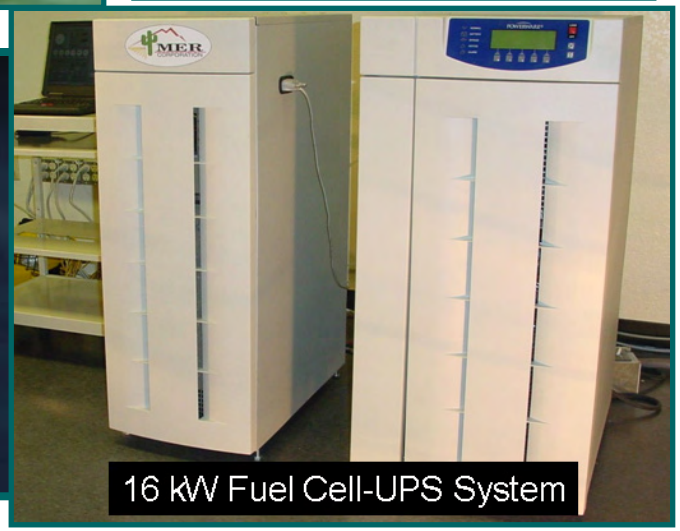
MER CORPORATION

- About 70 people and about half (~30) are Ph.D.'s
- Focused on – Engineering and Demonstration of M&E Technologies









MER NanoTube Company Background

- TMC started in 2004 as a JV between
  - Materials & Electrochemical Research.
  - FIC Corporation, and
  - NanoTech Partners (a private VC fund financed by Mitsubishi Companies).
- TMC received funds and licenses on various methods for making Double-Walled Carbon Nanotubes (DWNT).
- MER bought out TMC partners in 2007.

Carbon Nanotubes

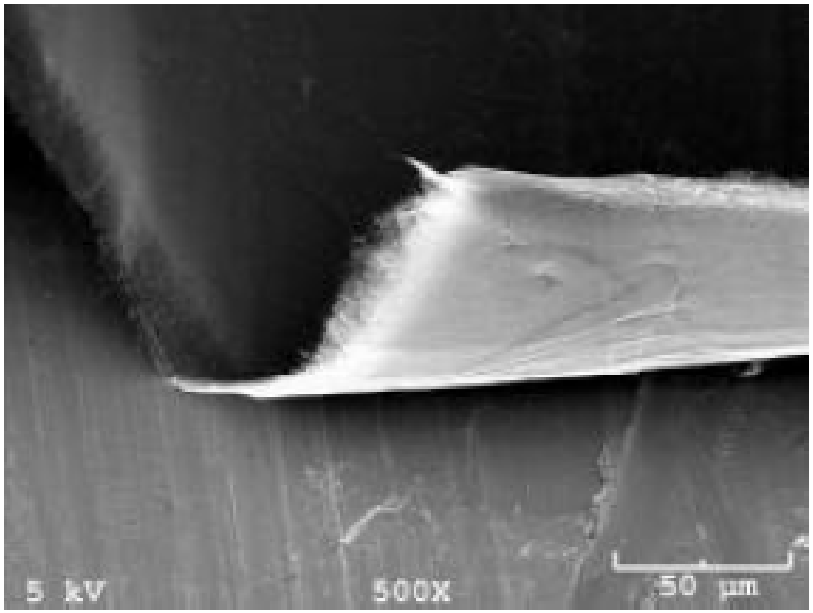
- Carbon nanotubes are the superstars of the Nano-materials world.
  - They are stronger, lighter, stiffer than other materials.
  - They conduct electricity and heat better than other materials.
  - They cold emit electrons at high current density, etc etc..
- But they are difficult to produce, handle and process into final products.

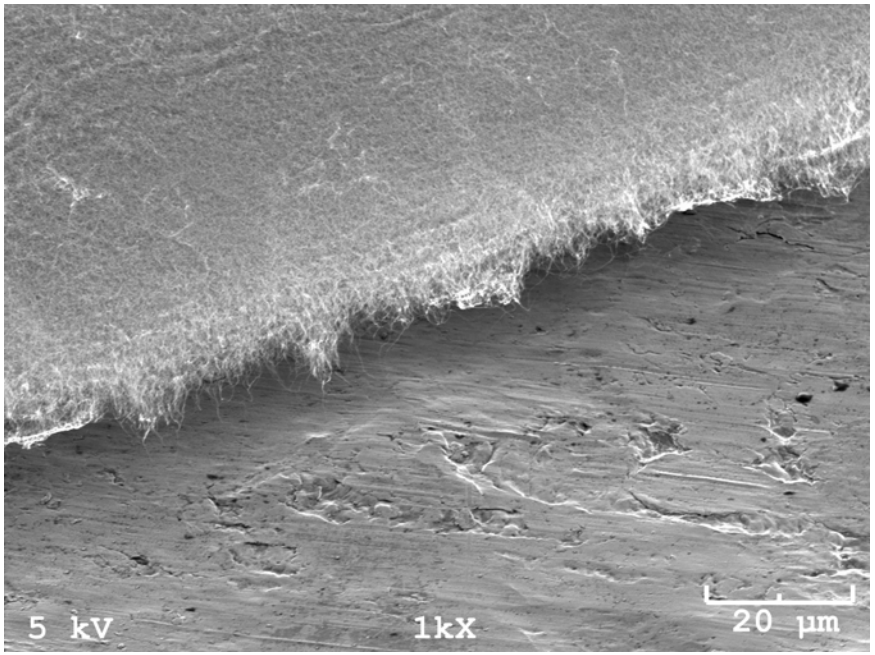
MER's *C*-Mats

- TMC has developed a powerful new solution to easily integrate nanotubes into high-value applications.
- This allows us to sell CNT by area not by weight.
- We can go directly from the reactor to a material that has direct applications - and without further processing.
- We call this material ***C*-Mat**.
- And here's a picture:

MER’s C-Mats

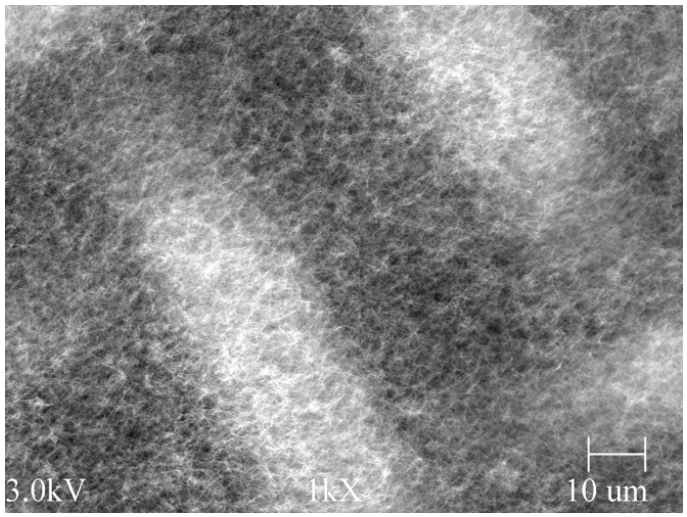
C-Mats

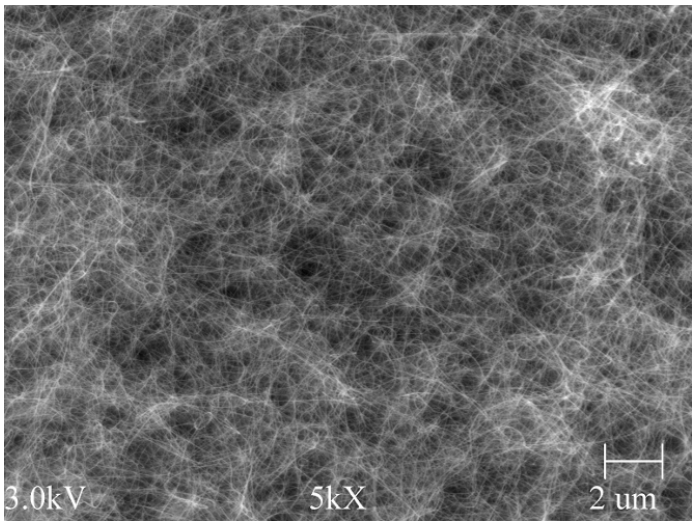


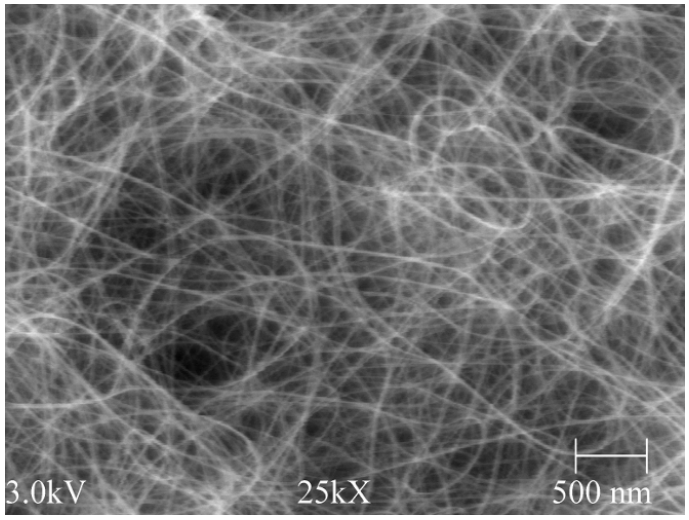


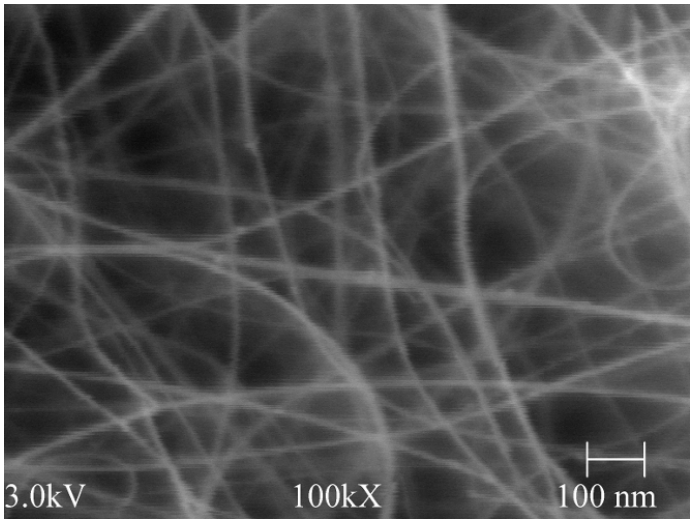
- C-mats are non-woven fabrics.

SEM OF AS-PRODUCED C-Mat

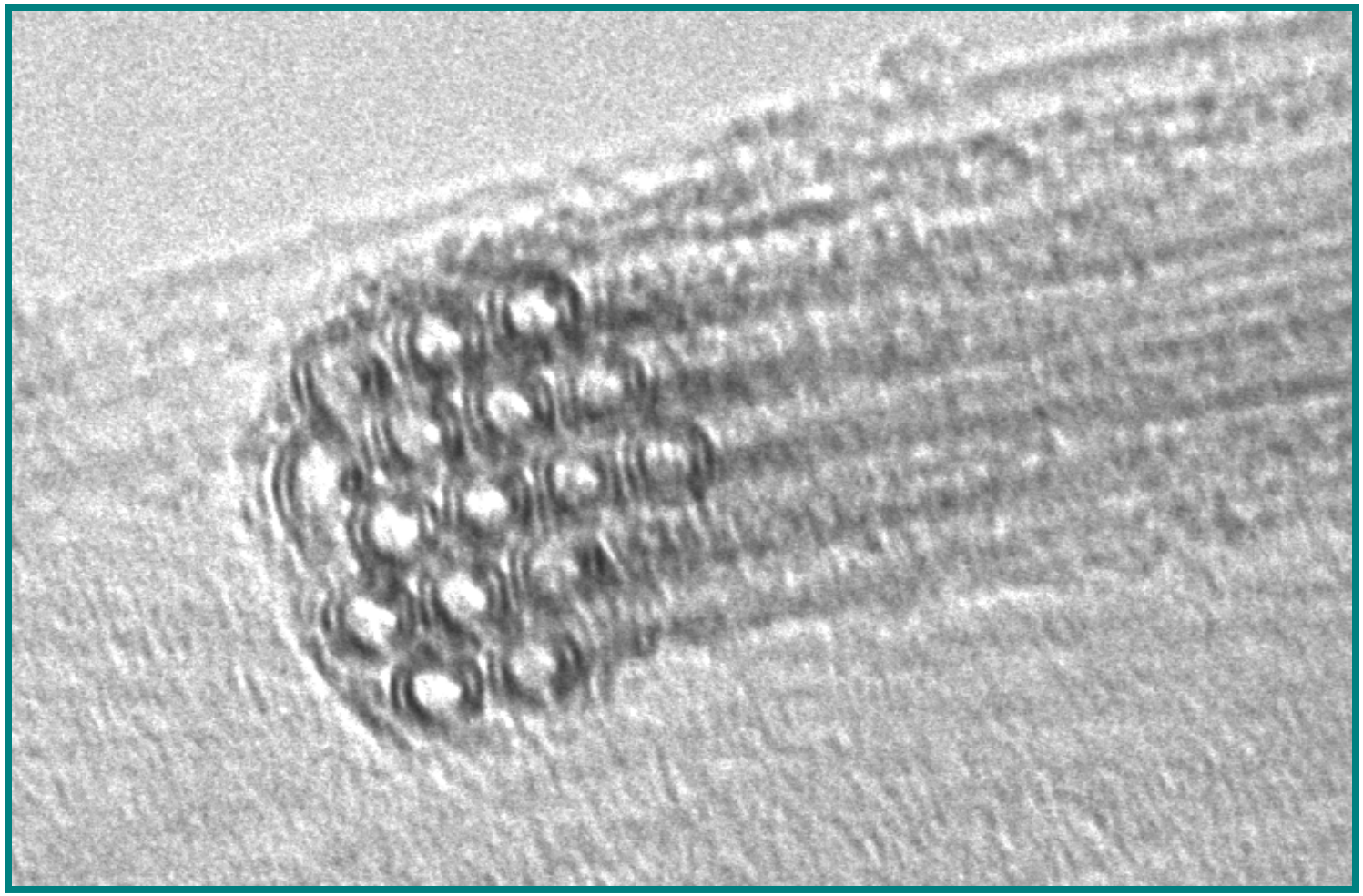








TEM OF TMC'S DWNT END



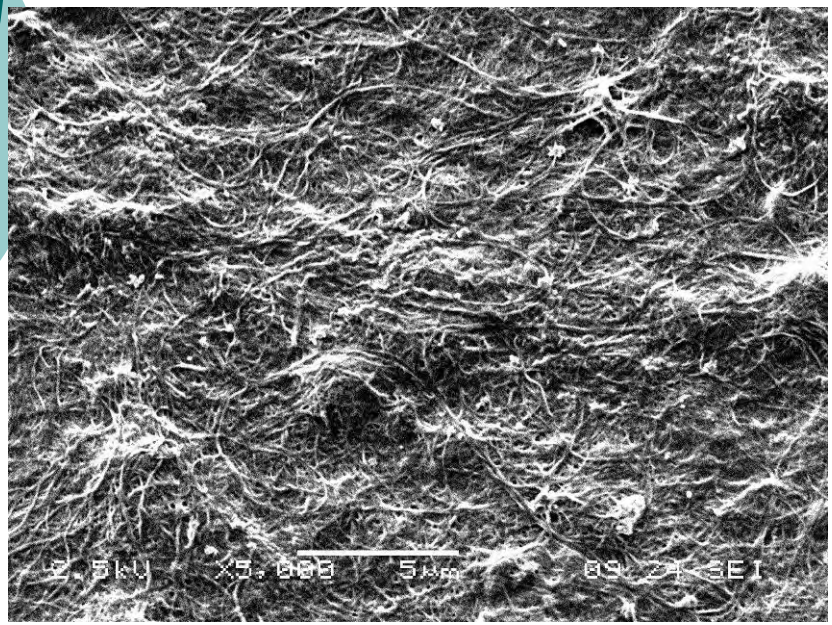
Advantages of DWNT

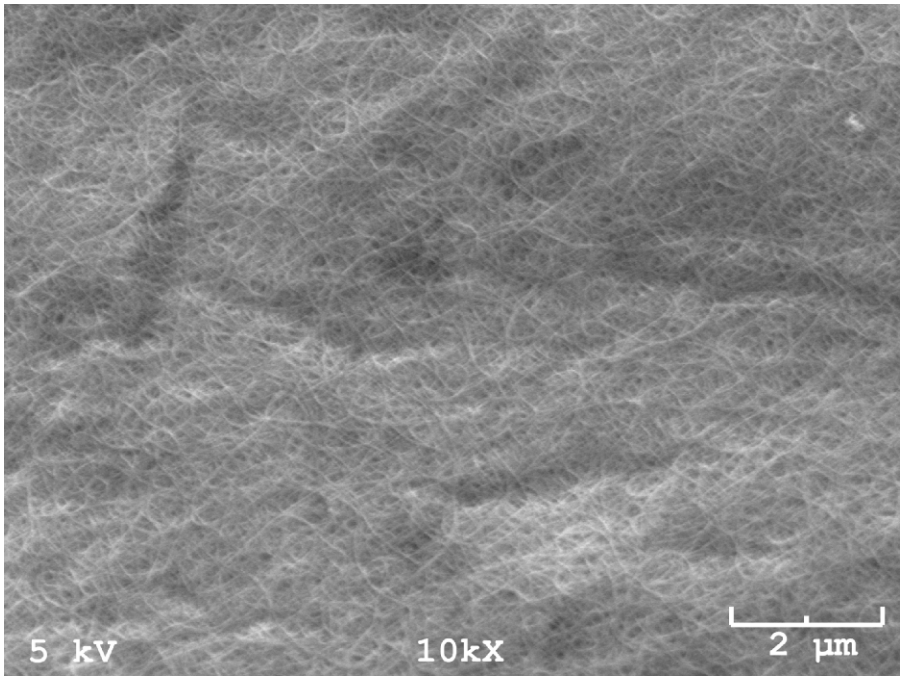
- DWNT have the best combination of properties with aspect ratio as high as 12,000.
- DWNT have greater thermal stability than SWNTs.
- Can be produced with the highest purity levels.
- DWNT can be produced as film “Mats” in which the DWNTs are very well-dispersed.


Free Standing DWNT Film


DWNT Film on Al Support

C-Mat is Better than BuckyPaper





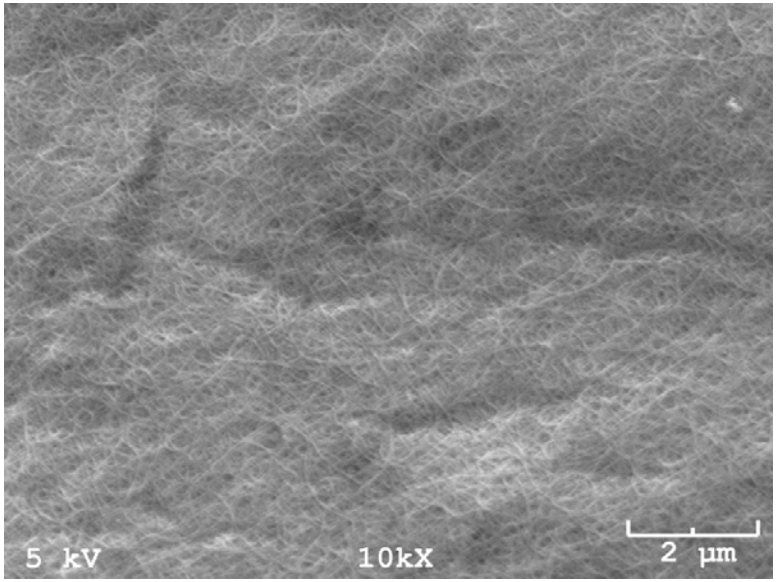
C-Mat is Better than BuckyPaper

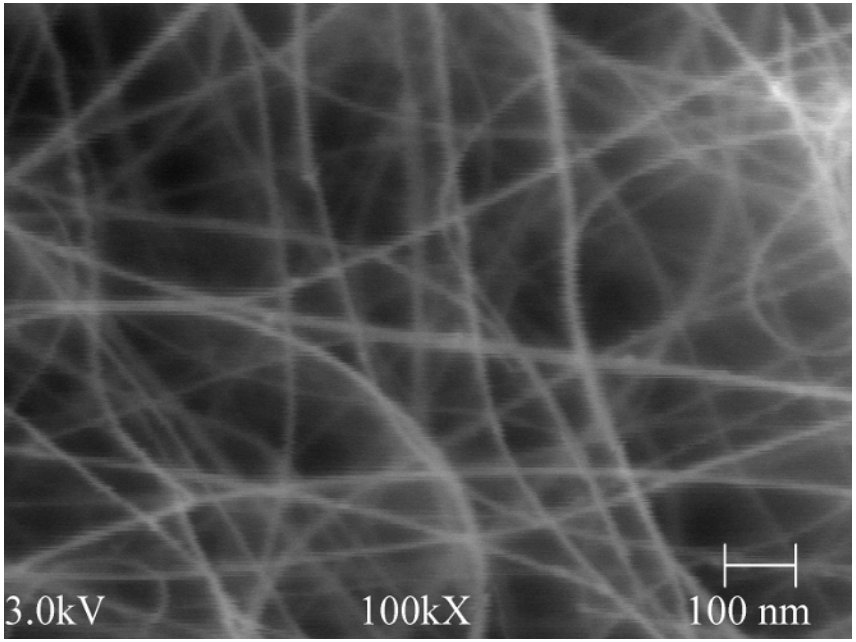
- C-Mat Tubes are less bundled
- C-Mat Tubes are longer
- C-Mats can be made much thinner than BuckyPaper
- C-Mats have large free volume (approx. 80% porosity)
- C-Mat pore size is smaller than BuckyPaper, and more controllable.

Applications

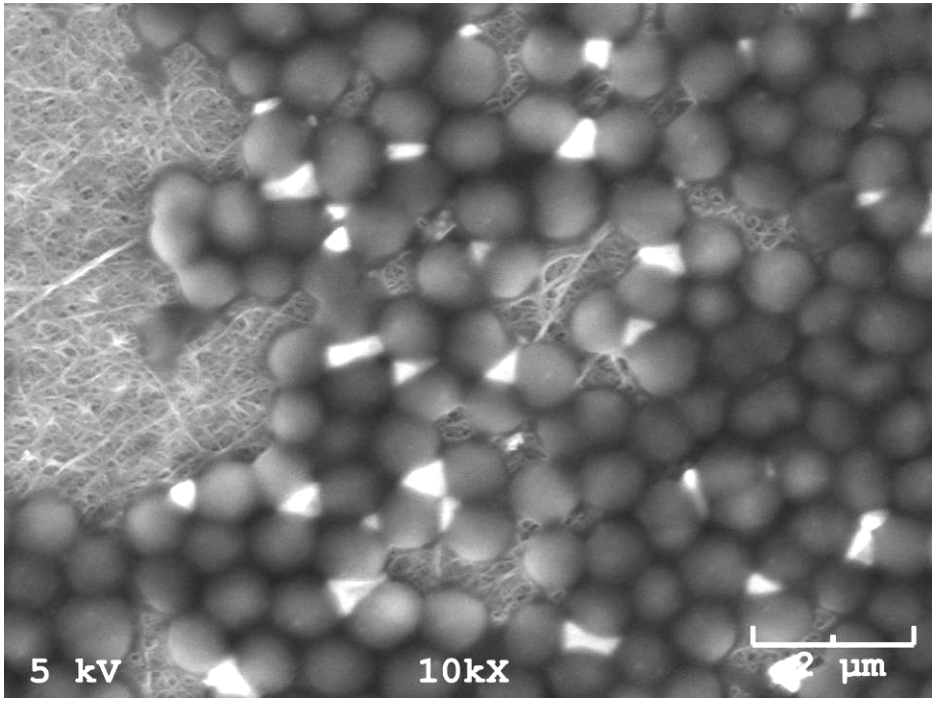
- MER plans to use its C-Mats in the following applications:
  - High performance filtration media,
  - Ultra-Strong Composite materials,
  - Electron-emitting cathodes,
  - Transparent, conductive flexible films

High Performance Filters





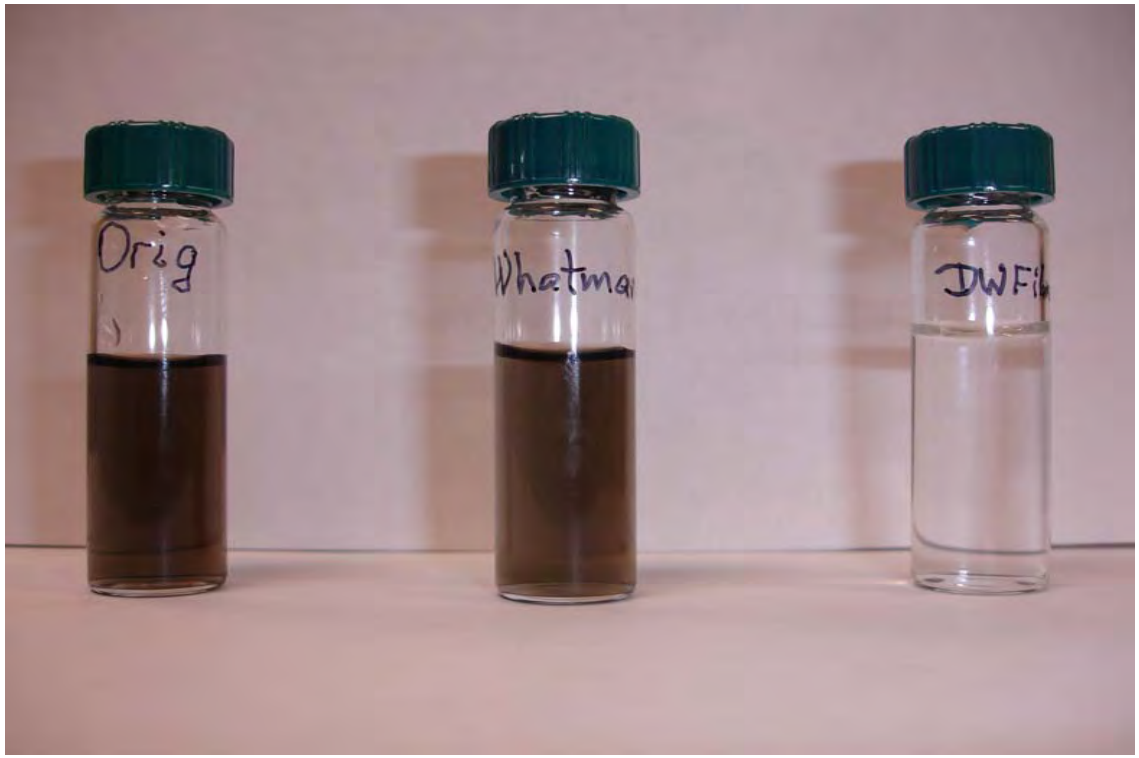
Bio-Filtration with C-Mats



SEM of S. Aureus on DWNT Filter. Note mat of DWNT at the left side of the picture.

C-Mat Ultra-Filtration Benefits

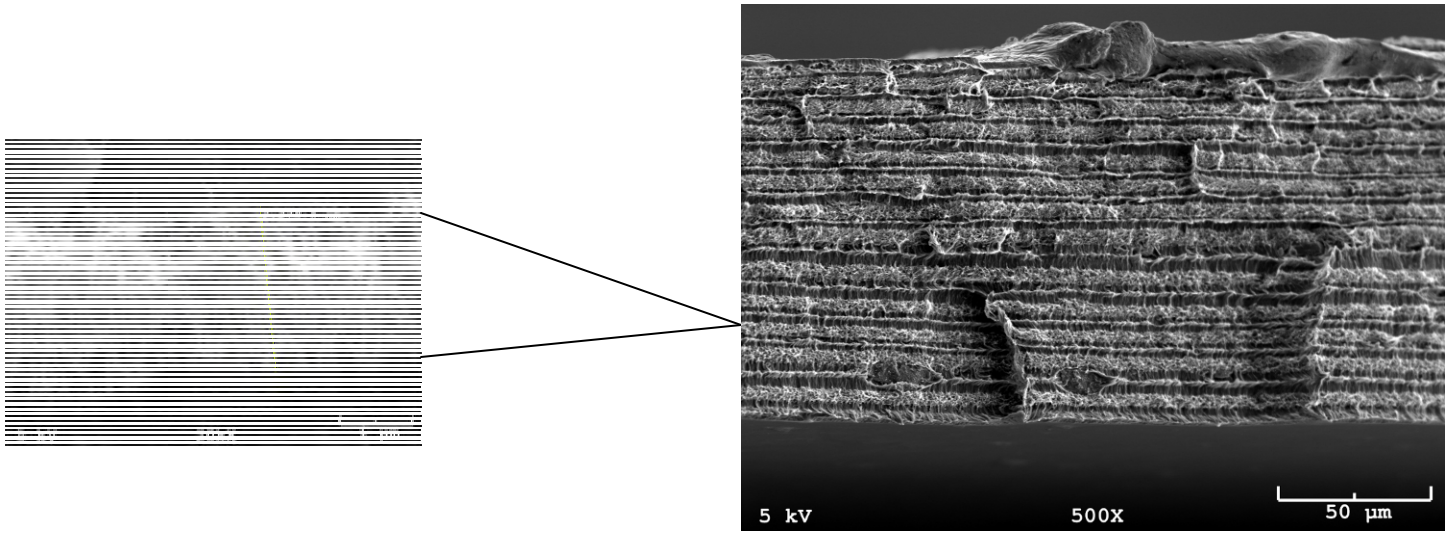
- Higher Flow Rate
- Lower pressure drop
- Heat resistant
- Tunable particle size



Advantages of DWNTs for Polymer Composites

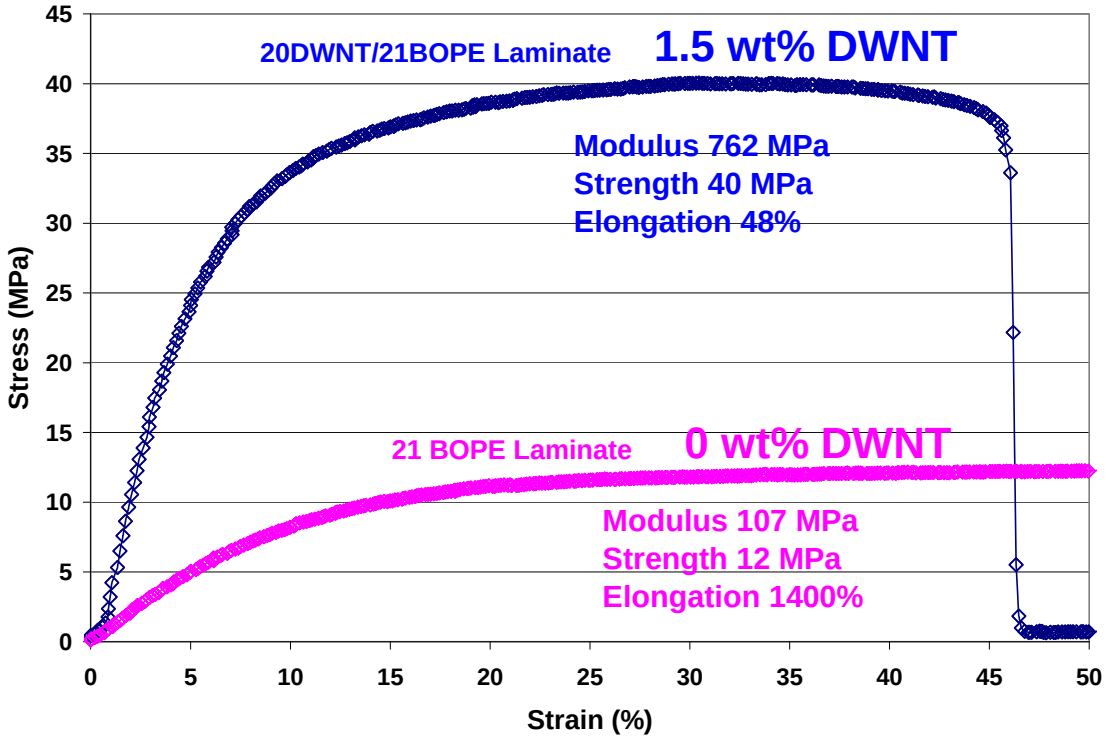
- As-Produced DWNTs are extremely long, with average L exceeding 50 micron; the pull-out energy should greatly increase
- DWNT microporous mat that can be infiltrated with polymers
- DWNTs can be functionalized in the very process of CVD production, for compatibility with various polymer matrixes
- Two walls: Functionalization will not deteriorate inner tube

Multi-Layer C-Mat / Polymer Composites



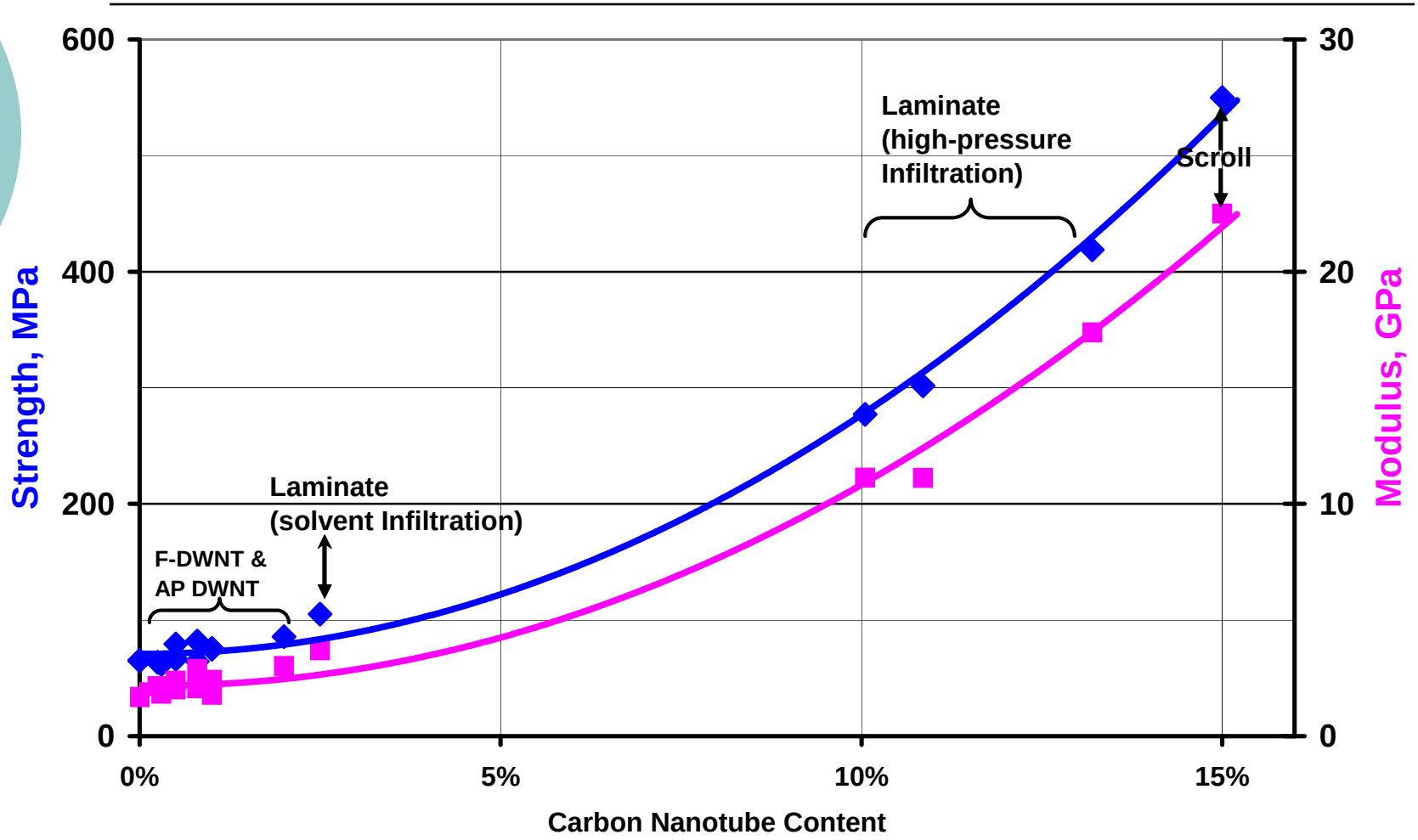
- Unique C-Mat structure provides huge increase in properties at low DWNT mass loading

Record-setting CNT composite strength



- 1.5% DWNT Quadruples PE Strength

Mechanical Properties of Epoxy 862/W - DWNT Composites

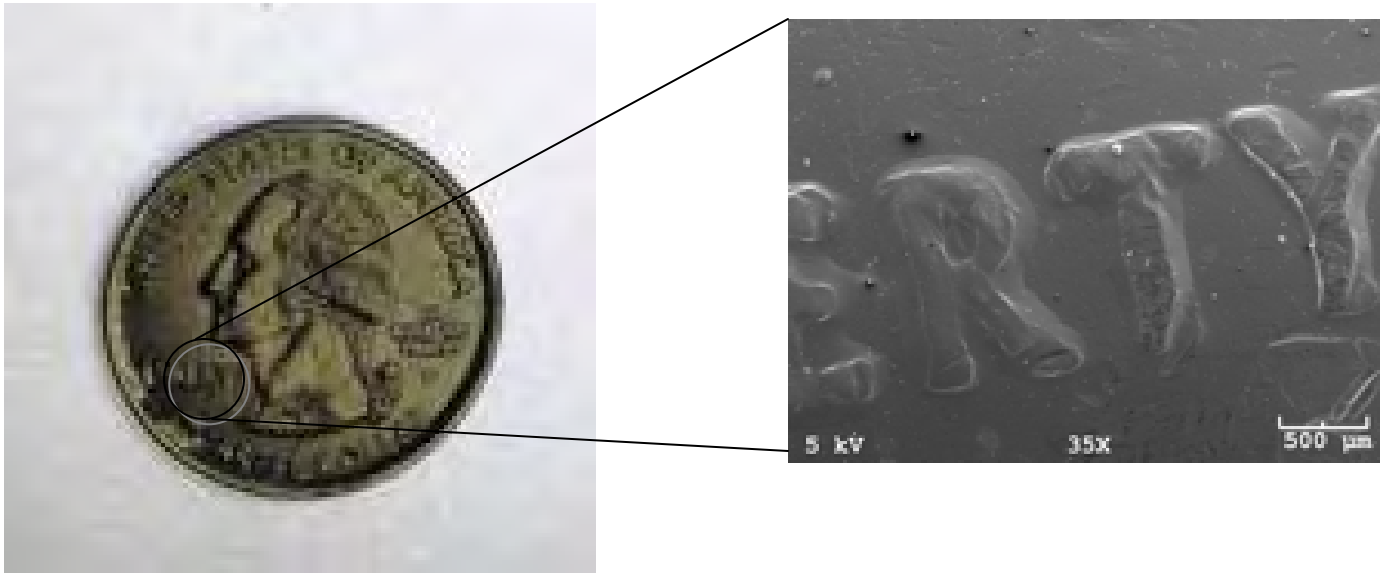


Other Applications

- TMC has shown that C-Mats
  - Emit electrons from the plane of the mat.
  - Introduce sheet conductivity to a plastic film
  - Double the visible light output from an incandescent DWNT light bulb filament compared to tungsten.

C-Mats

- C-Mats adhere well to surfaces.



IP Strategy

- MER has its own portfolio of CNT technology, with particular focus on double-walled carbon nanotubes.
- MER has patent applications on
  - Manufacturing processes for DWNT.
  - Methods of making the C-Mat.
  - Composition of matter patent of DWNT.

Summary

- C-Mats deliver on the promise of nanostructured materials
- Unique configuration allows big benefits from tiny amounts of material, allowing commercial applications even with today's prouction costs
- Arizona ingenuity leads nanotech development again!

Fullerene (C60 and C70) was the first Nanotech From Arizona

May 2003, Capacity = 40 metrics tons of Fullerenes/year