Rio Tinto Alcan

Carbon Nanotube Enhanced Aluminum

Prof. Dr. Horst Adams

Extending the application range of standard alloys.

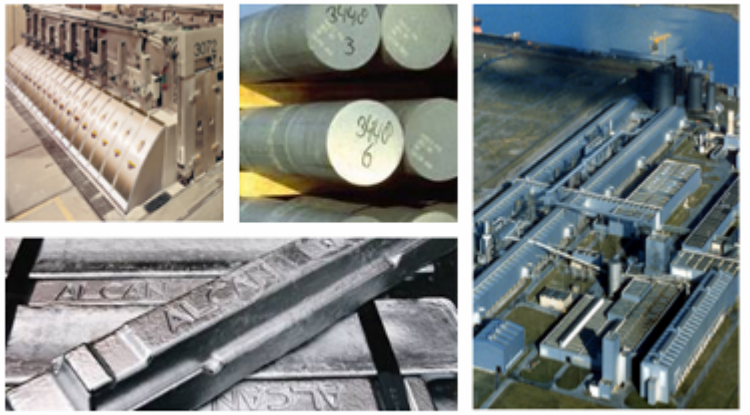
Rio Tinto Alcan

4 Business Groups

Total: ~70.000 employees

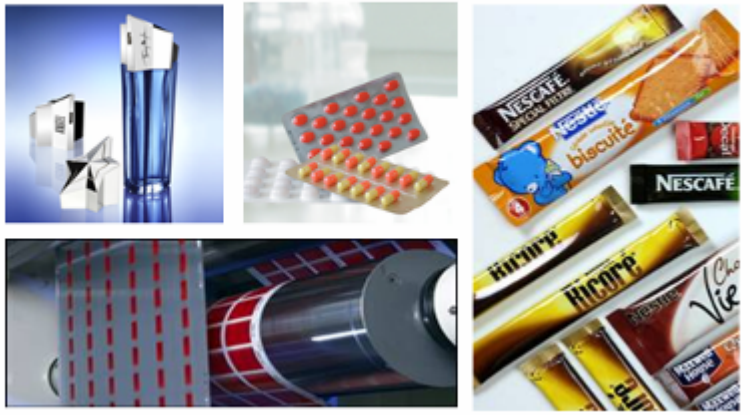
BAUXITE AND ALUMINA

PRIMARY METAL



ENGINEERED PRODUCTS

PACKAGING



Rio Tinto Alcan

Engineered Products

Range of business activities

Alcan Aerospace, Transportation and Industry

Alcan Specialty Sheet

Alcan Composites

Alcan Cable

Alcan Extruded Products

Alcan Engineered and Automotive Solutions

Alcan Service Centres

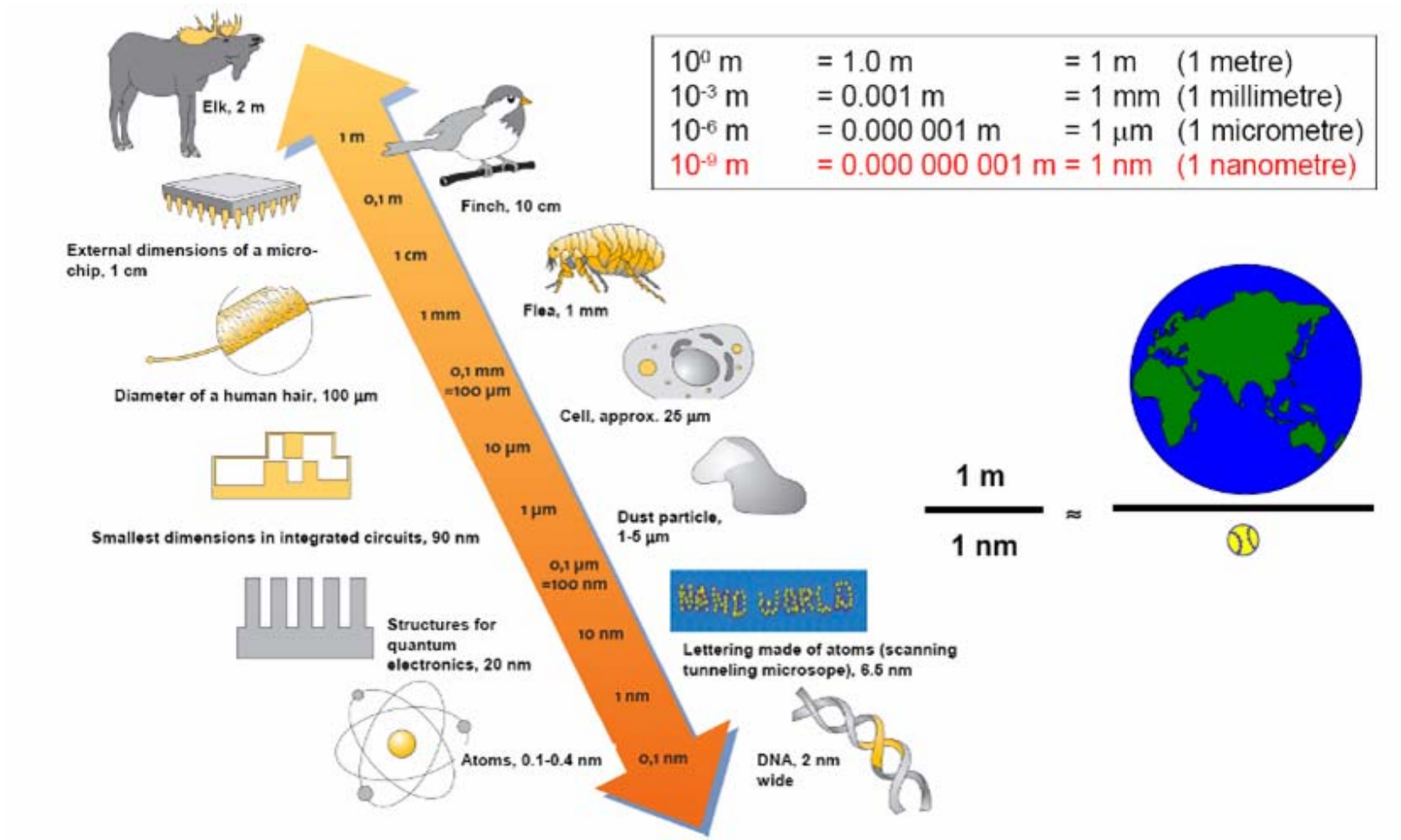
Alcan International Network

2001	
Employees	**6,200**
Sites	**30**
Sales (3rd)	**US$1.6B**
Countries	**14**

2006	
Employees	**15,000**
Sites	**120**
Sales (3rd)	**US$7.1B**
Countries	**32**

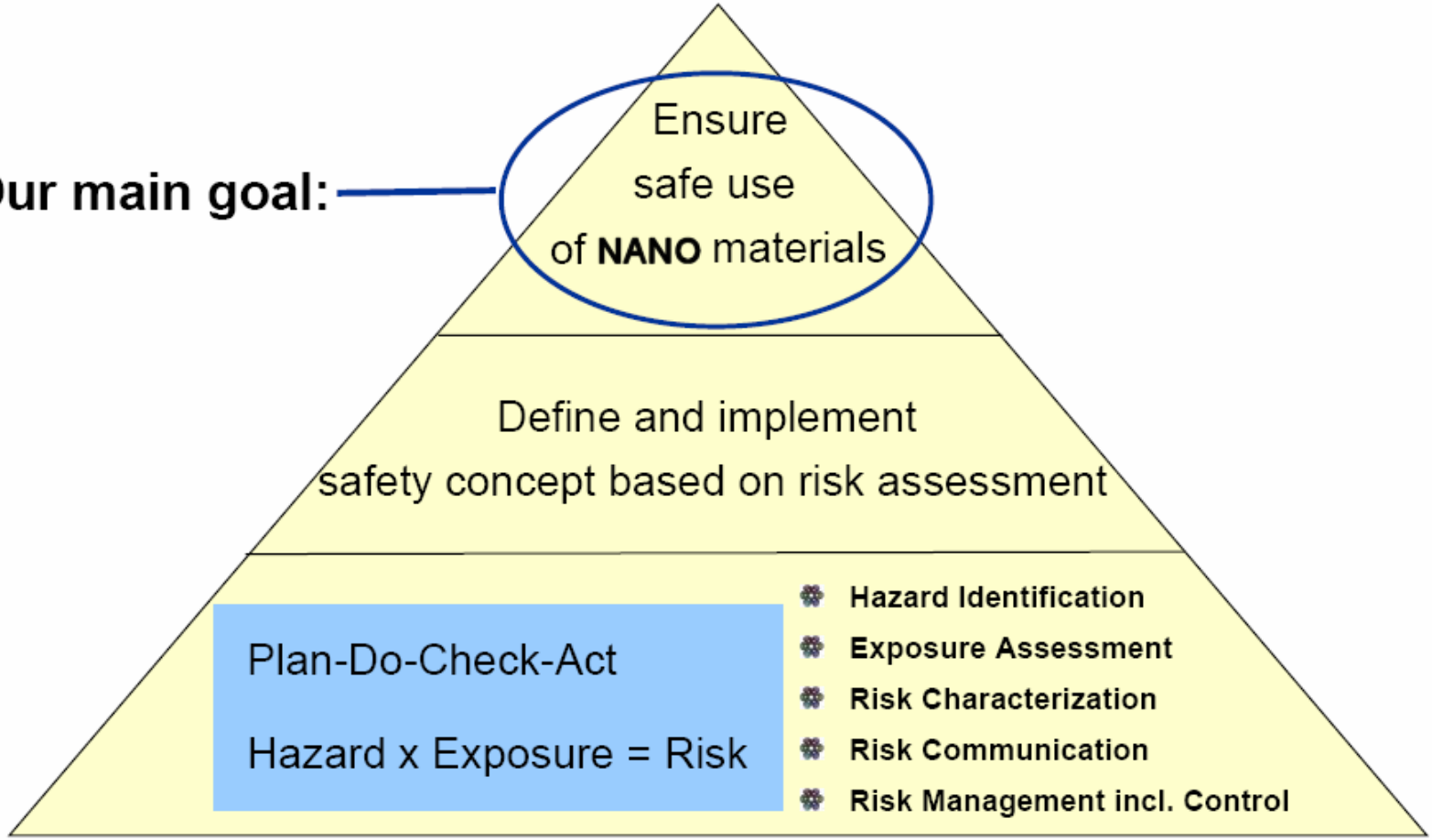
R&D Center Neuhausen, Switzerland

How big is nano?



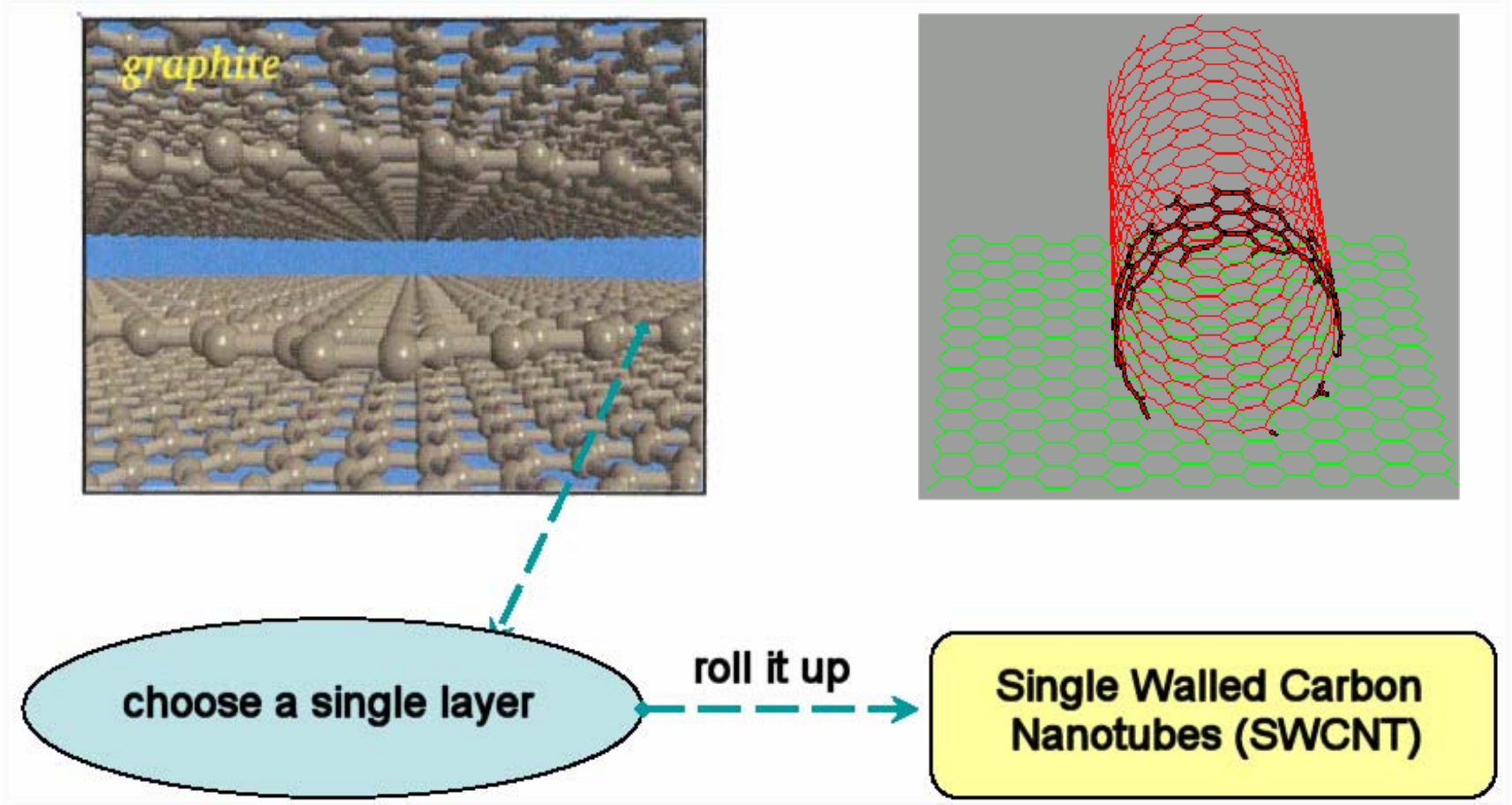
Nano Safety

Close collaboration with Bayer MaterialScience

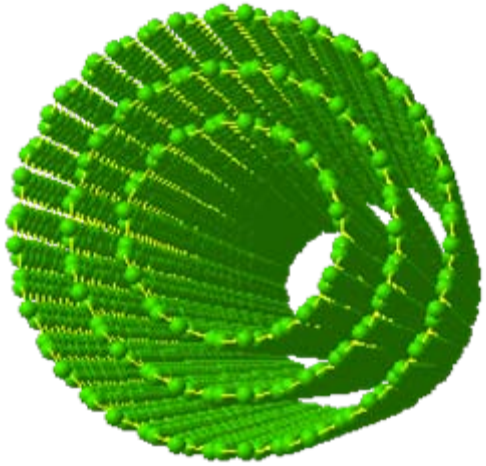


What are Carbon Nanotubes (CNTs) ?

- rolled-up sheets of graphite.

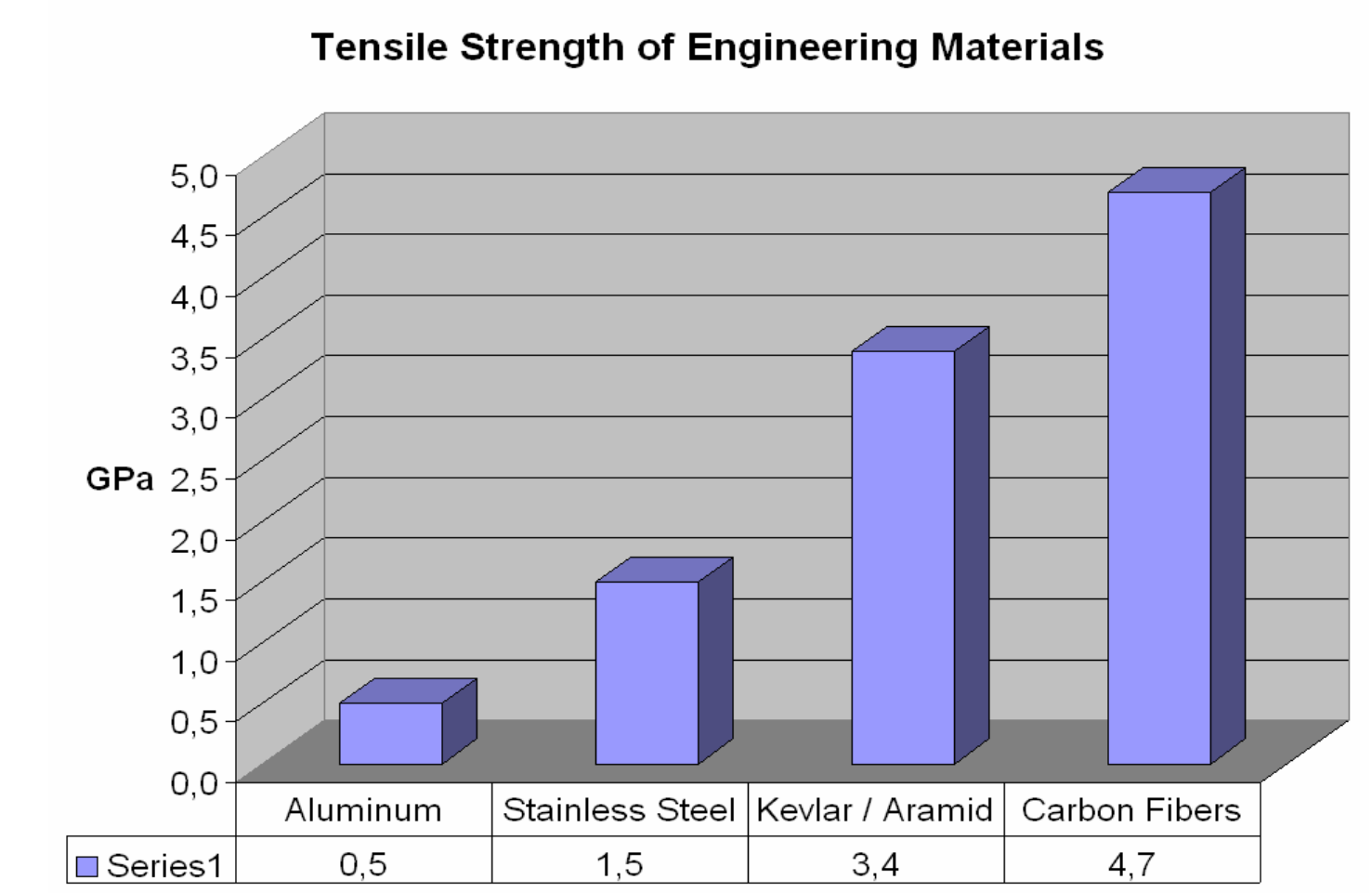


Why Carbon Nanotubes?

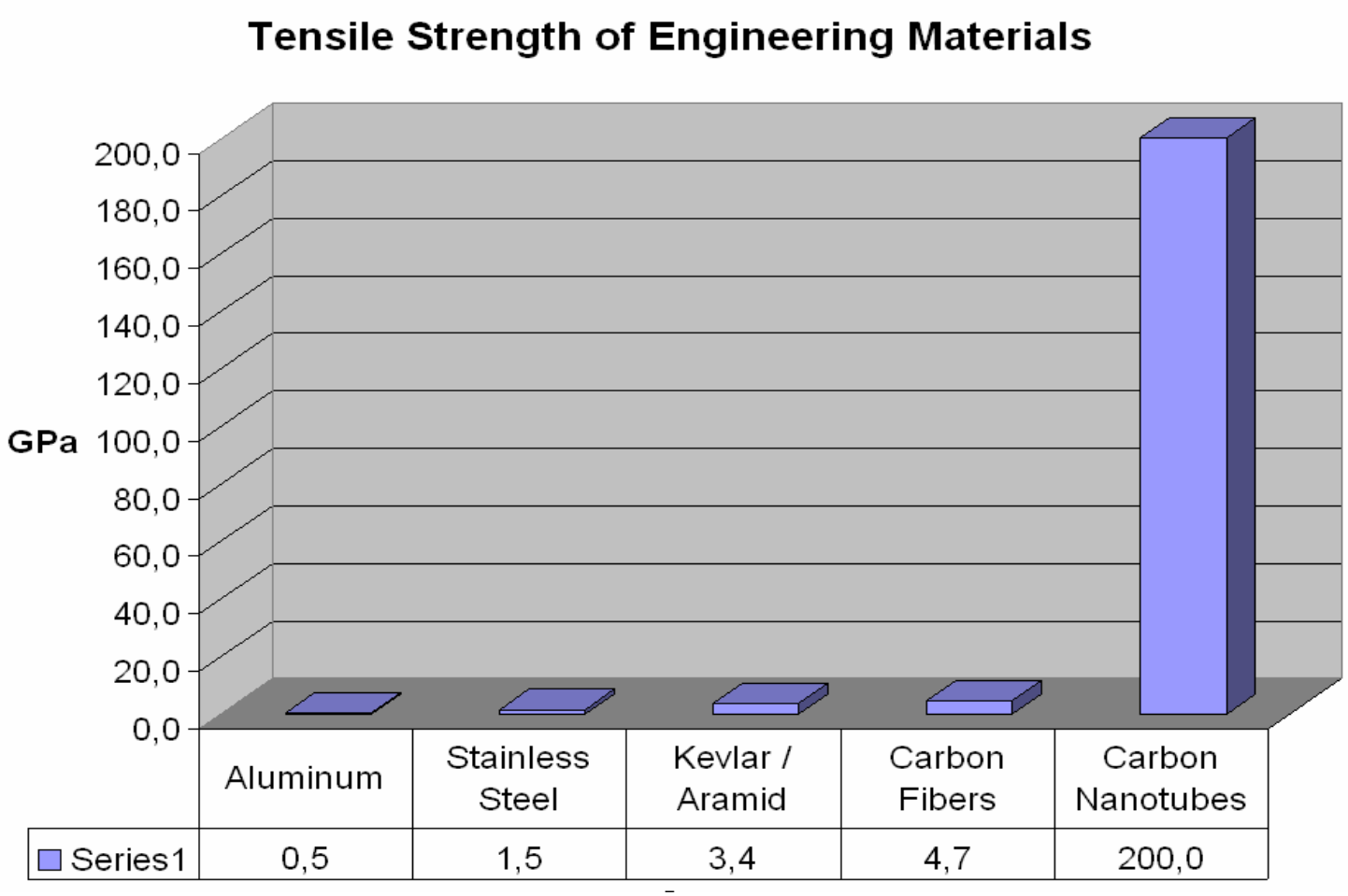


Modulus	**Al**	**70 GPa**
	Steel	**200 GPa**
	CNTs	**1000 GPa**
Tensile Strength	**Al**	**0.5 GPa**
	Steel	**1.5 GPa**
	CNTs	**200 GPa**
Thermal conductivity	**Al**	**240 W/(mxK)**
	Cu	**400 W/(mxK)**
	CNTs	**4000 W/(mxK)**
Current capacity	**Al**	**0.1 MAmp/cm^2**
	Cu	**1 MAmp/cm^2**
	CNTs	**1000 MAmp/cm^2**

Strength of Standard Materials

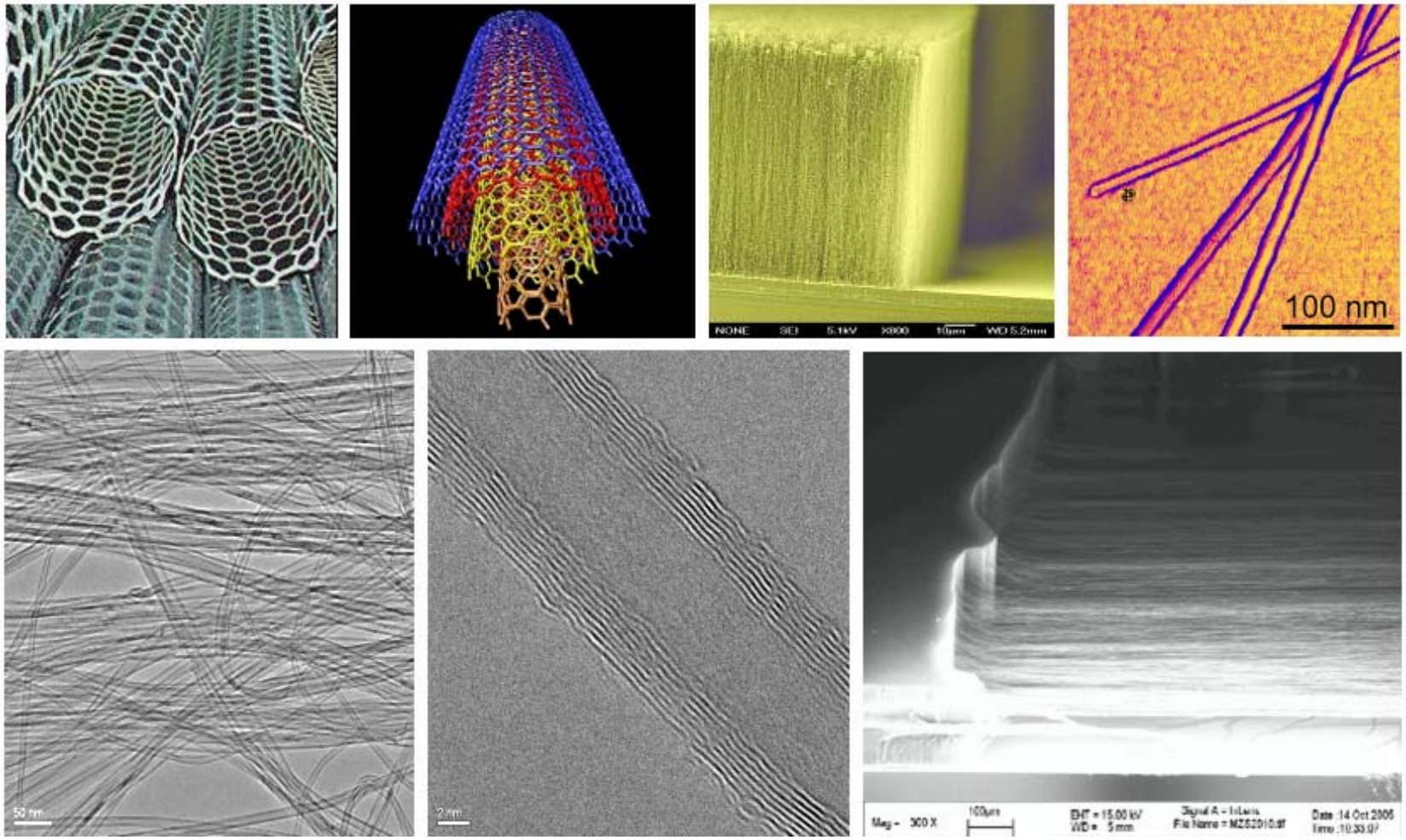


Strength of Carbon Nanotubes



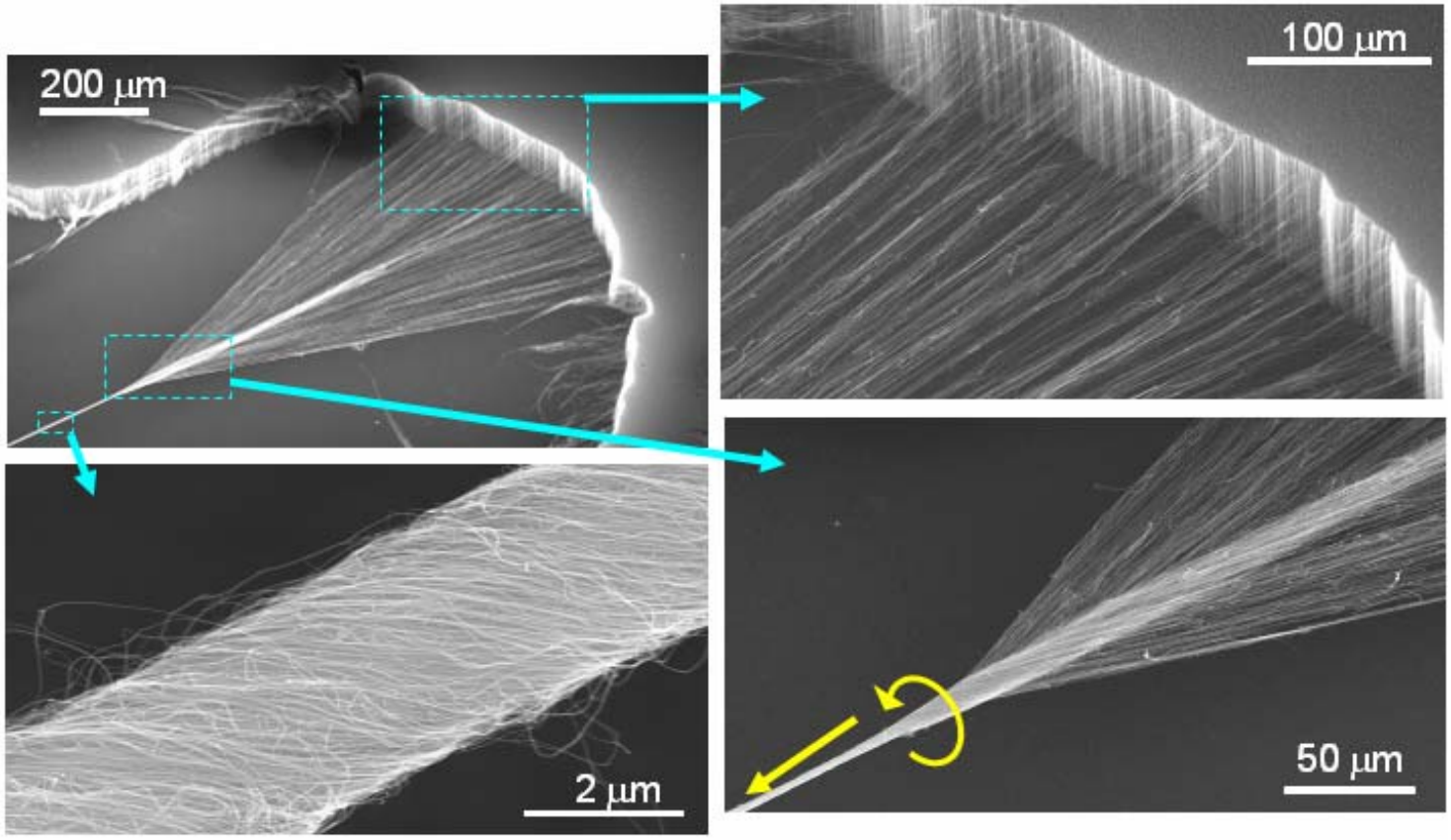
SWCNTs vs MWCNTs

(courtesy University of Texas at Dallas)



Carbon Nanotube Yarns

(courtesy University of Texas at Dallas)

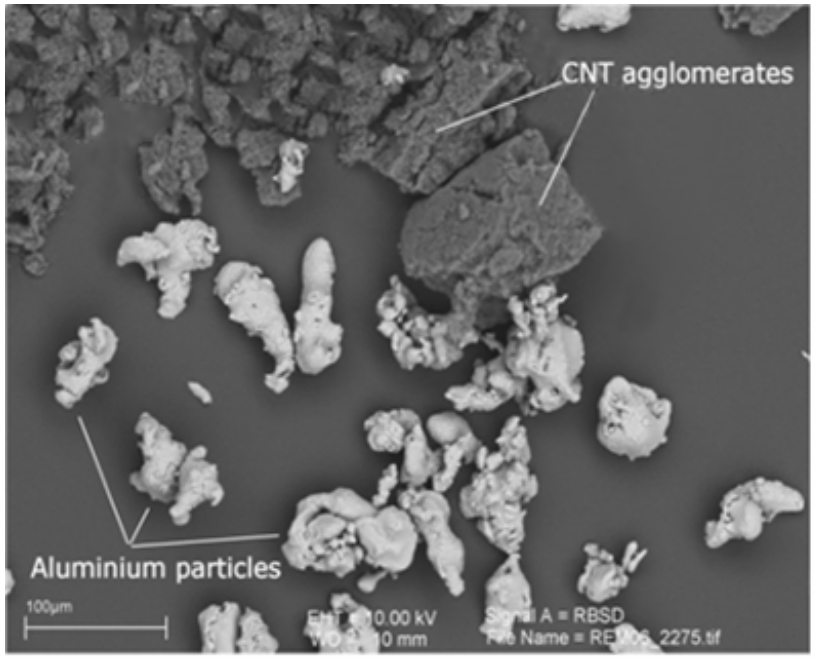


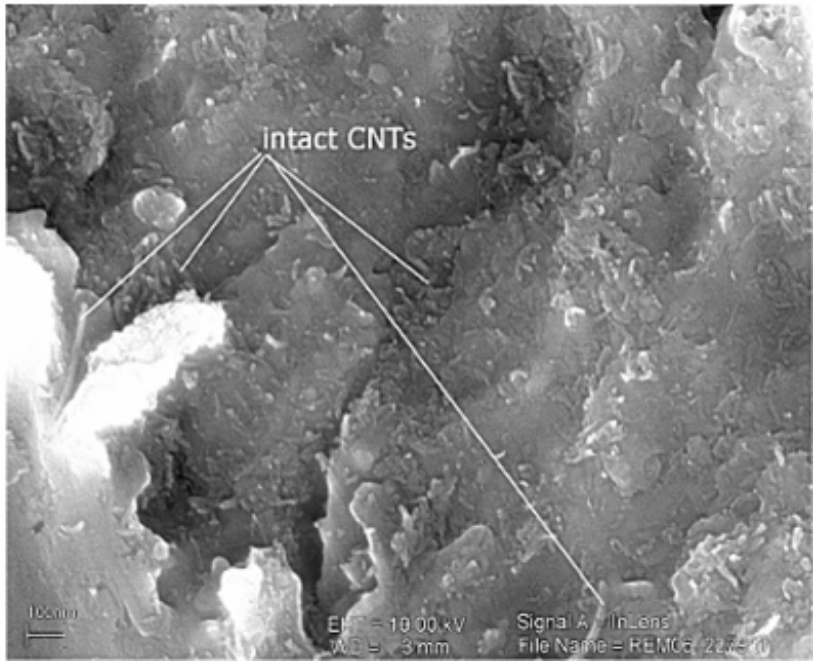
M. Zhang, K. Atkinson, R.H. Baughman, *Science* **306**, 1358-1361 (2007)

Jiang *et al.*, Nature **419**, 801 (2006)

CARBON NANOTUBE REINFORCEMENT

Dispersion of CNTs in aluminum matrix (CNTs: agglomerated Baytubes from Bayer)



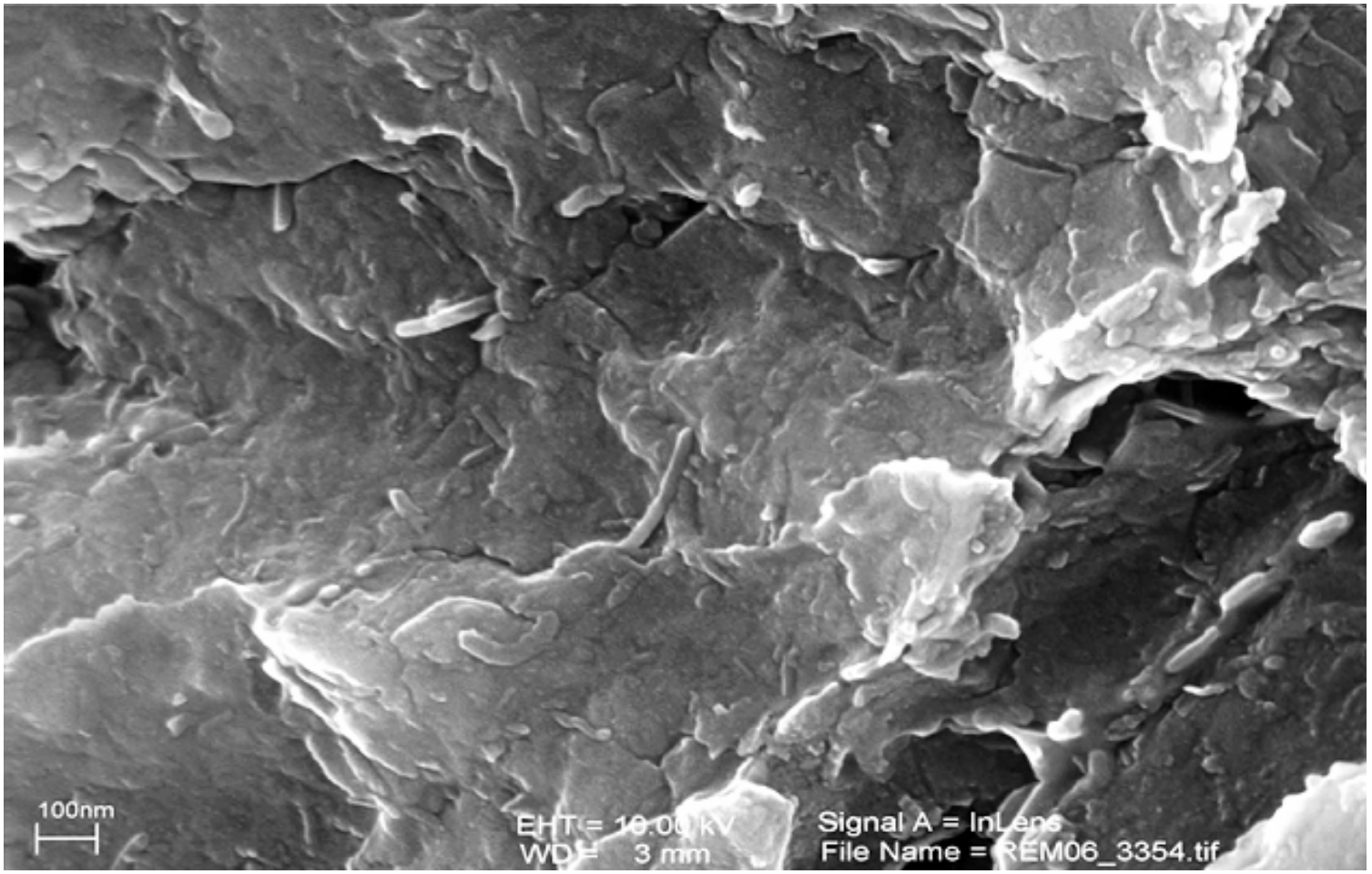


Main Parameters:

- Milling energy
  - Milling temperature
    - Milling time for pure aluminum particles
      - Milling time for aluminum particles with carbon nanotubes

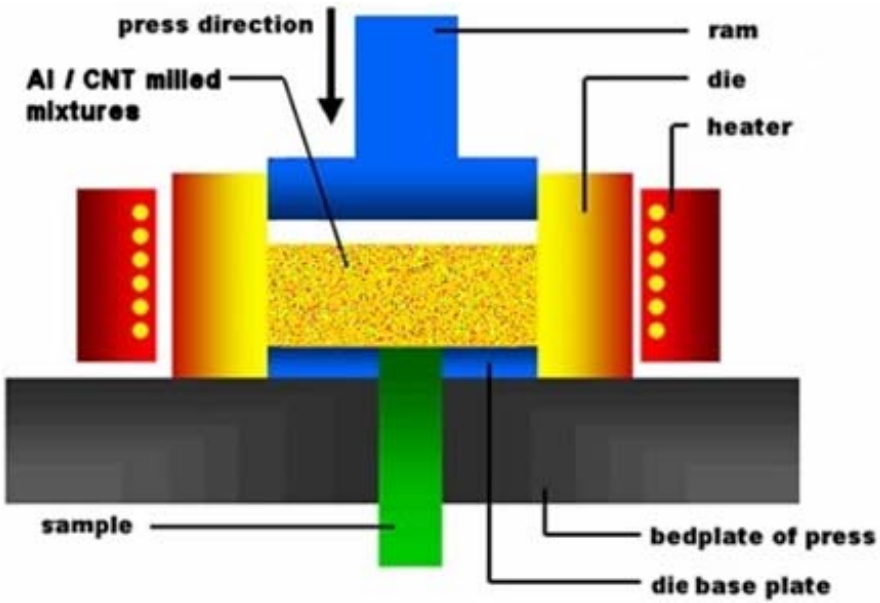
CARBON NANOTUBE REINFORCEMENT

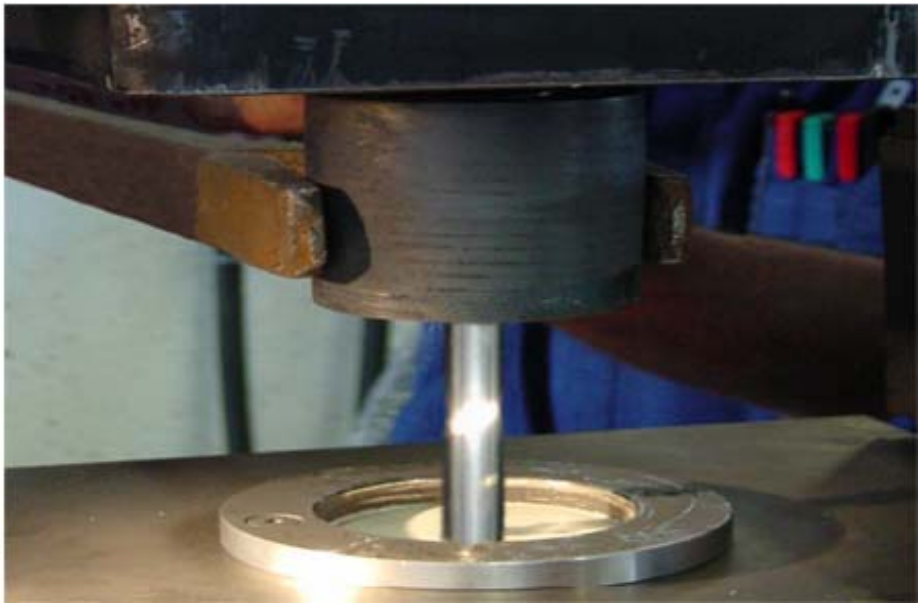
Aluminum Particle with Dispersed Carbon Nanotubes



HOT EXTRUSION

Consolidation of milled powder material



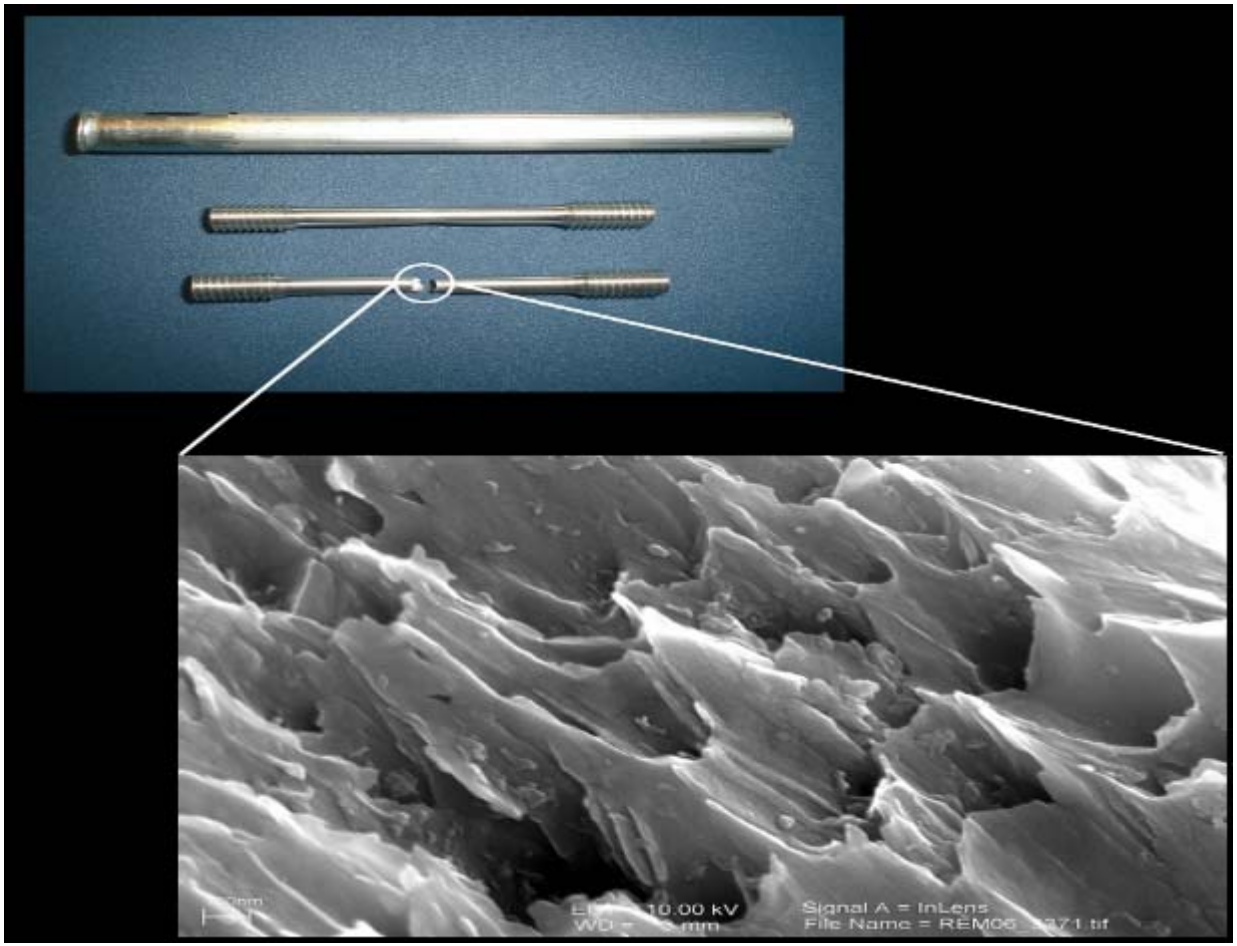


Main Parameters:

- Temperature
  - Extrusion ratio
    - Ram speed

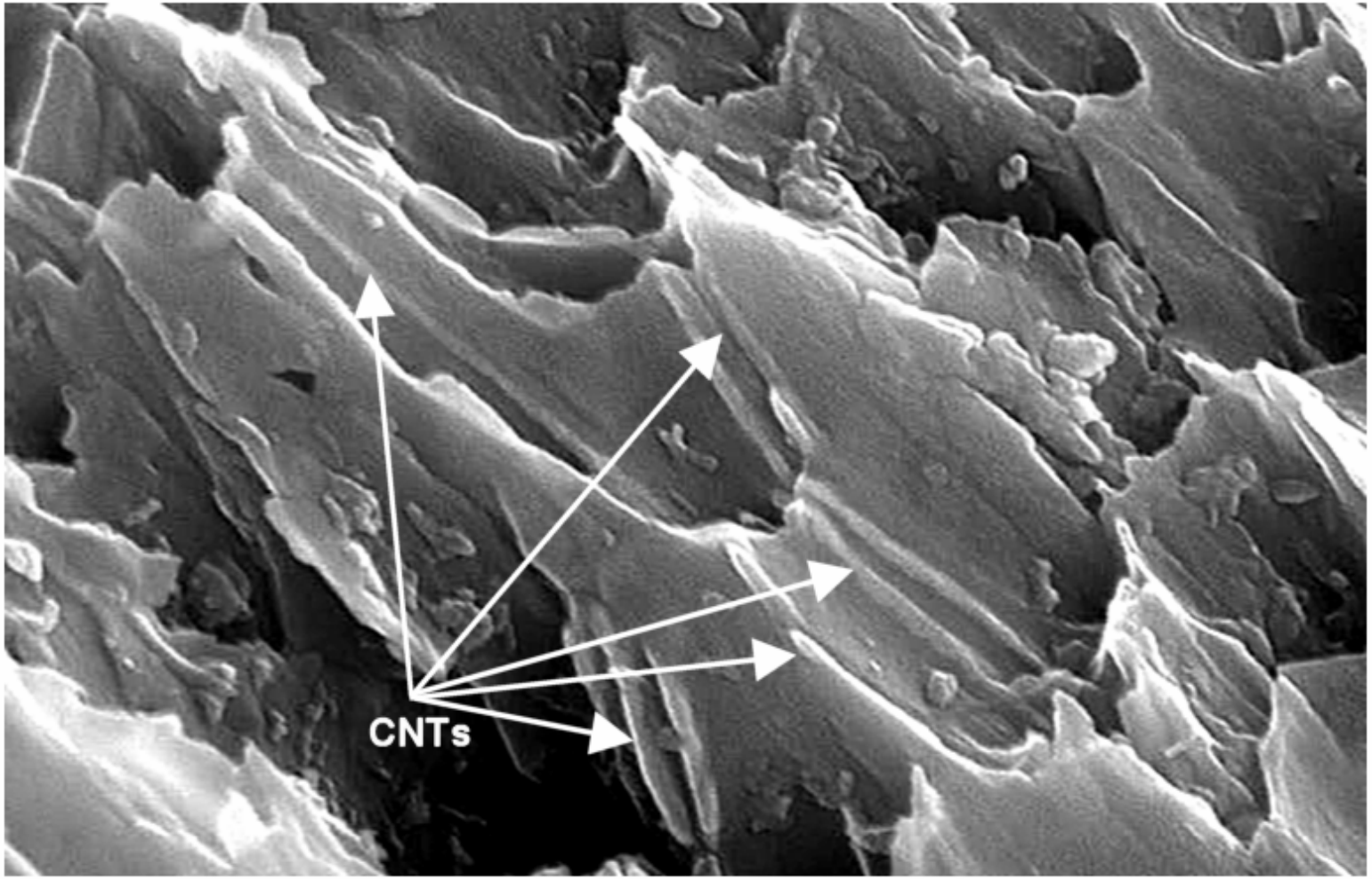
CARBON NANOTUBE REINFORCEMENT

Tensile test of extruded samples



CARBON NANOTUBE REINFORCEMENT

Fracture surface of tensile test sample



DUPLEX ALUMINUM

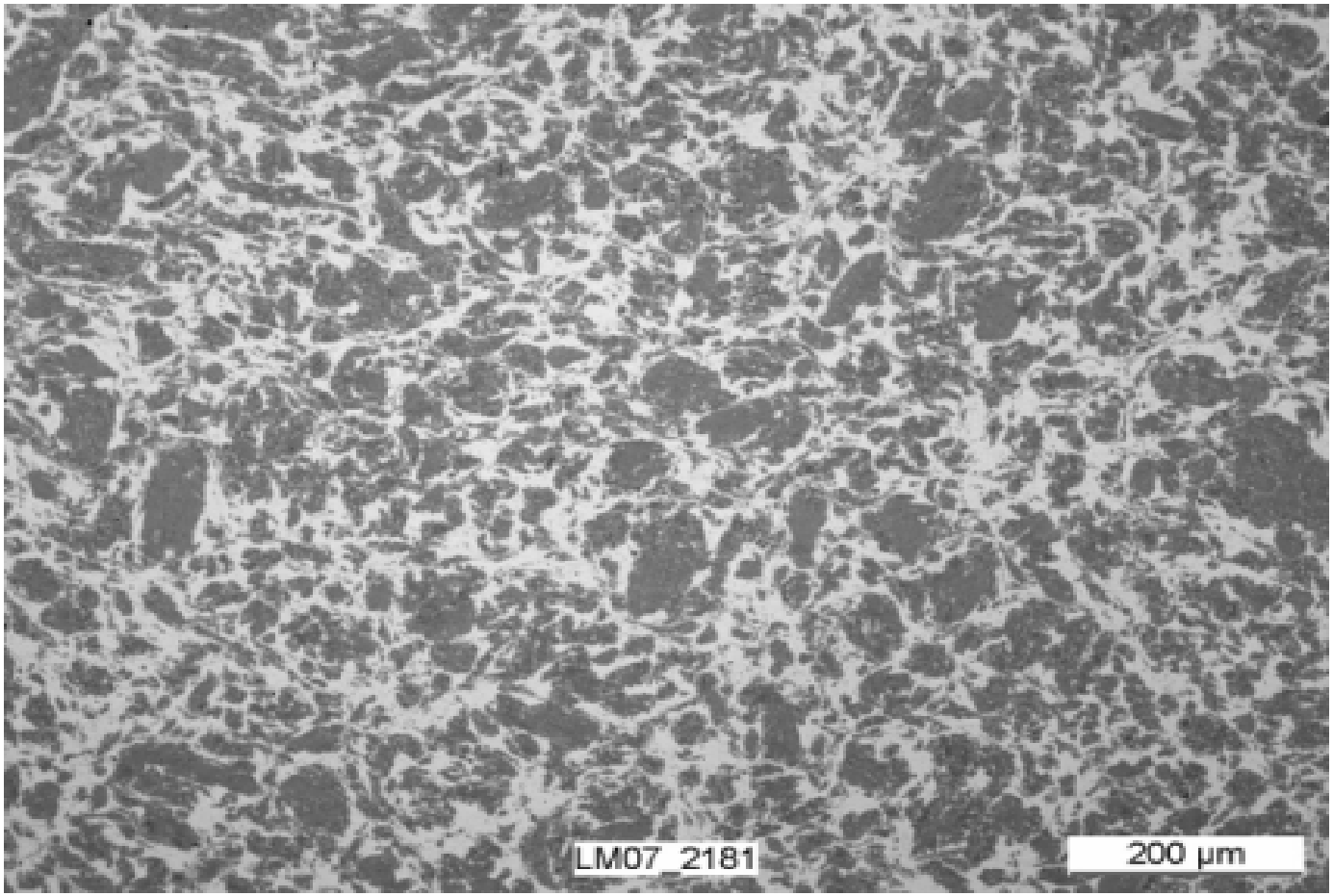
The ancient Samurai Sword technology

Technology:

- Folding over a stack of hard and flexible materials and repeated forging
  - Formation of many layers with irregular patterns
    - Creation of a composite material which is hard and flexible at the same time

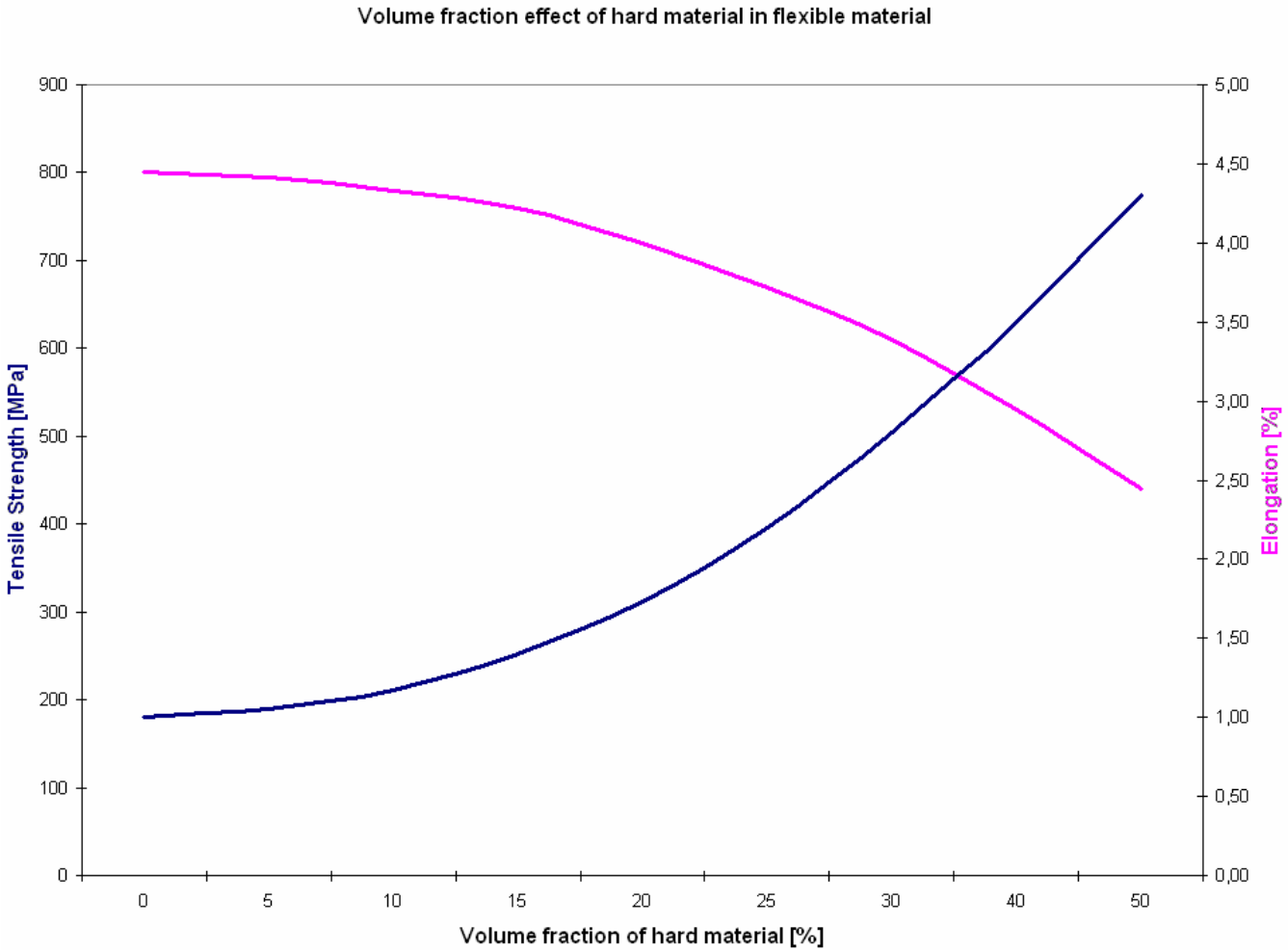
DUPLEX ALUMINIUM

The modern Samurai Technology (Duplex materials)



WINDOW OF OPPORTUNITIES

Definable range of material properties



Main Advantages of Aluminum / CNT Composites

- Weight reduction because of higher strength
- Tunable material properties
- Reduced materials mix
  - reduced corrosion
  - better joinability
- Improved thermal stability
- Improved thermal conductivity