Formation of thick dielectrophoretic carbon nanotube fibers

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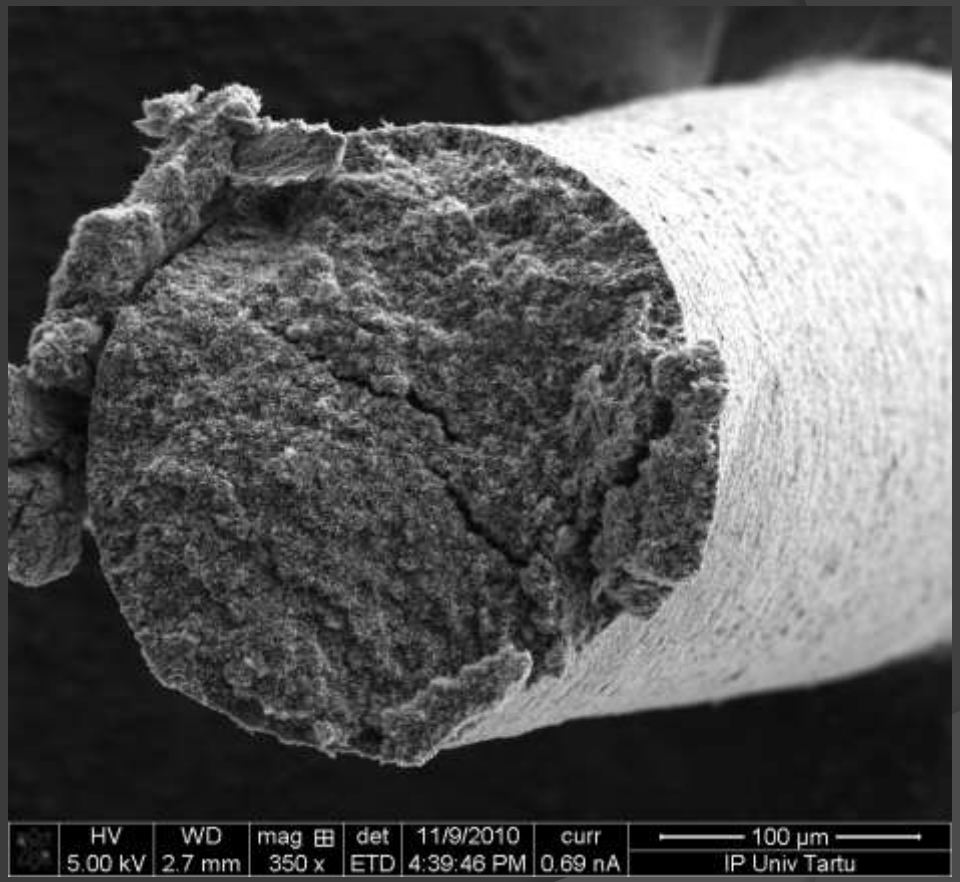
Materials Science

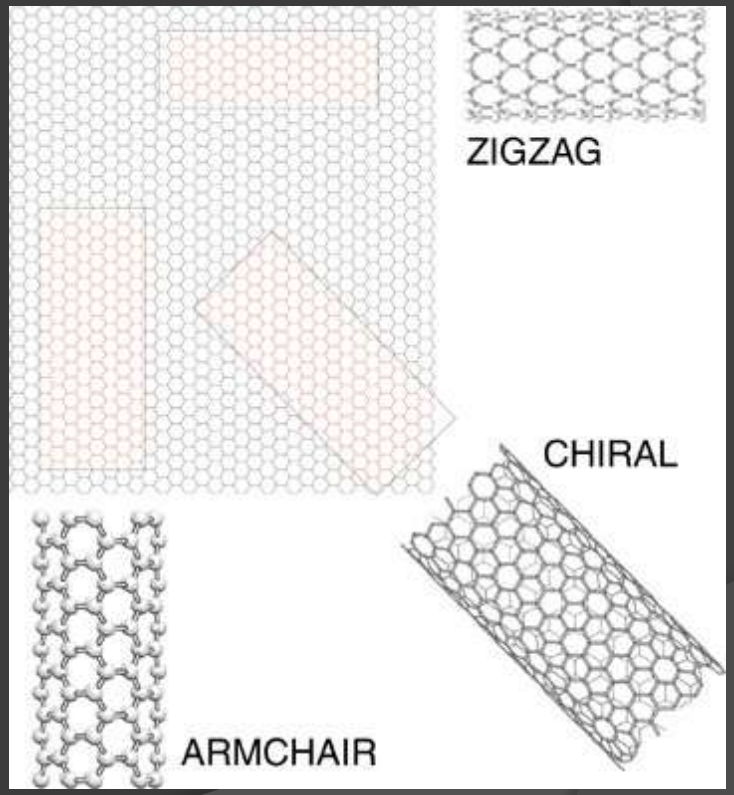
Outline

- Introduction
- Method
- Results
- Conclusion



Carbon nanotube (CNT)

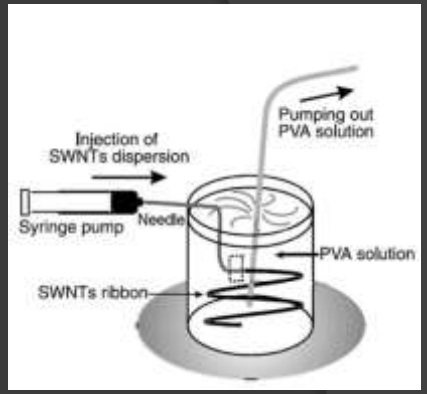
- Tensile strength ~150 GPa (steel ~1-2 GPa)
- Young's modulus ~1 TPa (diamond 1.22 TPa)
- Good thermal and electrical conductivity
- Aspect ratio ~ 10^6



CNT fiber production

- Liquid-state spinning

CNT dispersion is injected through a tiny nozzle, followed by immediate solvent evaporation and formation of fiber.

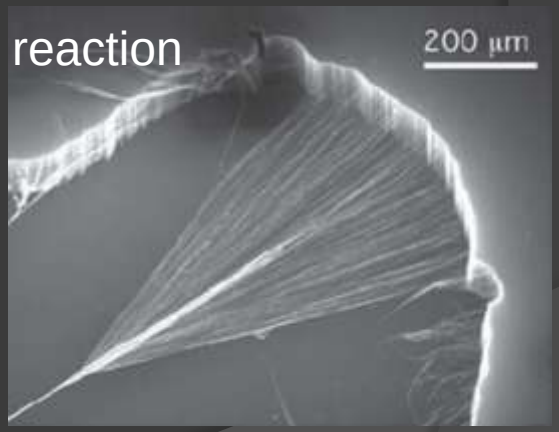


Vigolo, B., et al. 2002

- Solid-state spinning

Synthesized CNT aerogel is spun into fiber directly in reaction zone.

Pre-grown CNT forest is twisted into a yarn.

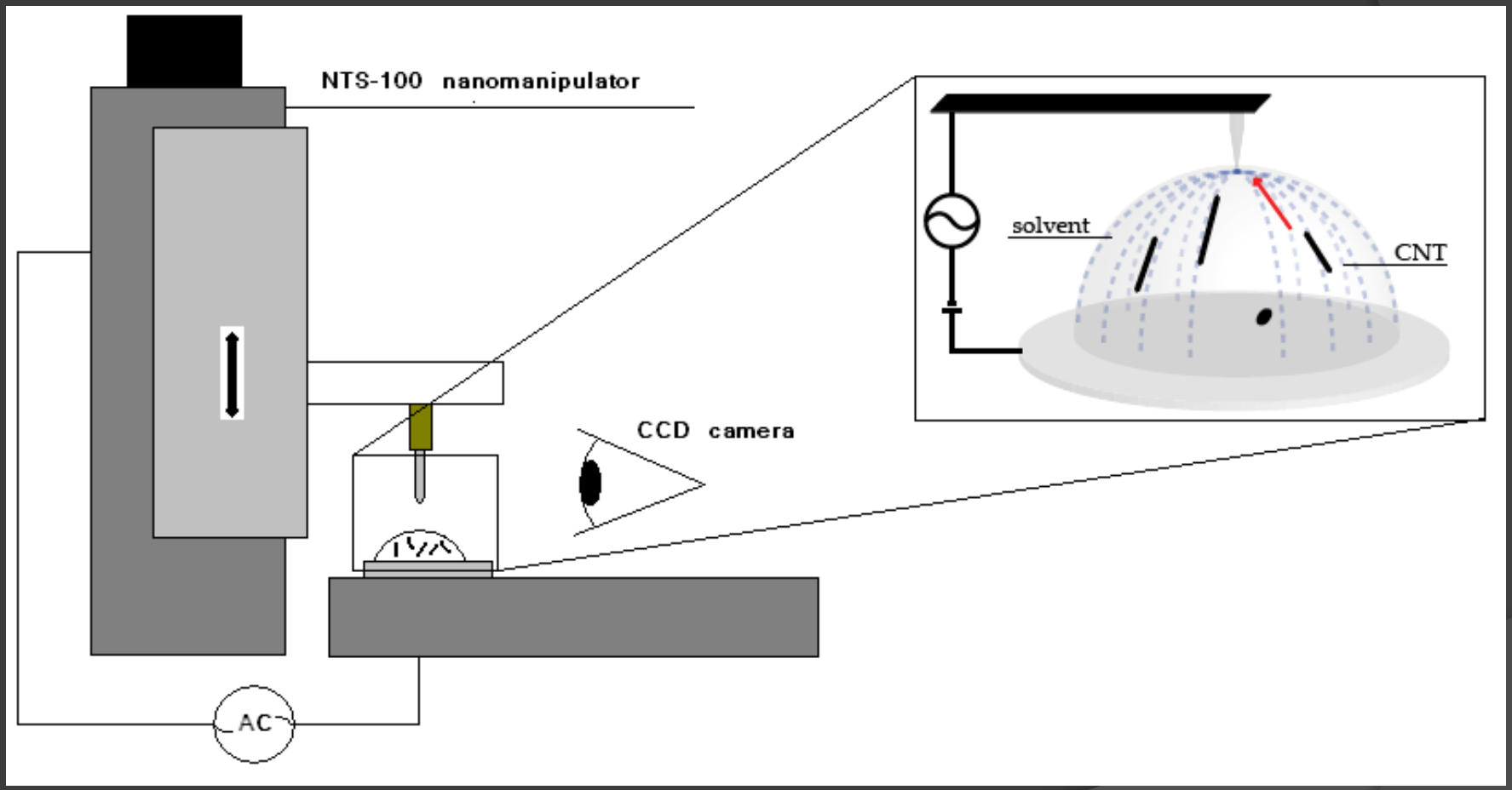


Zhang, M., et al. 2004

- Dielectrophoresis

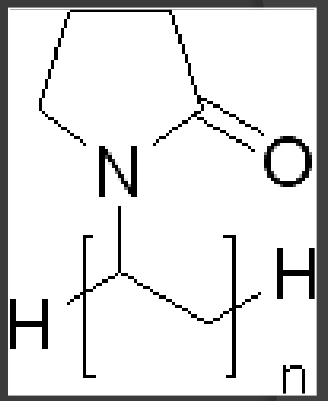
Tang, J., et al. 2003

Fiber drawing by dielectrophoresis



CNT dispersion preparation

- MWCNT
  - lengths 0.5 – 200 μm, ~500 μm, ~2 mm
- Polyvinylpyrrolidone (PVP)
  - surfactant is used to stabilize the CNT dispersion for extended periods of time
- Deionized water
- 1 : 4 : 1000 (PVP : CNT : water)
- Sonication



Experimental setup

Video of fiber drawing

Snapshots of fiber drawing

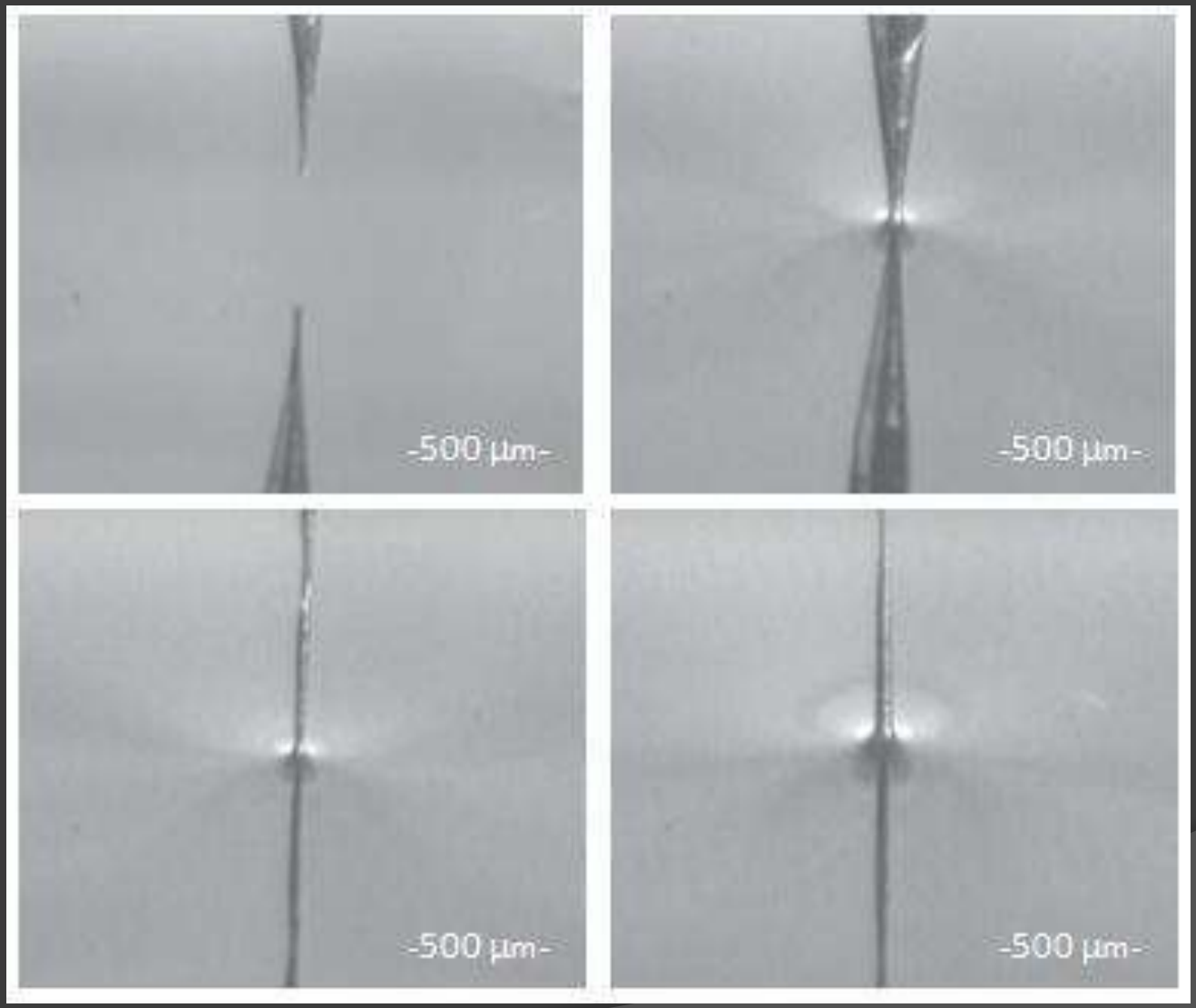
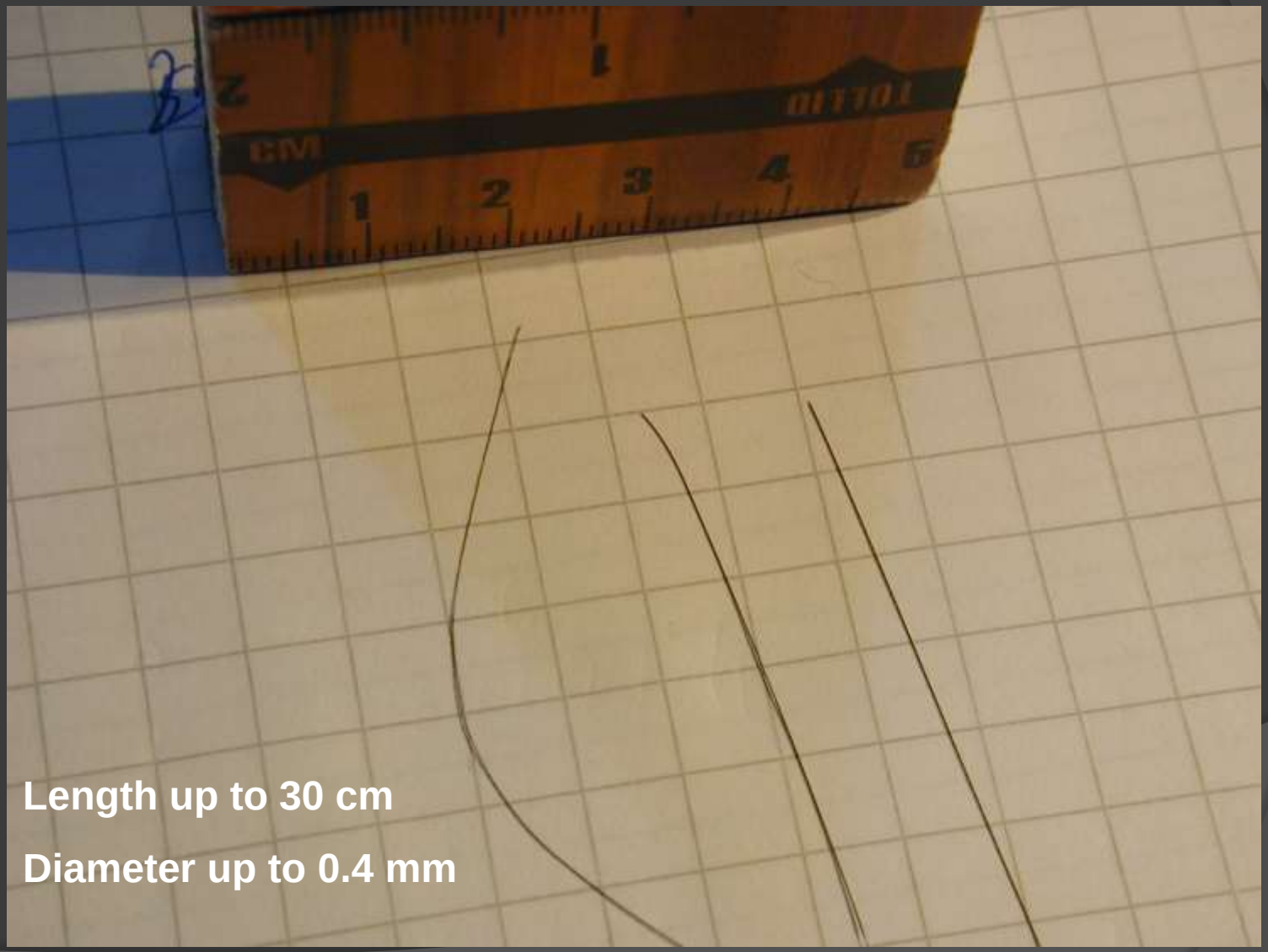
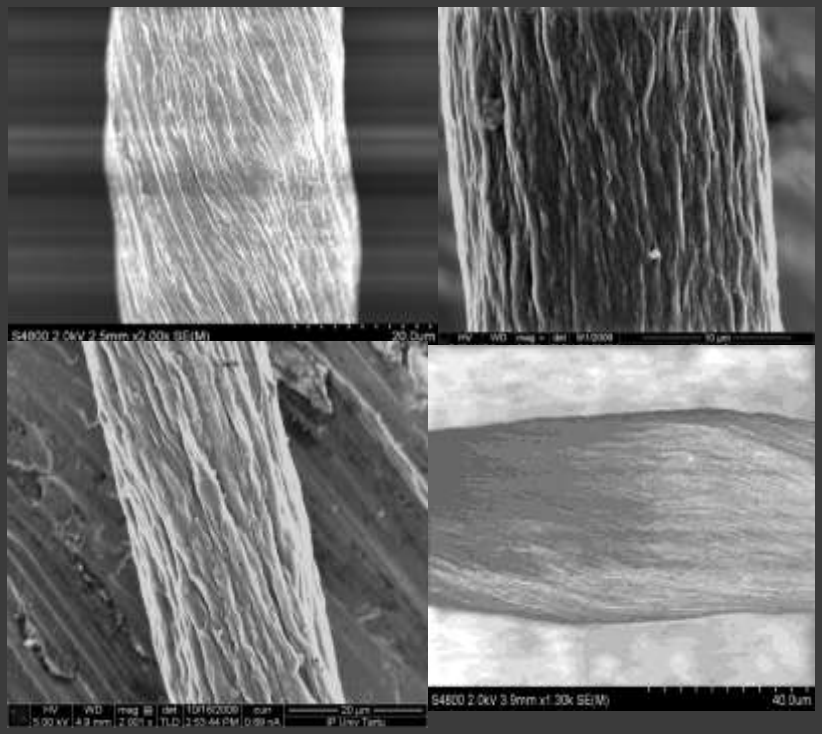


Photo of fibers

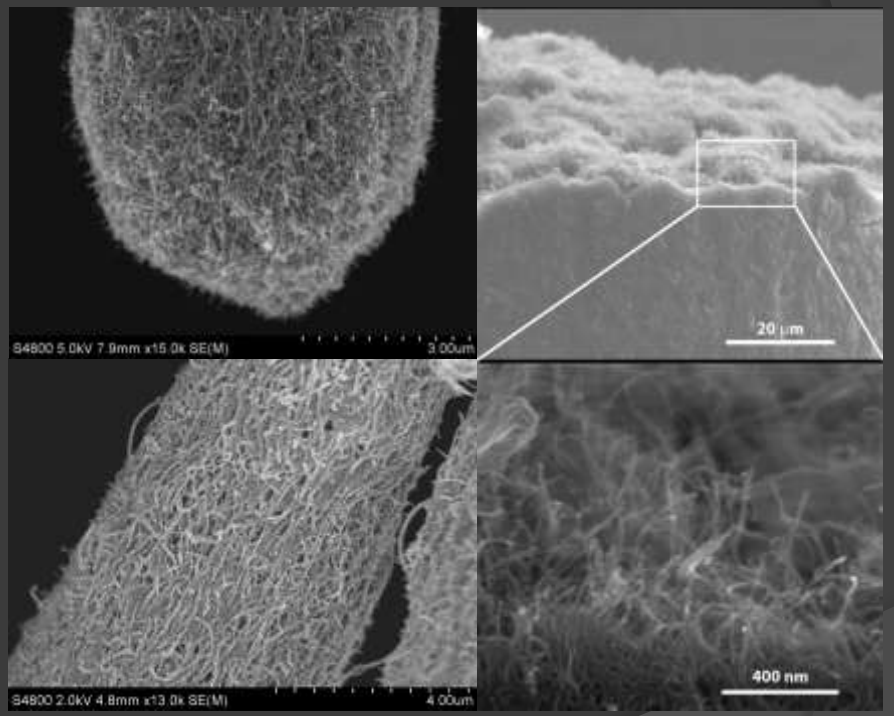


SEM images of fibers

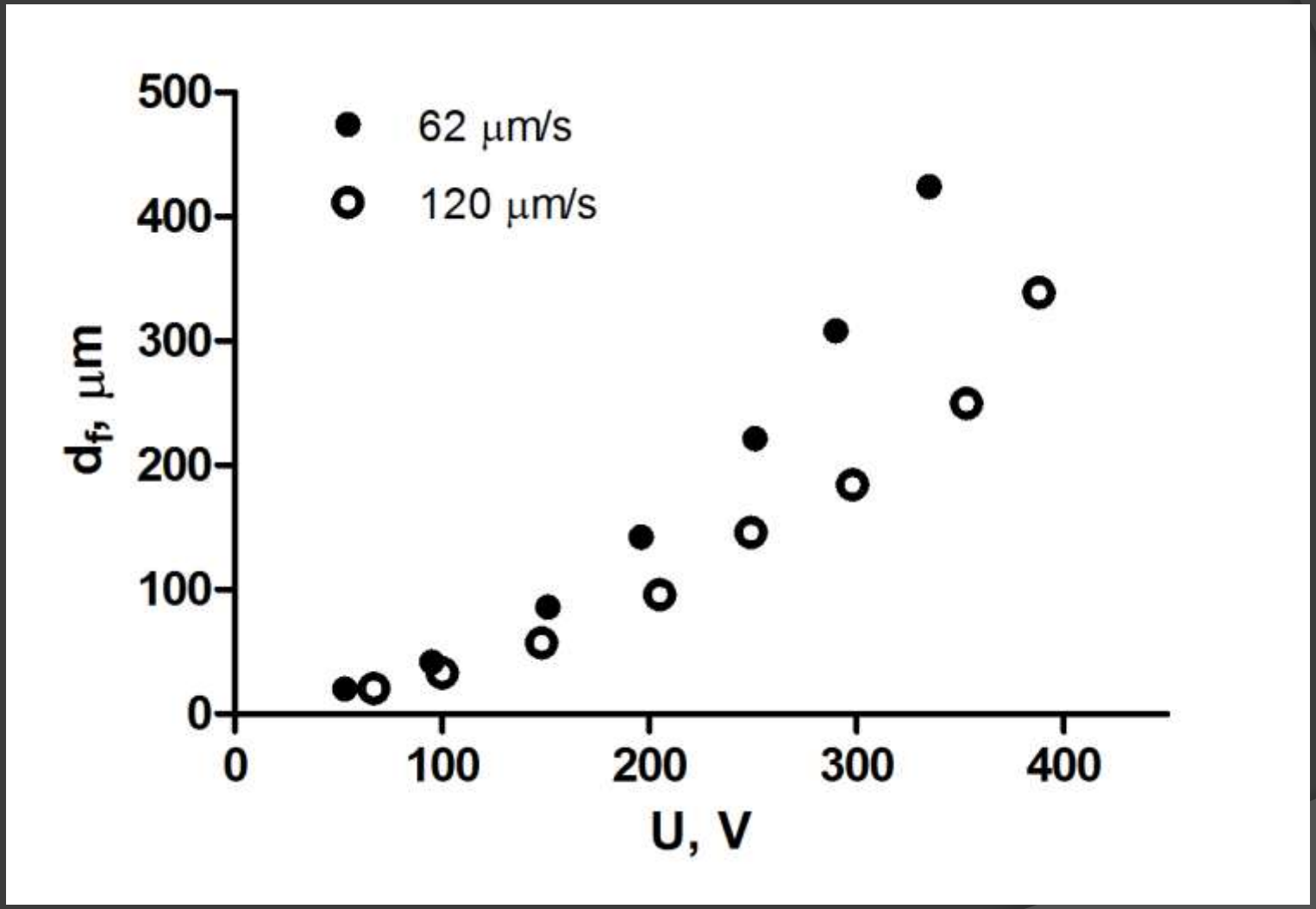
~ 500 μm MWCNT (~300 MPa)



0.5-200 μm MWCNT (~10 MPa)

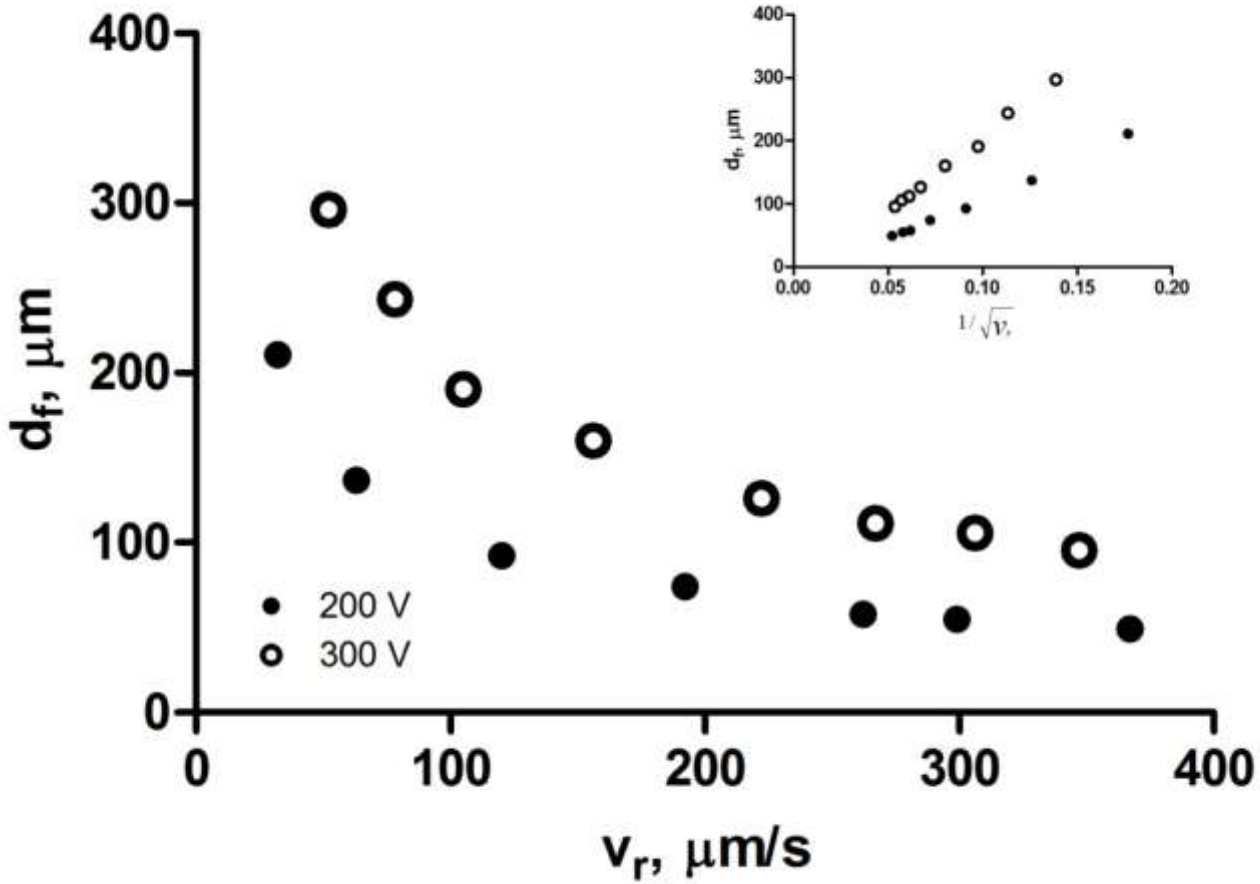


Fiber diameter vs applied voltage



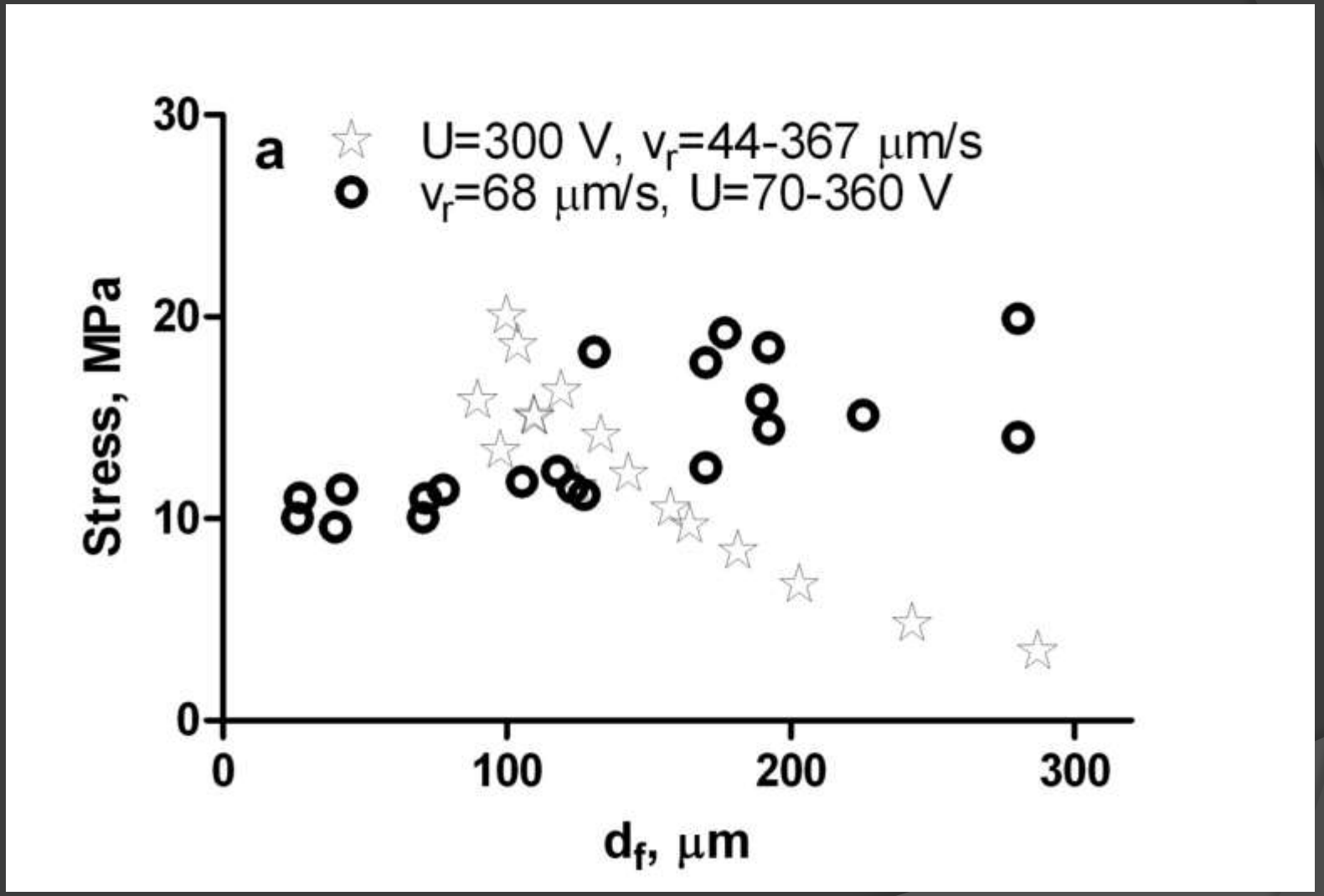
$d_{fiber} = Const \times U^{1.6}_{applied} \times v^{-1/2}_{retraction}$

Fiber diameter *vs* drawing speed



$d_{fiber} = Const \times U^{1.6}_{applied} \times v^{-1/2}_{retraction}$

Fiber tensile strength *vs* fiber diameter



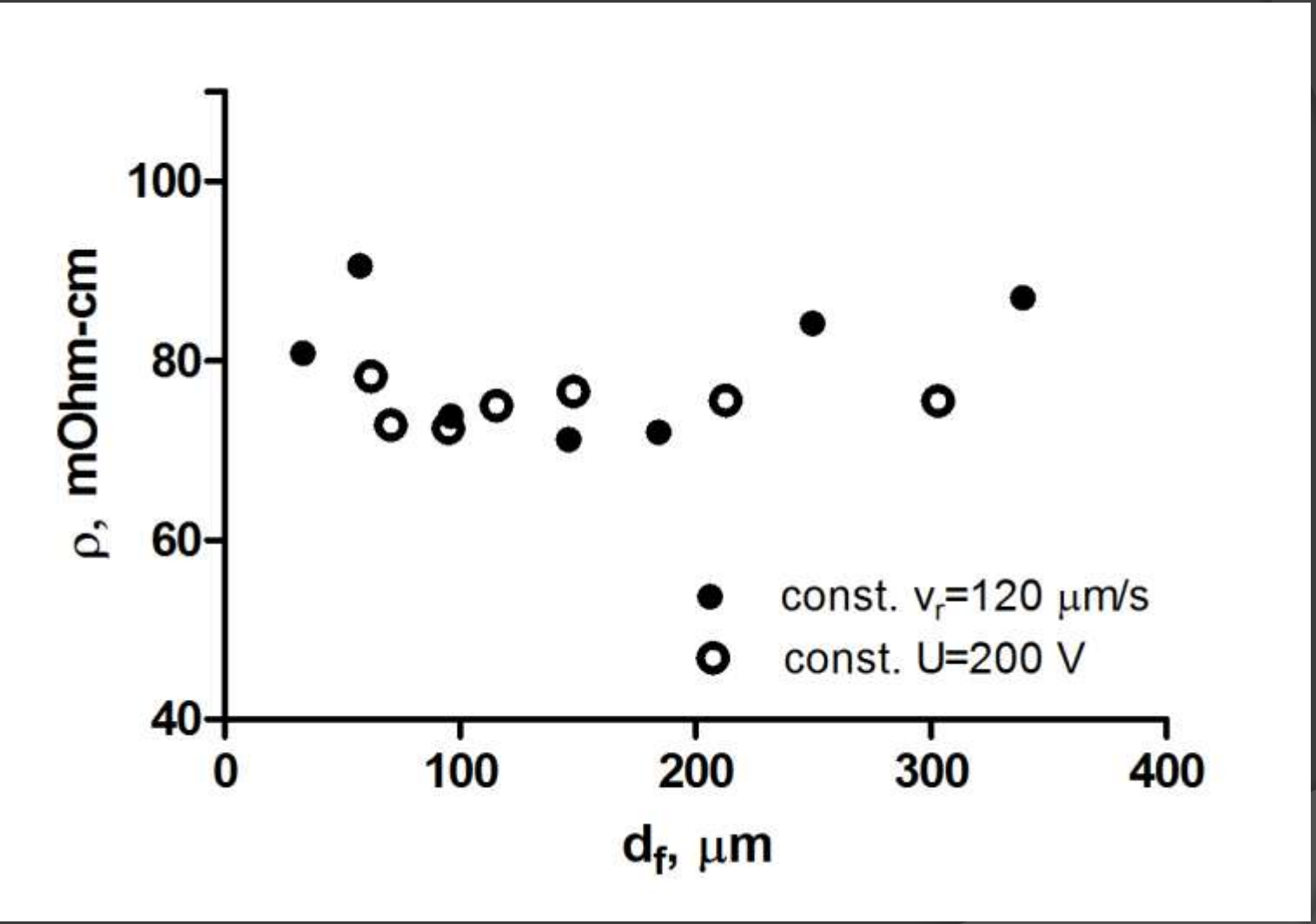
Fiber density

Density was obtained for three sets of preparation parameters:

1. v_r= 57 μm/s, U = 155 V, density 0.30 g/cm^3
2. v_r= 57 μm/s, U = 255 V, density 0.36 g/cm^3
3. v_r= 112 μm/s, U = 255 V, density 0.34 g/cm^3

Fiber density is somewhat affected by applied voltage, but quite indifferent to retraction speed.

Fiber resistivity *vs* fiber diameter



Retraction speed and applied voltage have little effect on interfacial connections in terms of affecting the electrical resistivity.

Conclusions

- Thick (up to 0.4 mm) CNT-fibers can be obtained using dielectrophoresis.
- CNT-fibers' tensile strength is affected by lenght of individual CNTs.
- Fiber diameter increases with increasing driving voltage, while the diameter is inversly related to drawing speed.
- The magnitude of the applied voltage seemingly contributes to the density and mechanical strength of the fiber, but has no effect on the electrical resistivity.

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Thank you very much for your attention!

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