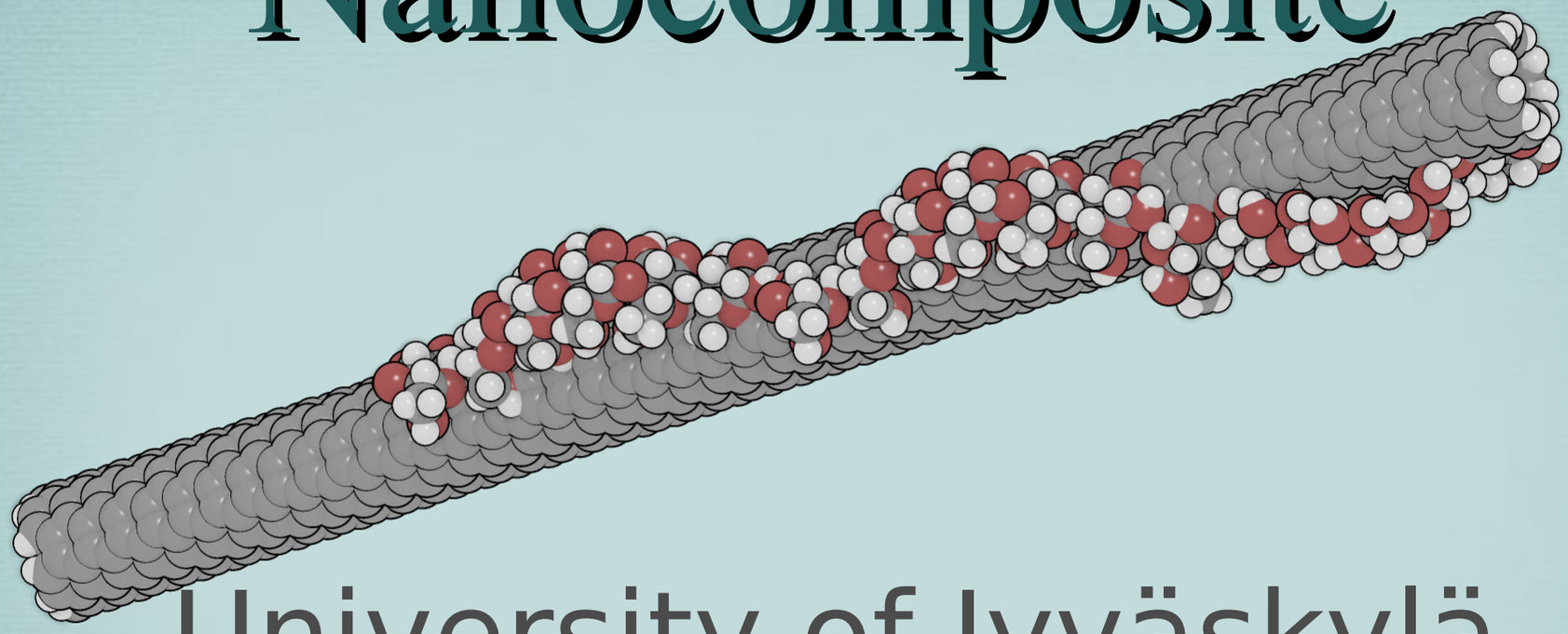
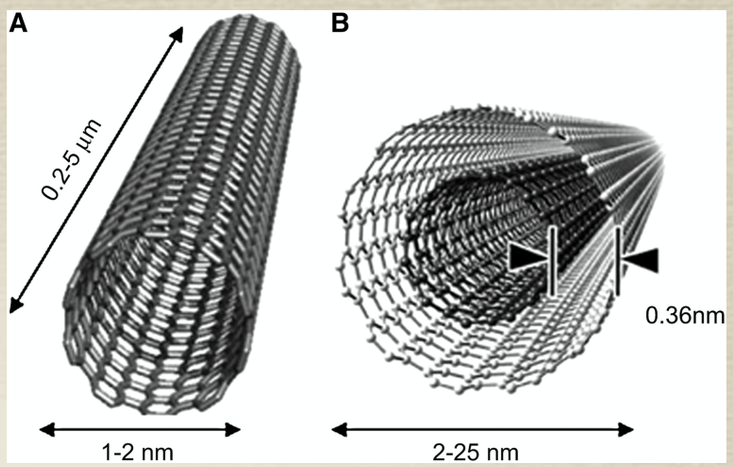
Carbon Nanotube Cellulose Nanocomposite



University of Jyväskylä
7.6. 2010
Pasi Moilanen
Nanotechnology clusters programme

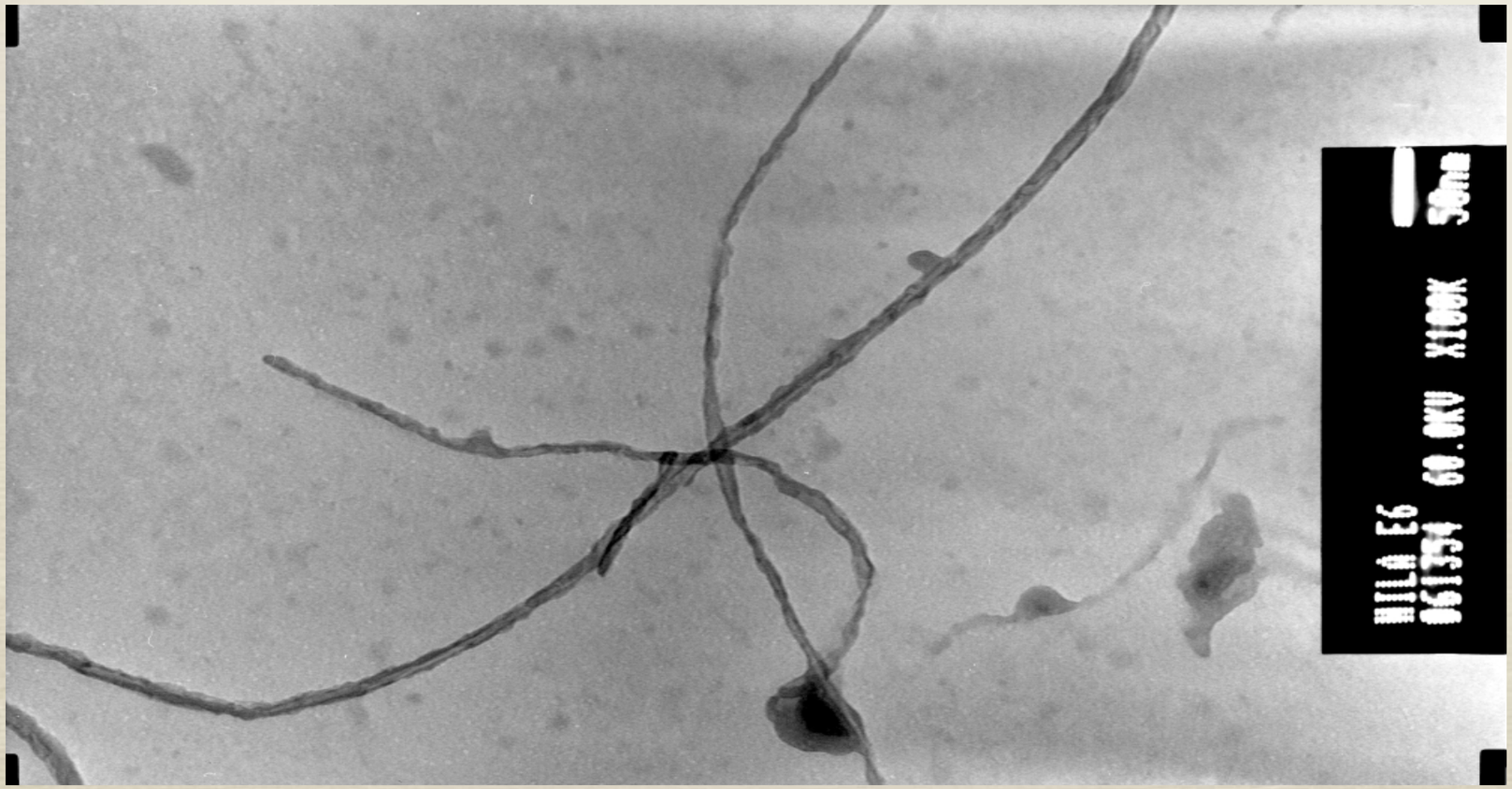
Carbon nanotubes



- Carbon nanotubes have many unique properties, their strength and conductivity are phenomenal.
- Also the shape of the carbon nanotubes suites well in applications where conductivity is needed. Thus their percolation threshold is much lower than for example carbon black's.
- Problem is that carbon nanotubes as such are almost impossible to harness for use in macroscopic applications
- One solution is cellulose, nature's most abundant polymer. Cellulose offers versatile and cheap matrix for carbon nanotubes.

Carbon nanotube cellulose nanocomposite

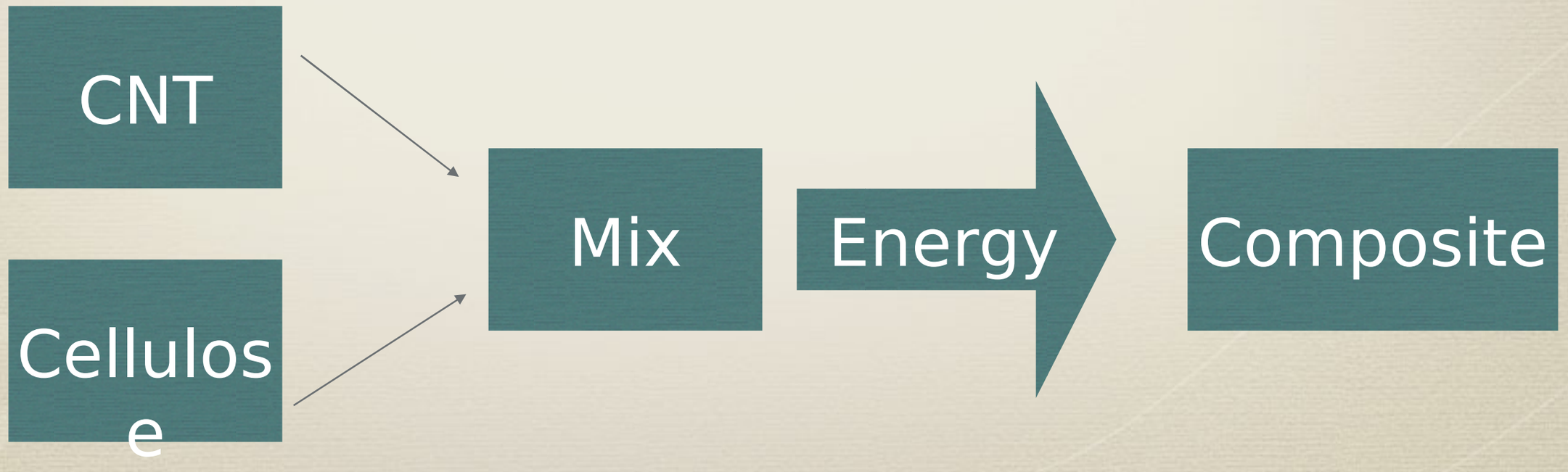
- Not just two solid materials mixed together
- Two materials interact at molecular level



TEM image

Preparation of composite

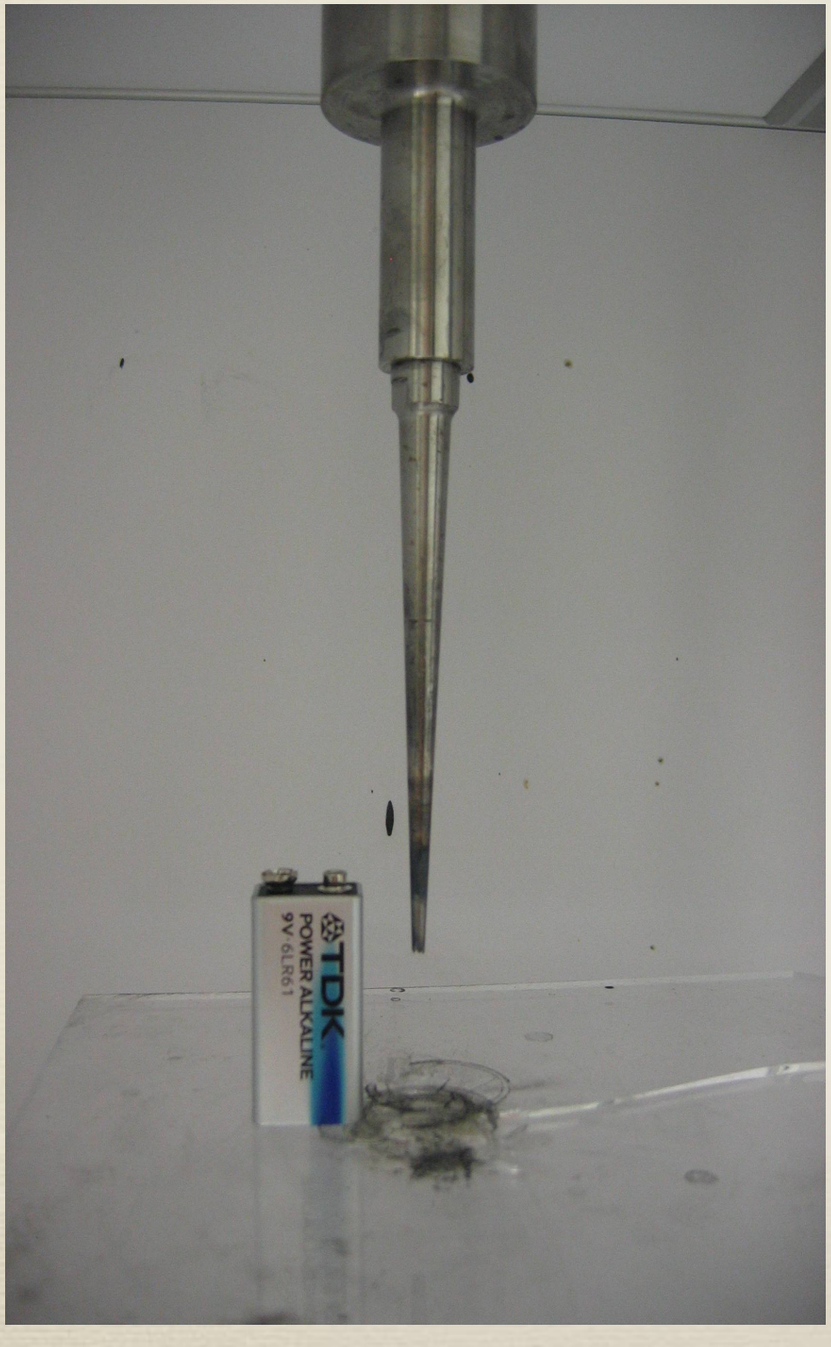
- Even though there is great deal of variables, the basic procedure is simple

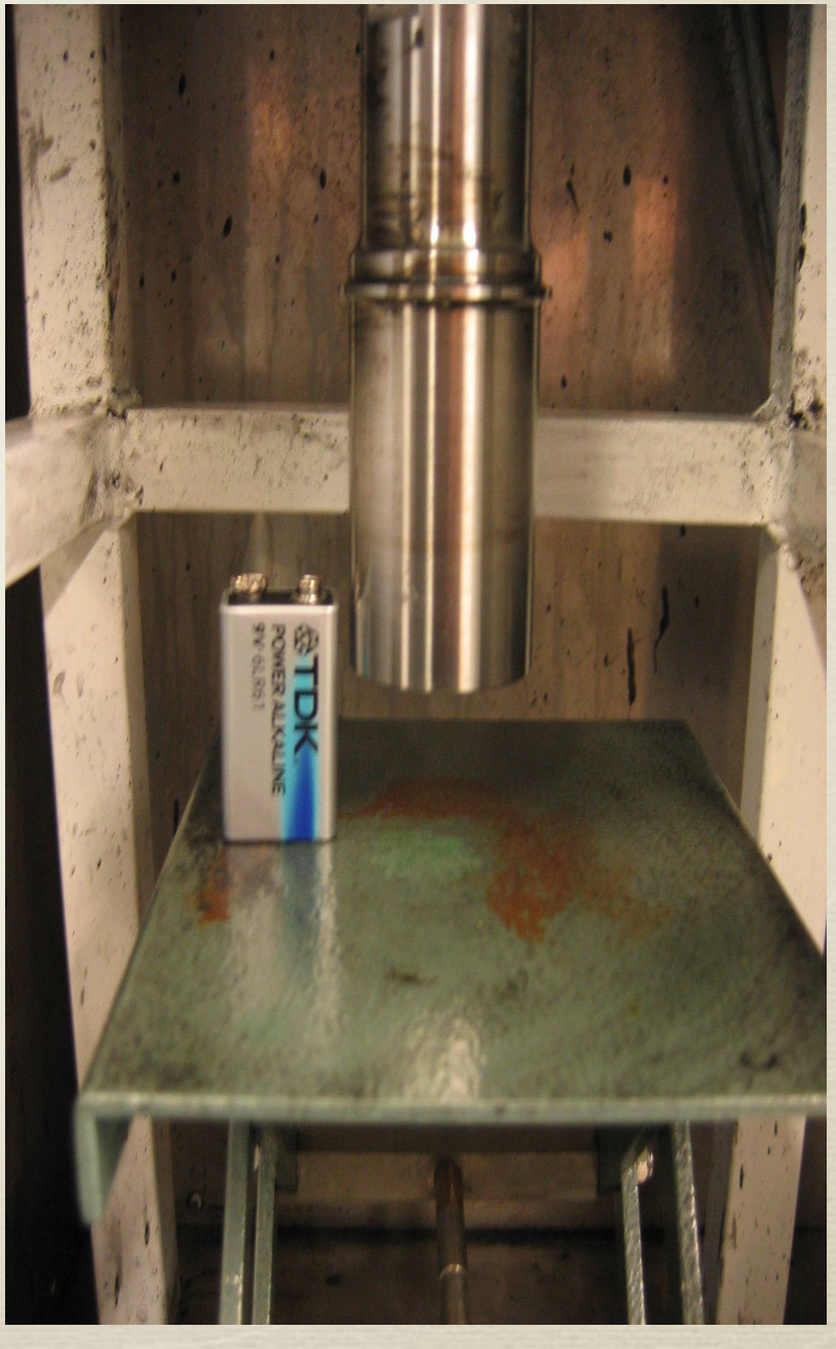


Preparation of composite

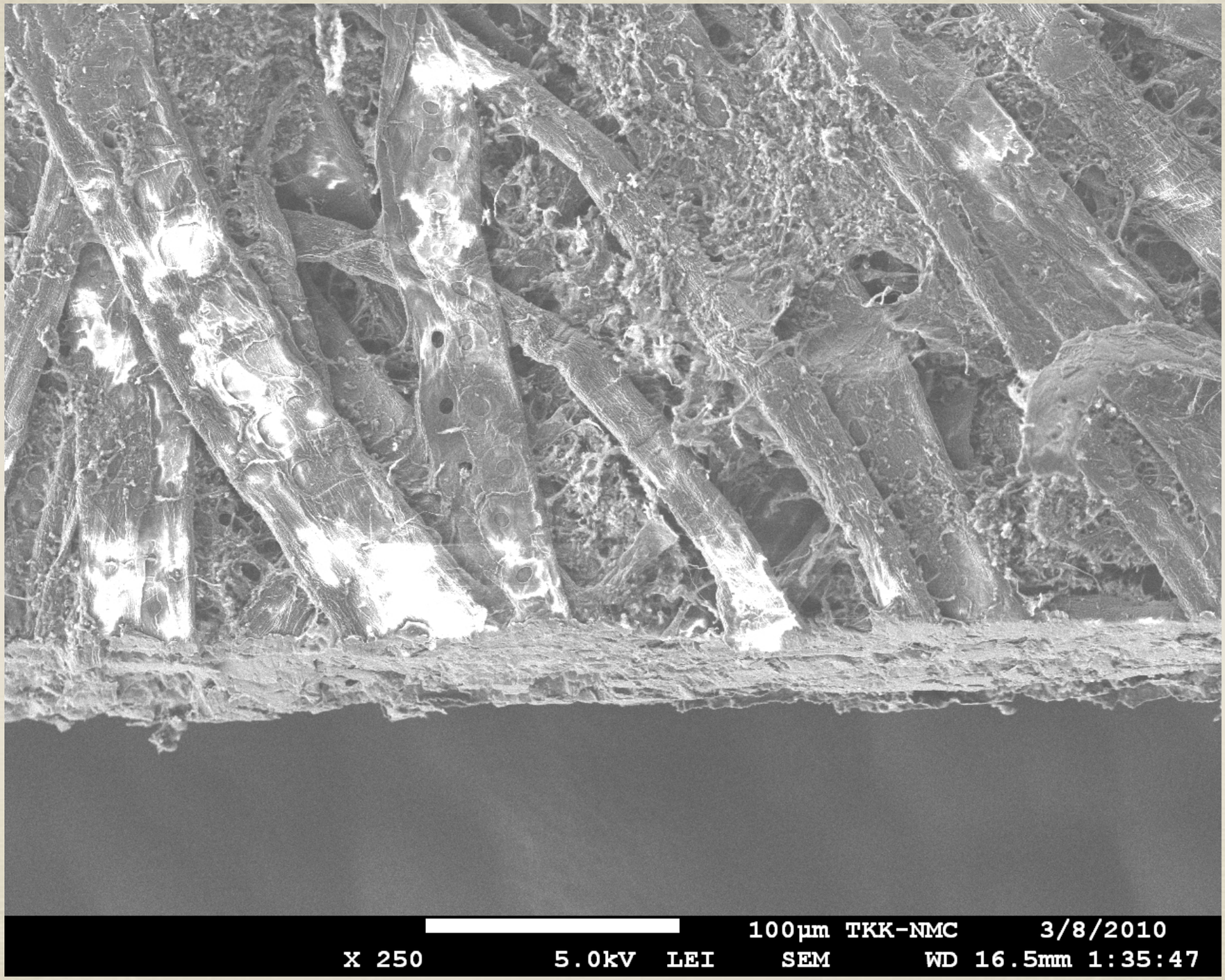
- Carbon nanotubes can be modified as well as cellulose can be one of its many derivatives
- Solvent can be selected accordingly, in our studies water is most often used
- Preliminary mixing can be made dry or wet, in this step bigger agglomerates are broken for example in mortar.
- Energy in our case is sonication, extruders could also be used

Preparation, equipment



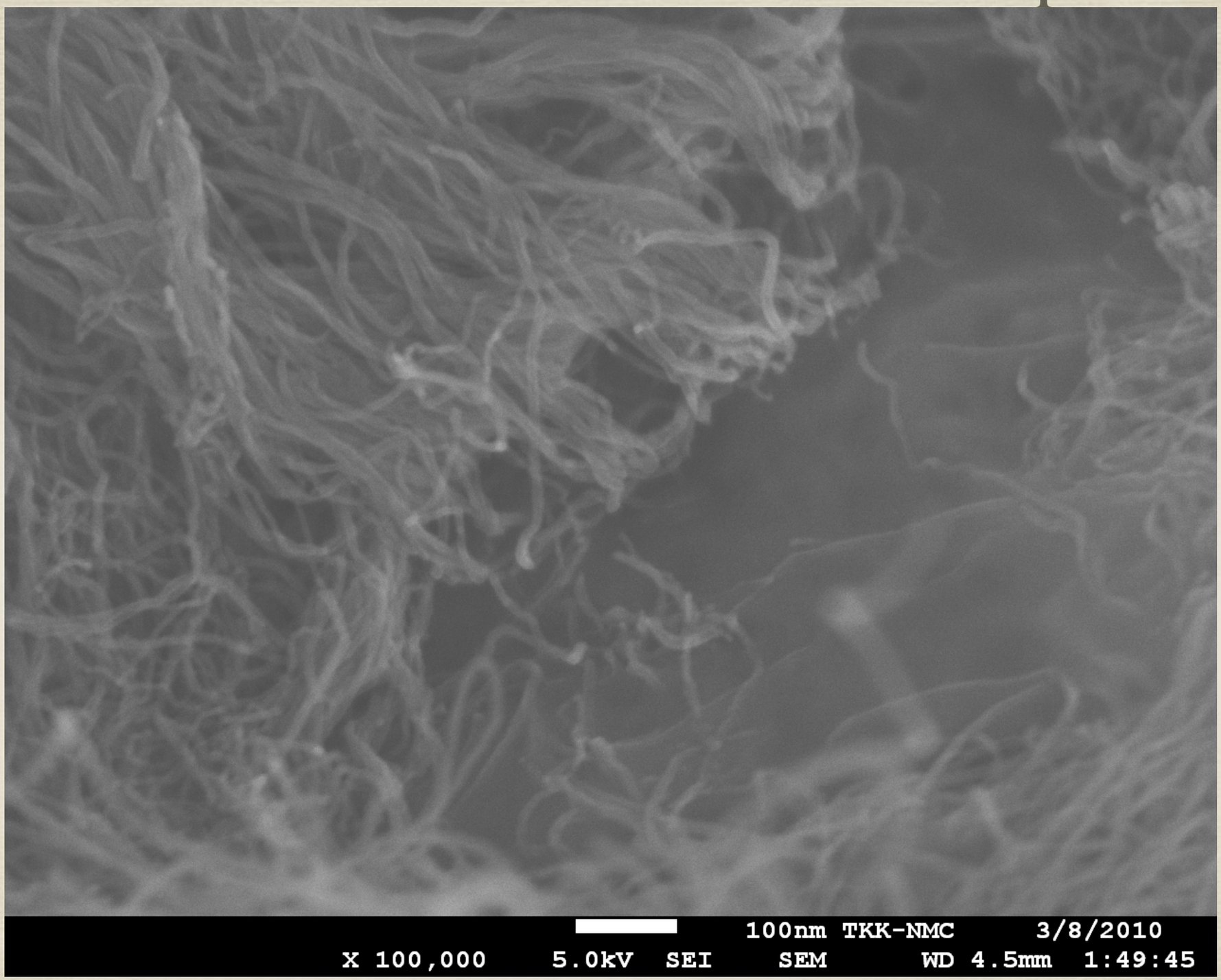


Carbon nanotube cellulose composite



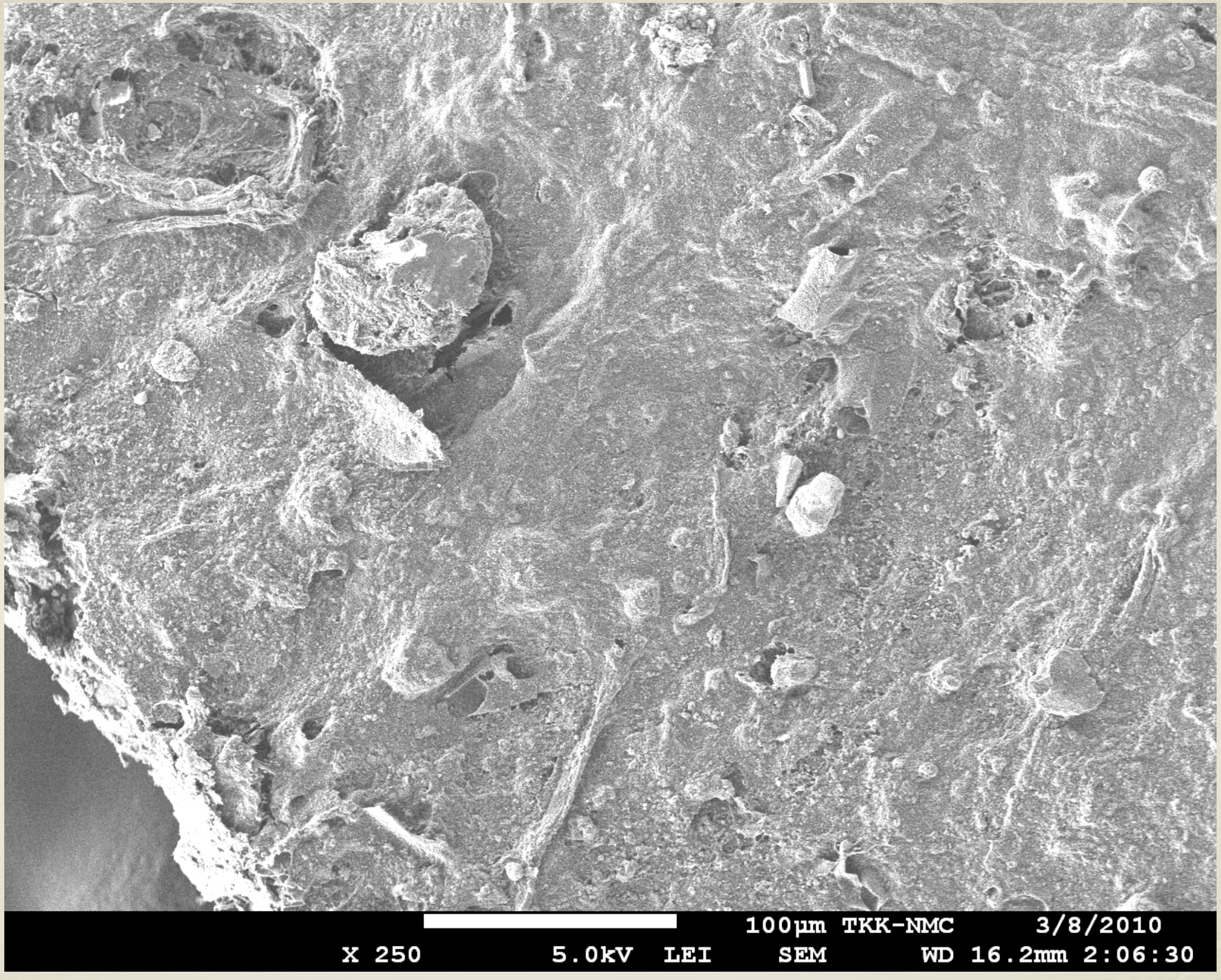
SEM image of CNT-cellulose composite, 250 x magnification.

Carbon nanotube cellulose composite



SEM image of CNT-cellulose composite, 100 000 x magnification.

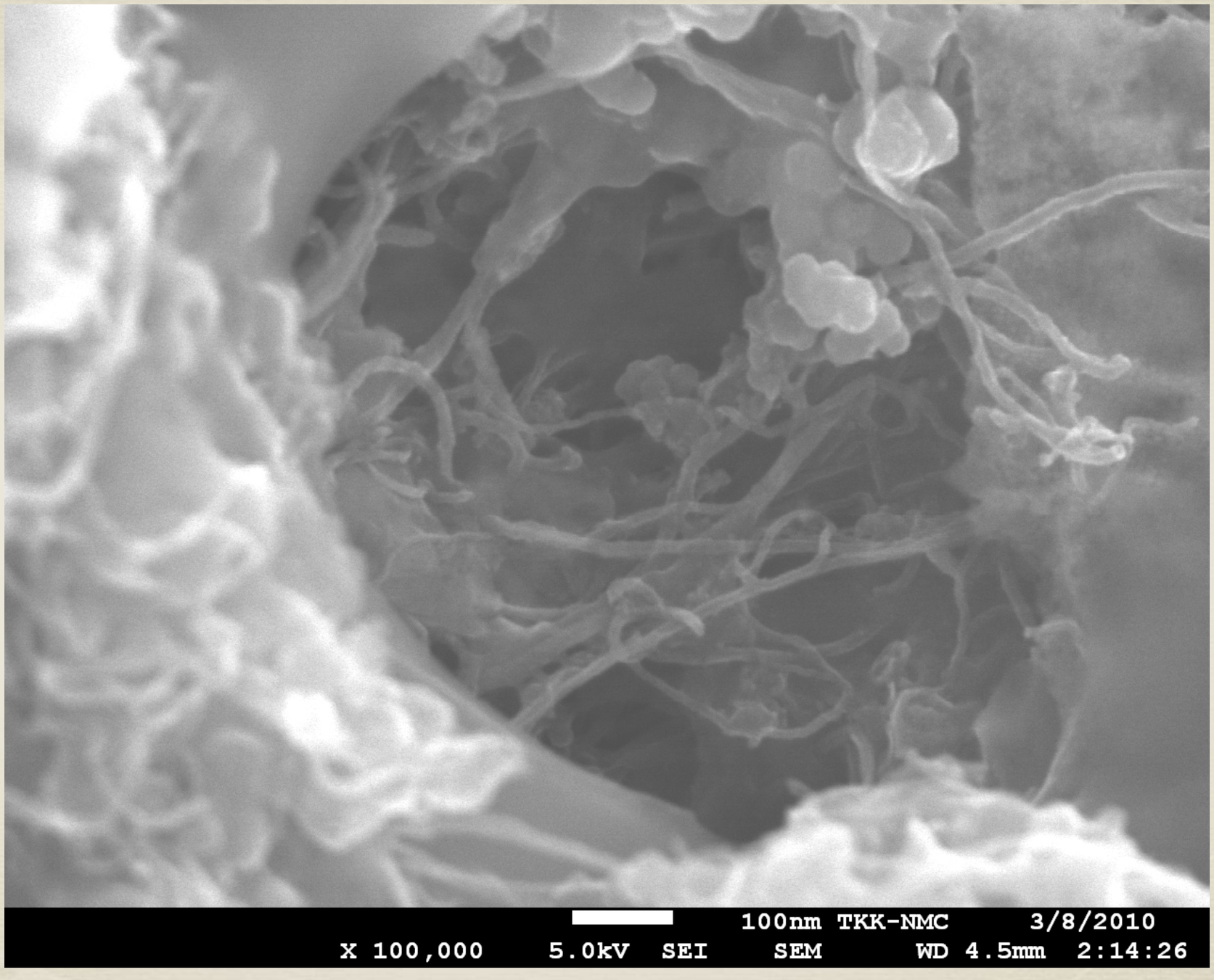
Carbon nanotube cellulose nanocomposite



SEM image of CNT-cellulose gel nanocomposite, 250 x magnification.

Cellulose gel is provided by mZymes Ltd.

Carbon nanotube cellulose nanocomposite



SEM image of CNT-cellulose gel nanocomposite, 100 000 x magnification.

Conductivity of CNT-cellulose composite

- Resistivities of composite as a function of CNT mass percentage

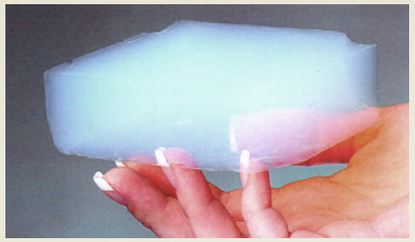
Applications

- Is it possible to introduce some of the properties of carbon nanotubes to cellulose?
- Electric conductance? Yes
- More strength to paper? Not so far

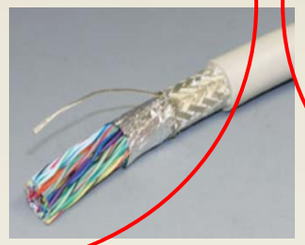
POTENTIAL PRODUCTS

Conductive CNT Paste

Aerogel

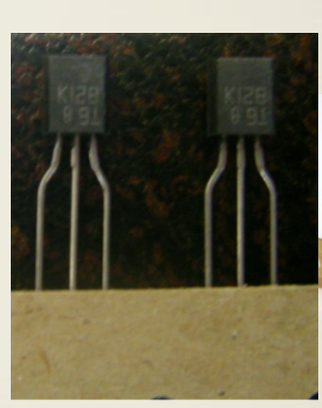


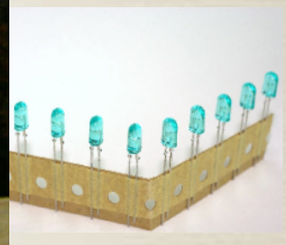
EMI-Shielding



Super Capacitor

Taping

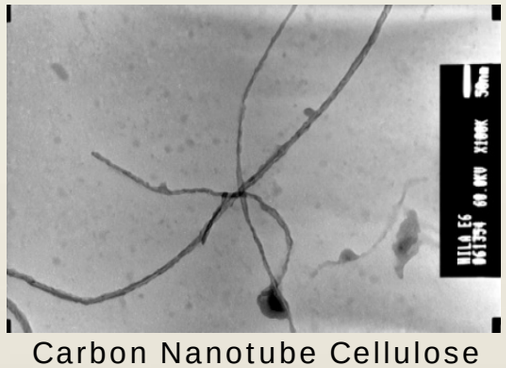




Electro Static Speaker

Component Carrier

ECOLOGY

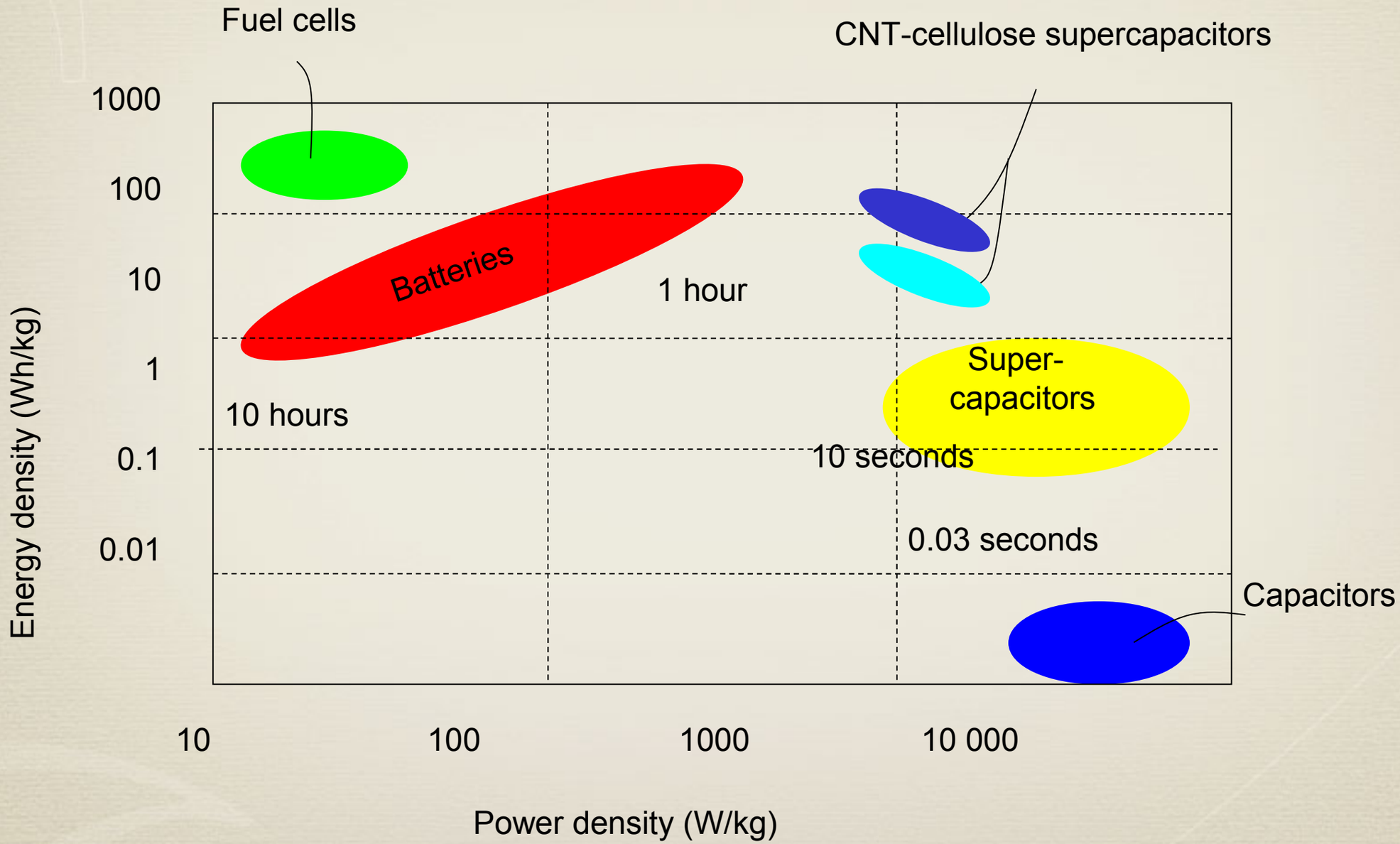


Carbon Nanotube Cellulose Nanocomposite Technology by Finnish University
Shielding / Capacitor / Speaker

nEMCel ltd.

www.nemcel.com

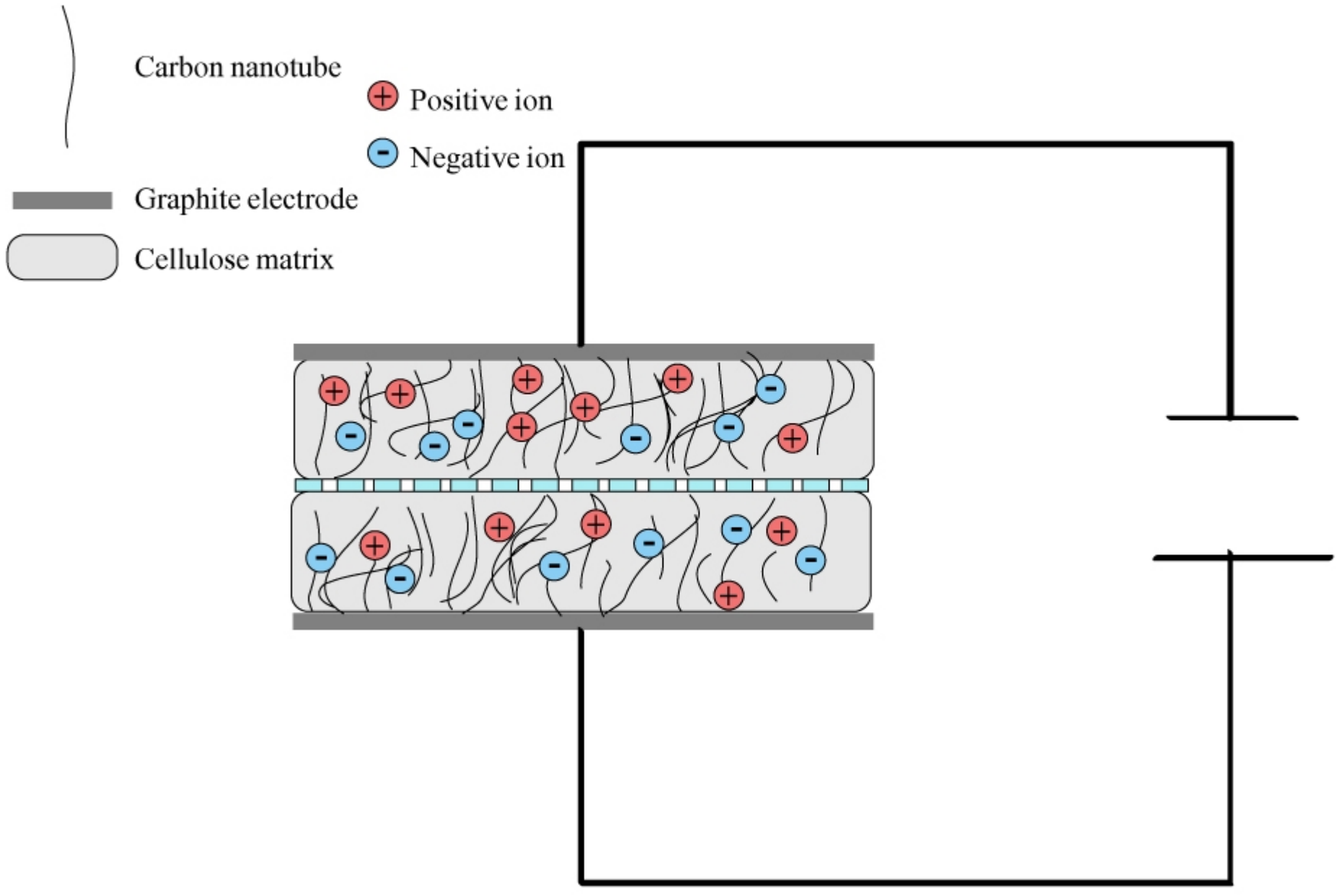
Electric Storage



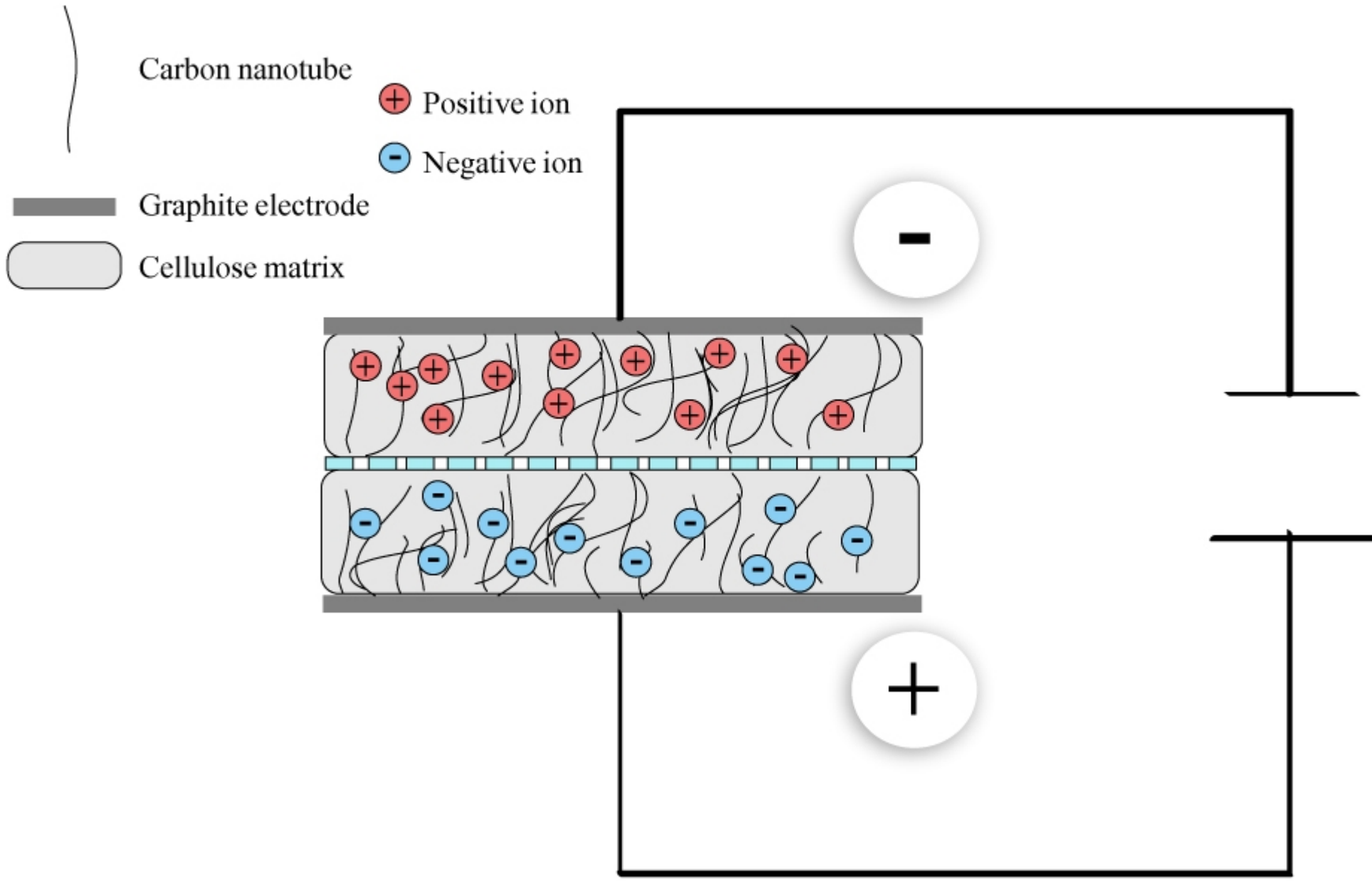
Supercapacitor

- One of the most promising areas of research.
  - ✳ Capacitance of capacitor $C = \epsilon_r \frac{A}{d}$
- CNT’s have very large area, cellulose helps in dispersion and thus in reaching higher capacitances.

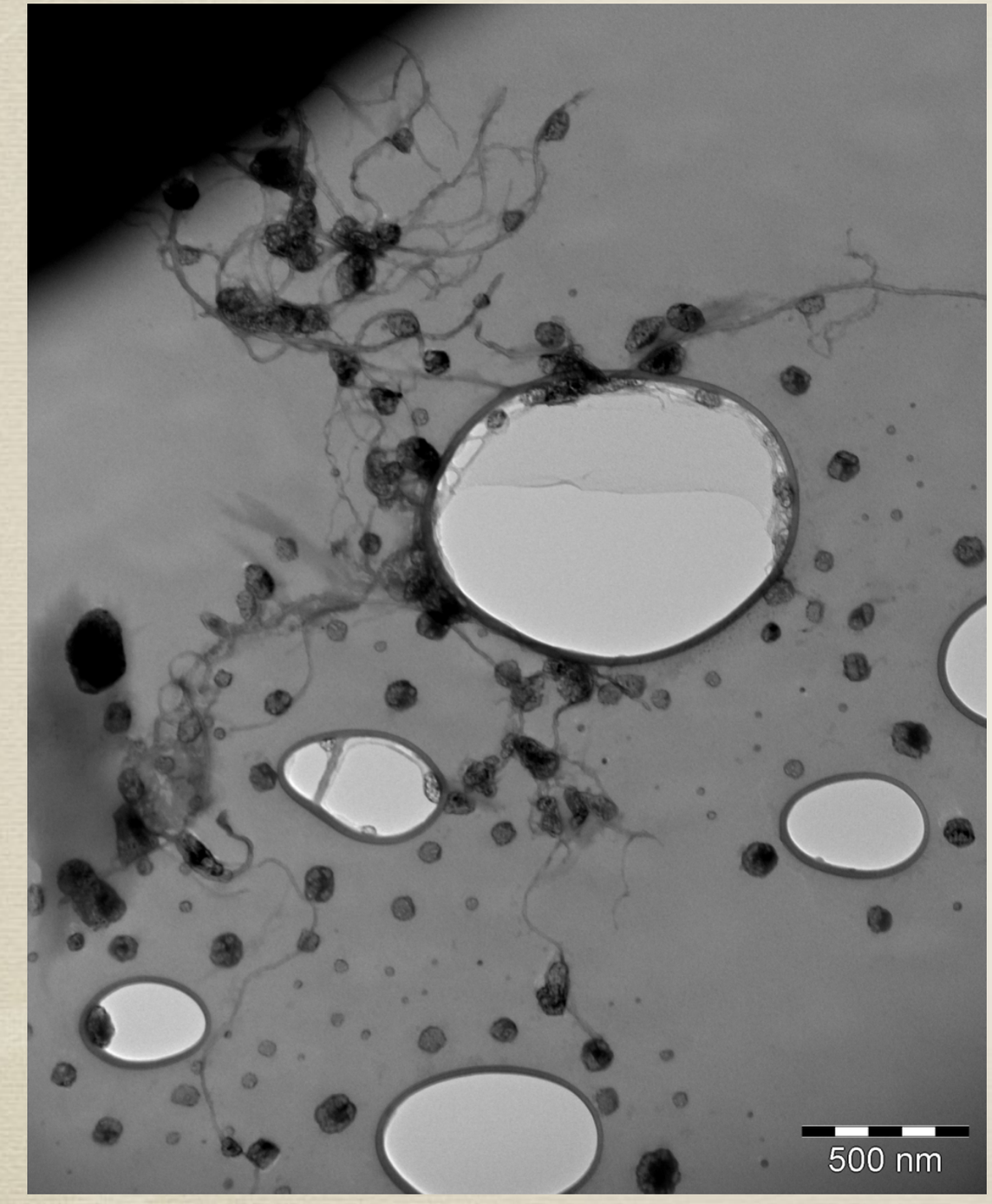
Capacitor when potential is not applied

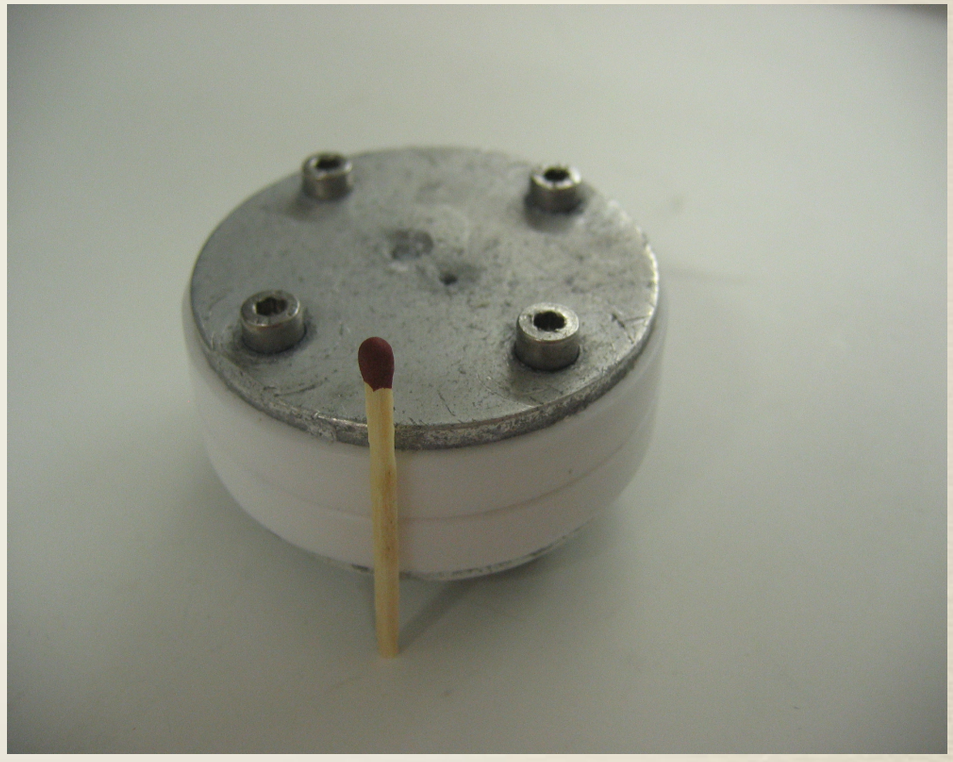


Capacitor when potential is applied

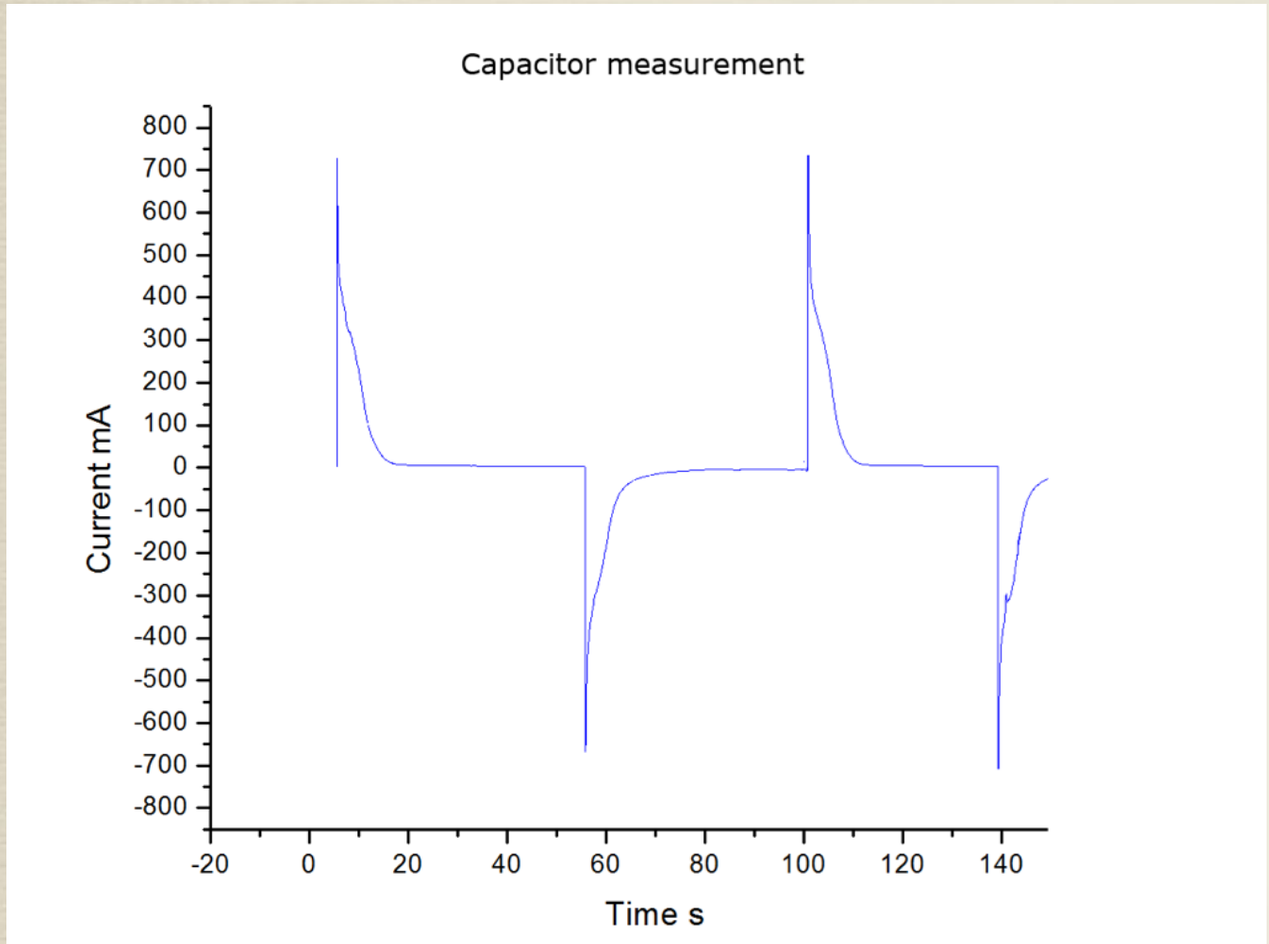


Supercapacitor





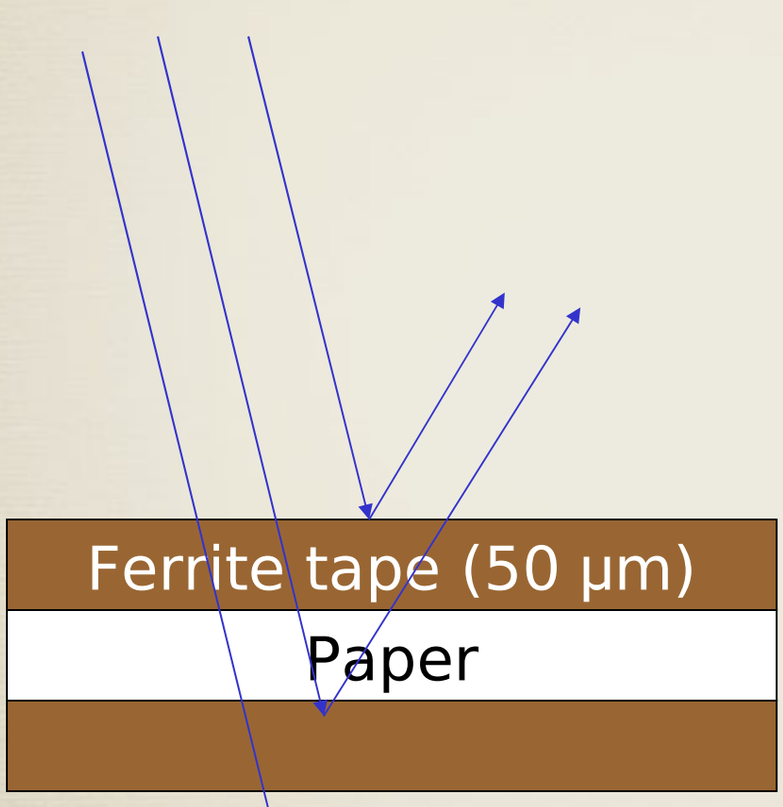
Supercapacitor

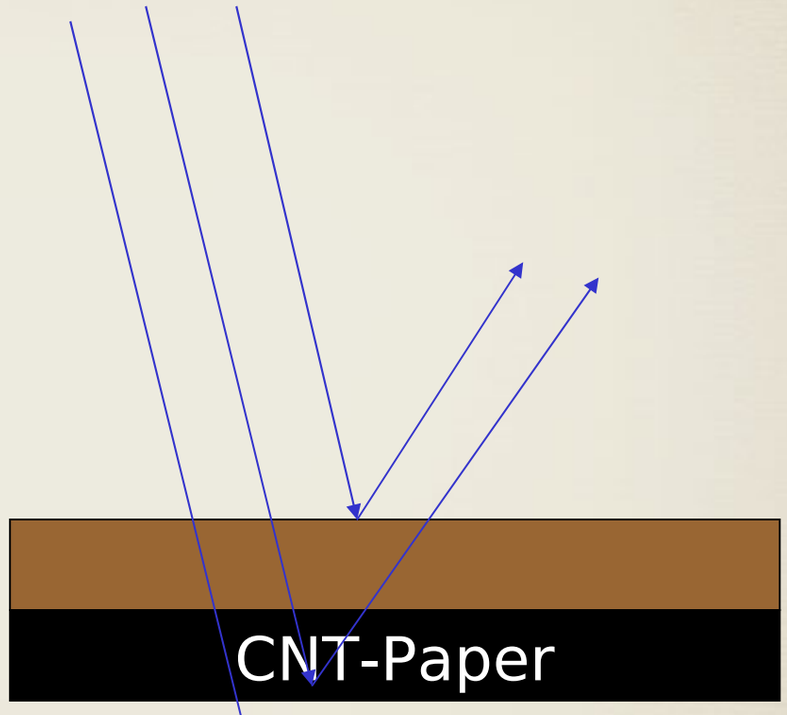


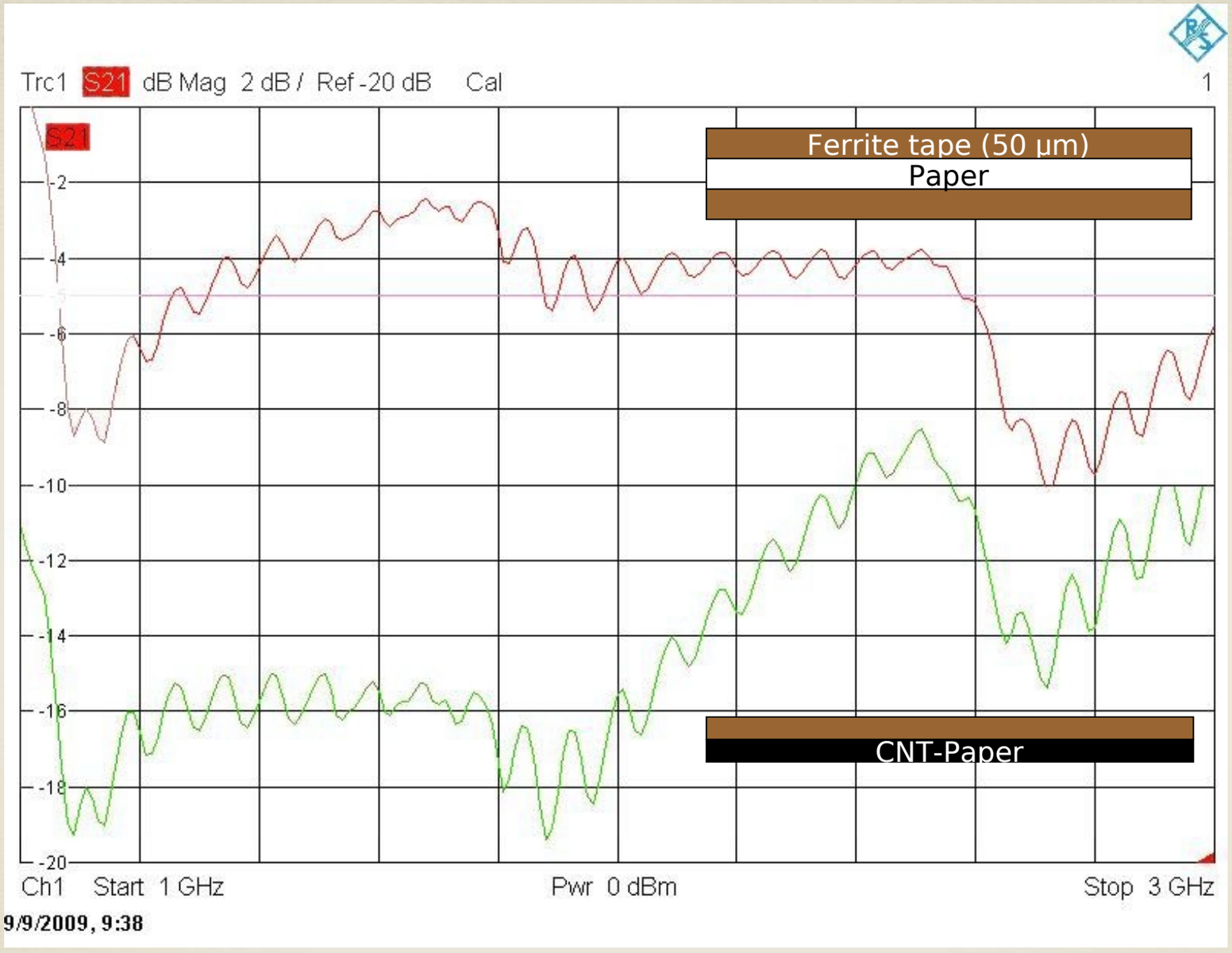
- The best measured specific capacitance so far is about 1000 F/g
- As we are using water based electrolyte, voltage is limited to bit over 1V

EMI-shielding

Electromagnetic radiation






Trc1 S21 dB Mag 2 dB / Ref -20 dB Cal
1
S21
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
Ferrite tape (50 μm)
Paper
CNT-Paper
Ch1 Start 1 GHz
Pwr 0 dBm
Stop 3 GHz
9/9/2009, 9:38

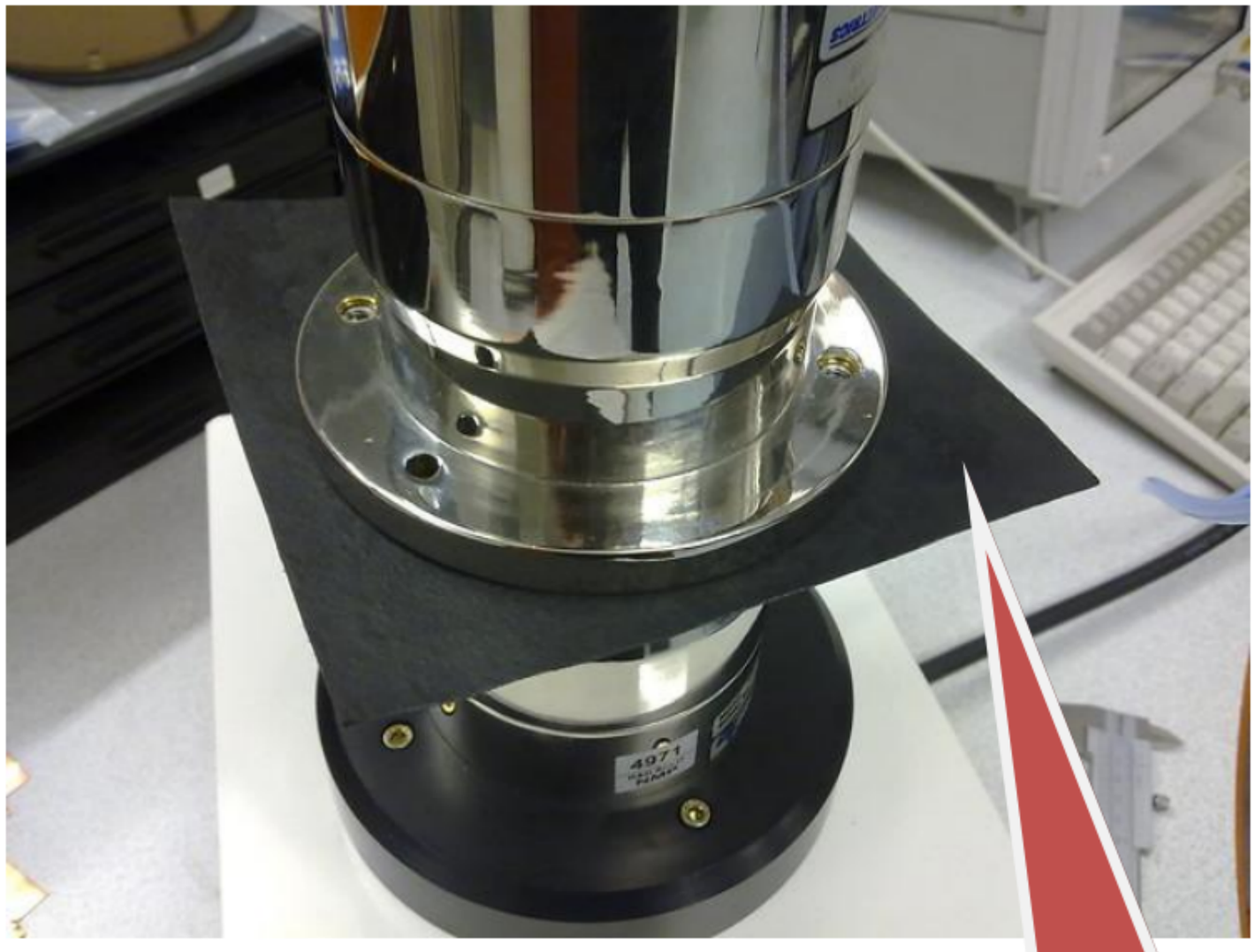


Fig. 14. Test sample assembly in Jig.

Sample nr	Supplier	Shielding Effectiveness @1.5GHz	Surface Resistanse (Ω/cm²)	Volume resistanse (Ω)
1	nEMCEL	25.5 dB	22	60
2	Competitor A	15.7dB	173	∞
3	Competitor B	9.1dB	1.1k	∞
4	nEMCEL	CNT ink; 1 layer (cellulose substrate)	0.56dB	11000
5	nEMCEL	CNT ink; 2 layers (cellulose substrate)	2.33dB	1200
6	nEMCEL	CNT ink; 4 layers (cellulose substrate)	7.09dB	300

Future challenges

-Larger scale production

-Optimization (goal at least 30dB) and installation of EMI-shields

-Partners for further research and applications

Thank you for listening!

- I would like to thank professor Jorma Virtanen, Elja Kallberg, nEMCel and MZYMES. Also I would like to thank people at Nanotechnology clusters programme, early days Dr. Petri Nyberg, and recently Dr. Mauno Harju.

MZYMES
ENZYME TECHNOLOGIES FOR FUTURE

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