

Nanofabrication with Peptide and Protein tubes

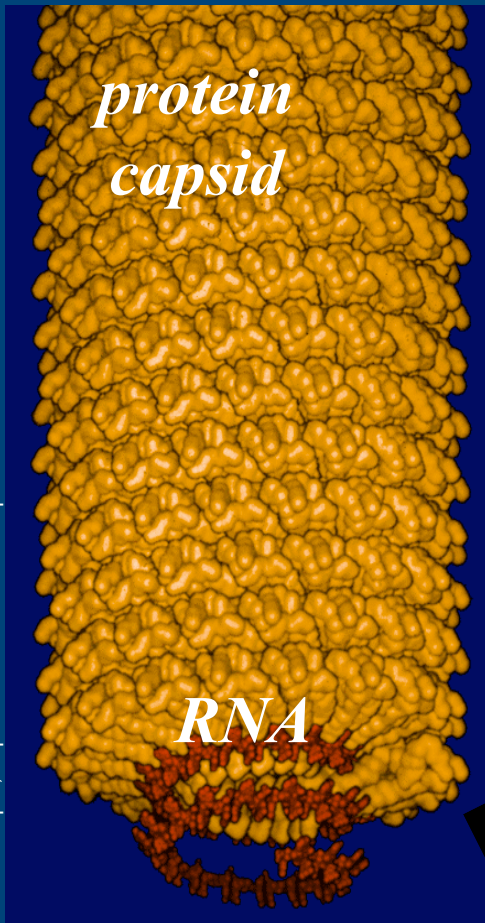
Alexander Bittner

Group "Self-Assembly"

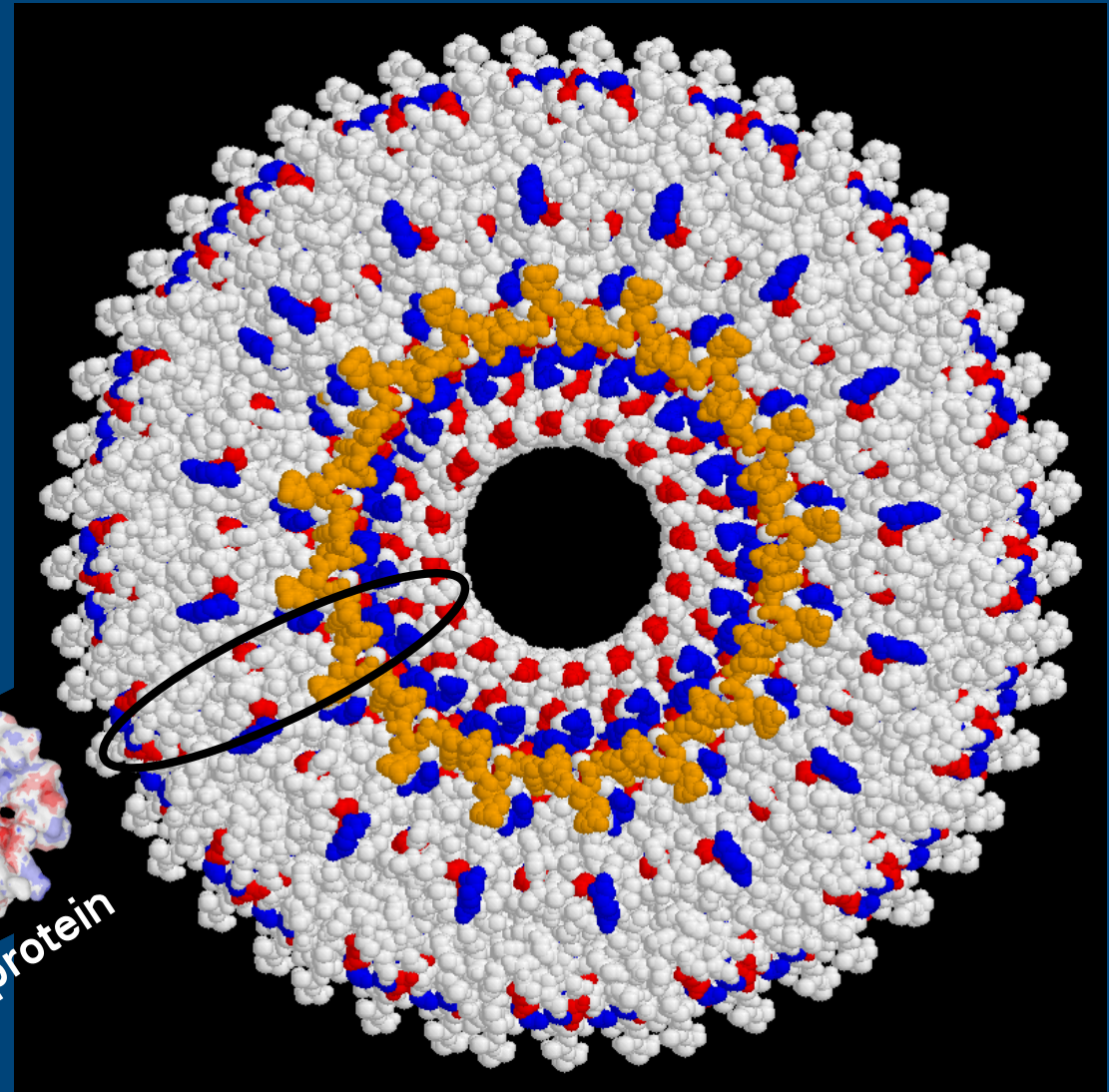
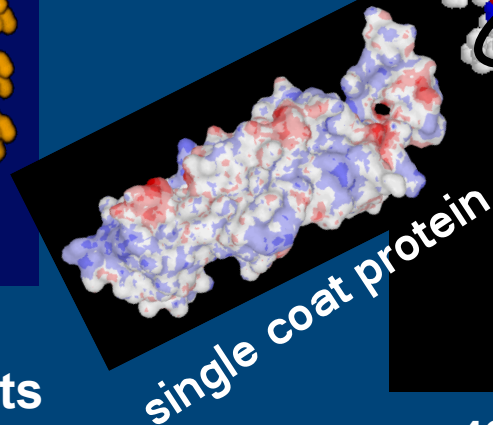
CIC Nanogune Consolider, Donostia-San Sebastian, ES



Tobacco mosaic virus (TMV)



viral rod (partial)
2100 protein subunits
300 nm length

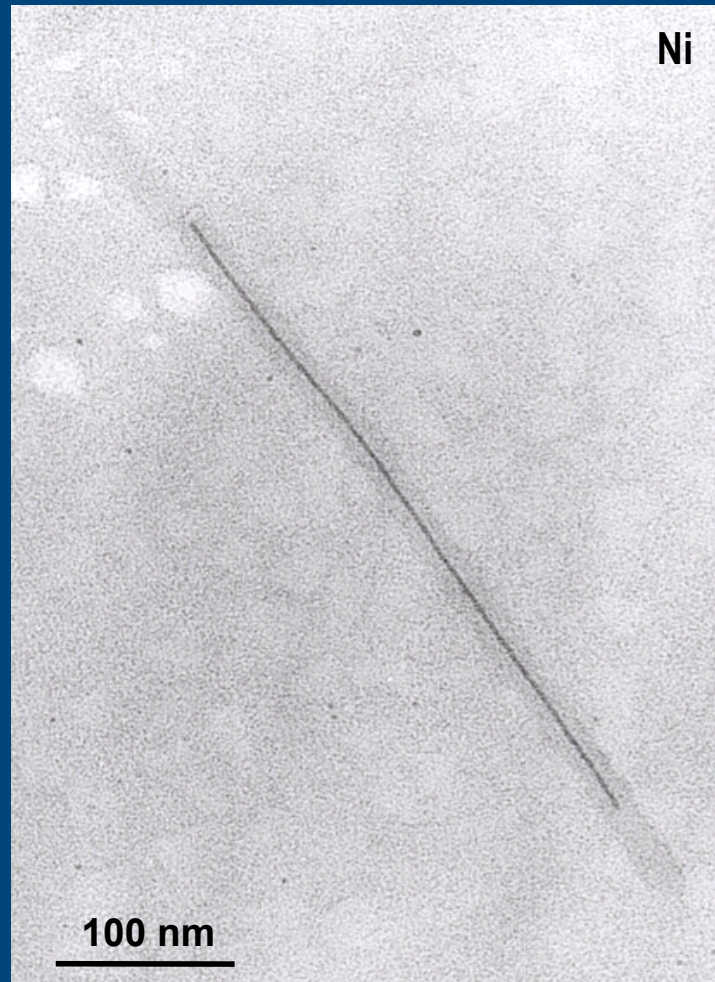


Molecular models of the virus:

K. Henrick, J.M. Thornton, Trends Biochem. Sci. 23 (1998) 358; <http://pqs.ebi.ac.uk/pqs-bin/macmol.pl?filename=1vtm>

R. Pattanayek, G. Stubbs, J. Mol. Bio. 228 (1992) 516; K. Namba, R. Pattanayek, G. Stubbs, J. Mol. Bio. 208 (1989) 307

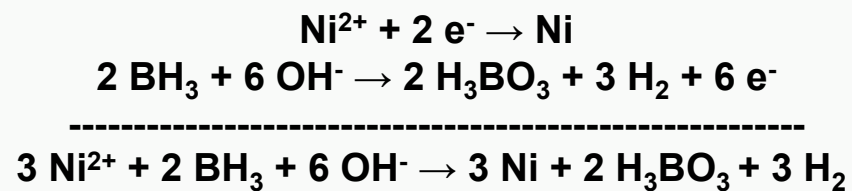
3 nm metal wires inside TMV



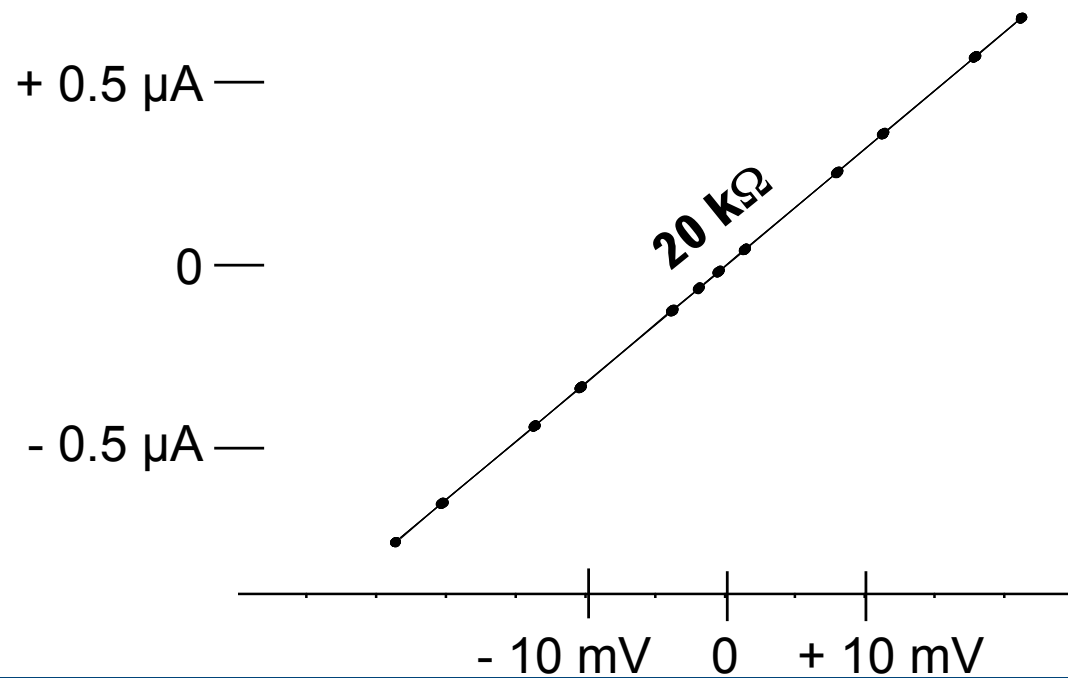
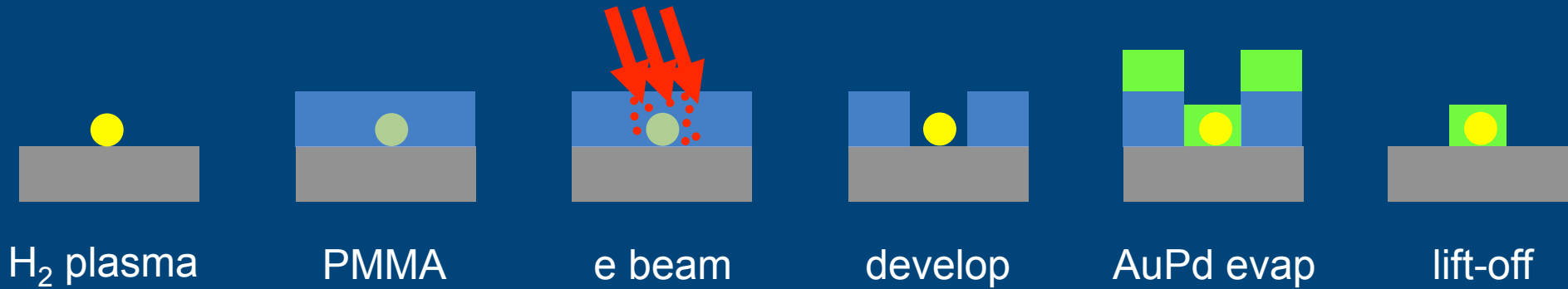
**Knez et al,
Nano Lett. (2003)**

TEM after Pd(II) activation and Ni deposition

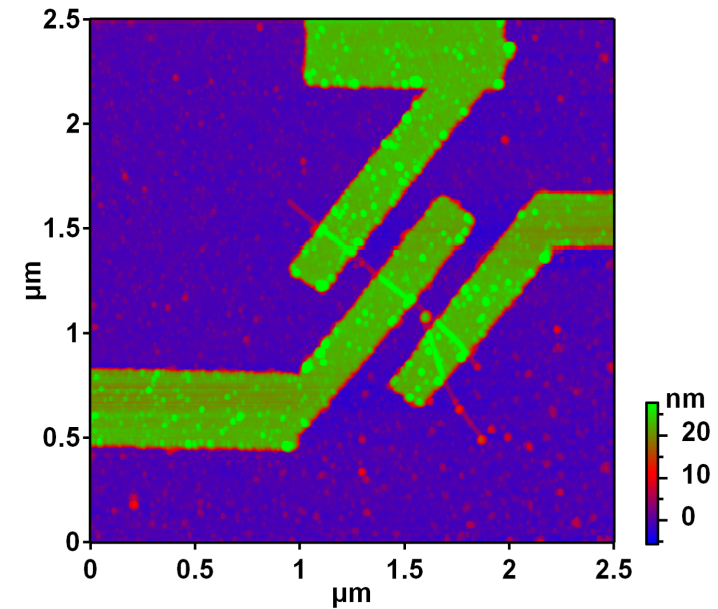
**Balci et al.,
Adv. Mater. (2008)
Angew. Ch. (2007)
Elec. Acta (2006)**



Electrically contacted 3 nm nickel wires

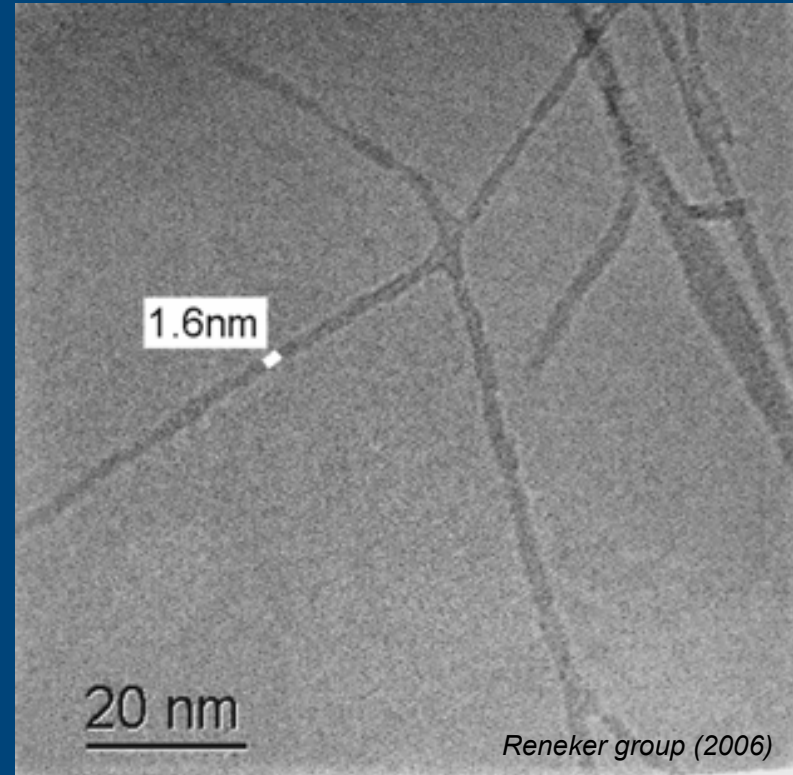
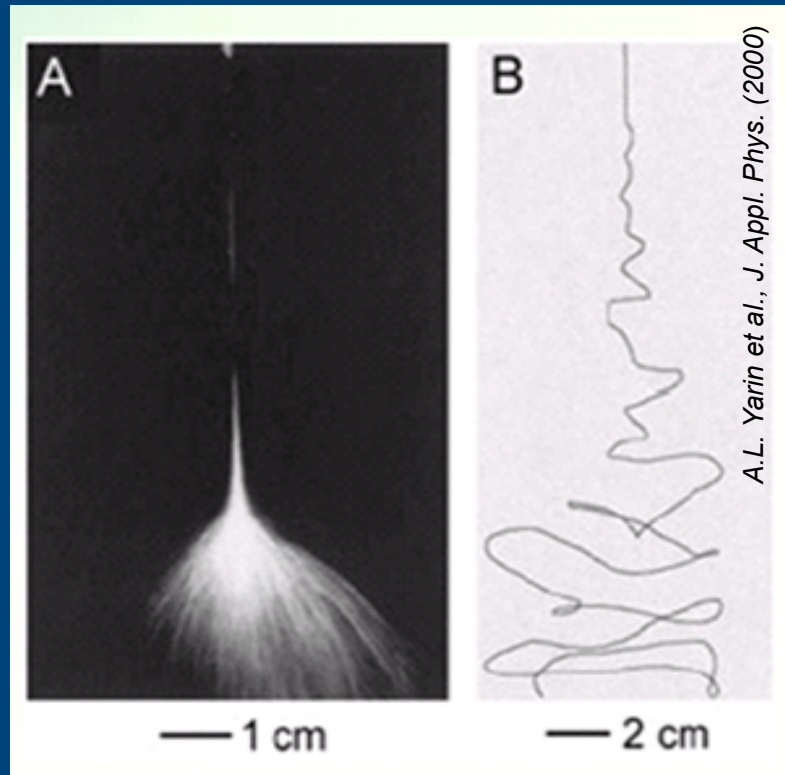


Current-voltage curve



AFM topography

Electrospinning (of dissolved polymers)



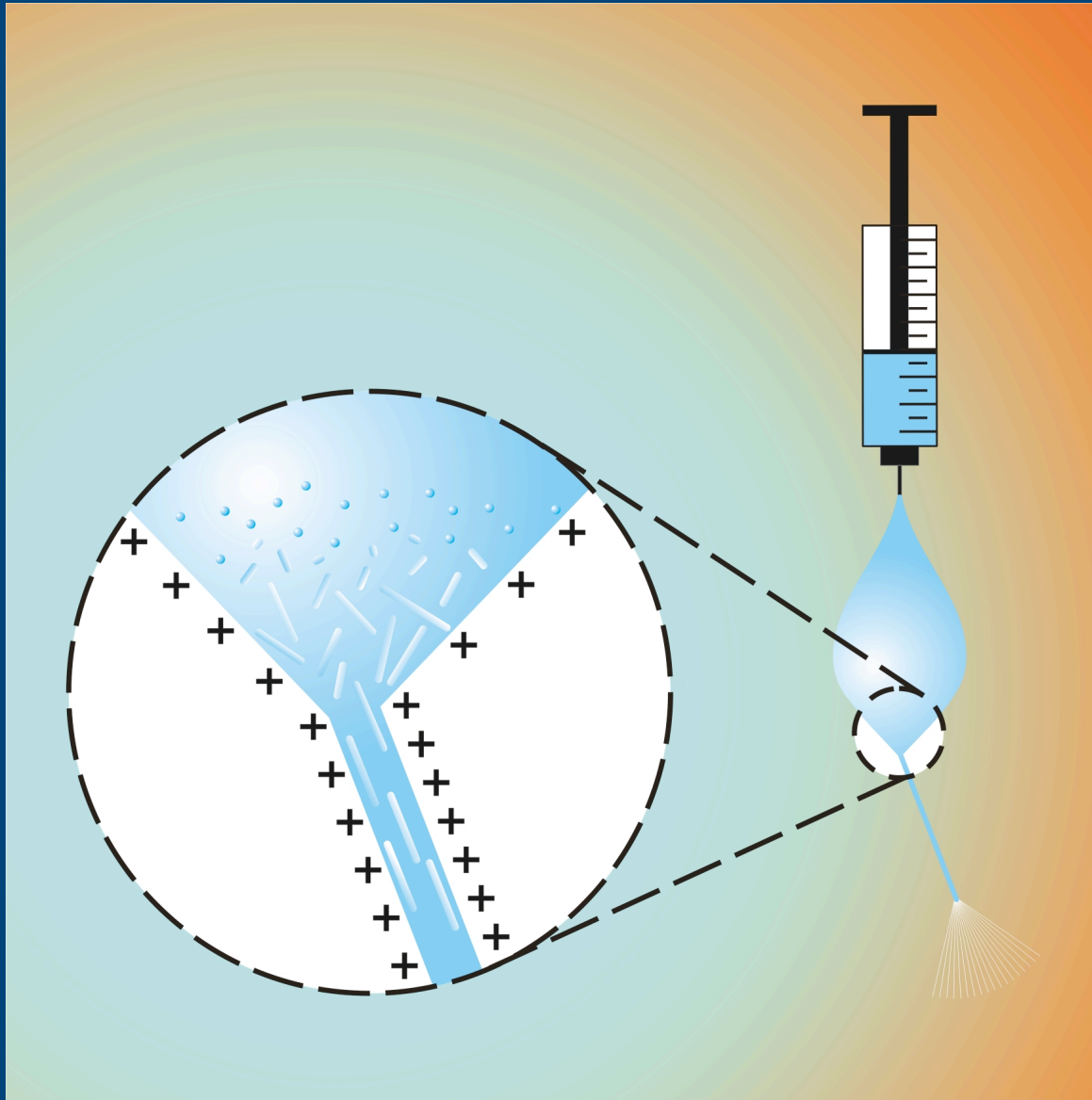
Straight jet, then instabilities („honey-like“)

Spun nylon

! Viscosity η changes with radius r ! But: high η (droplet).

Evaporation of solvent: Concentration \uparrow vapour pressure \uparrow

Electrospinning of *pure monomers*

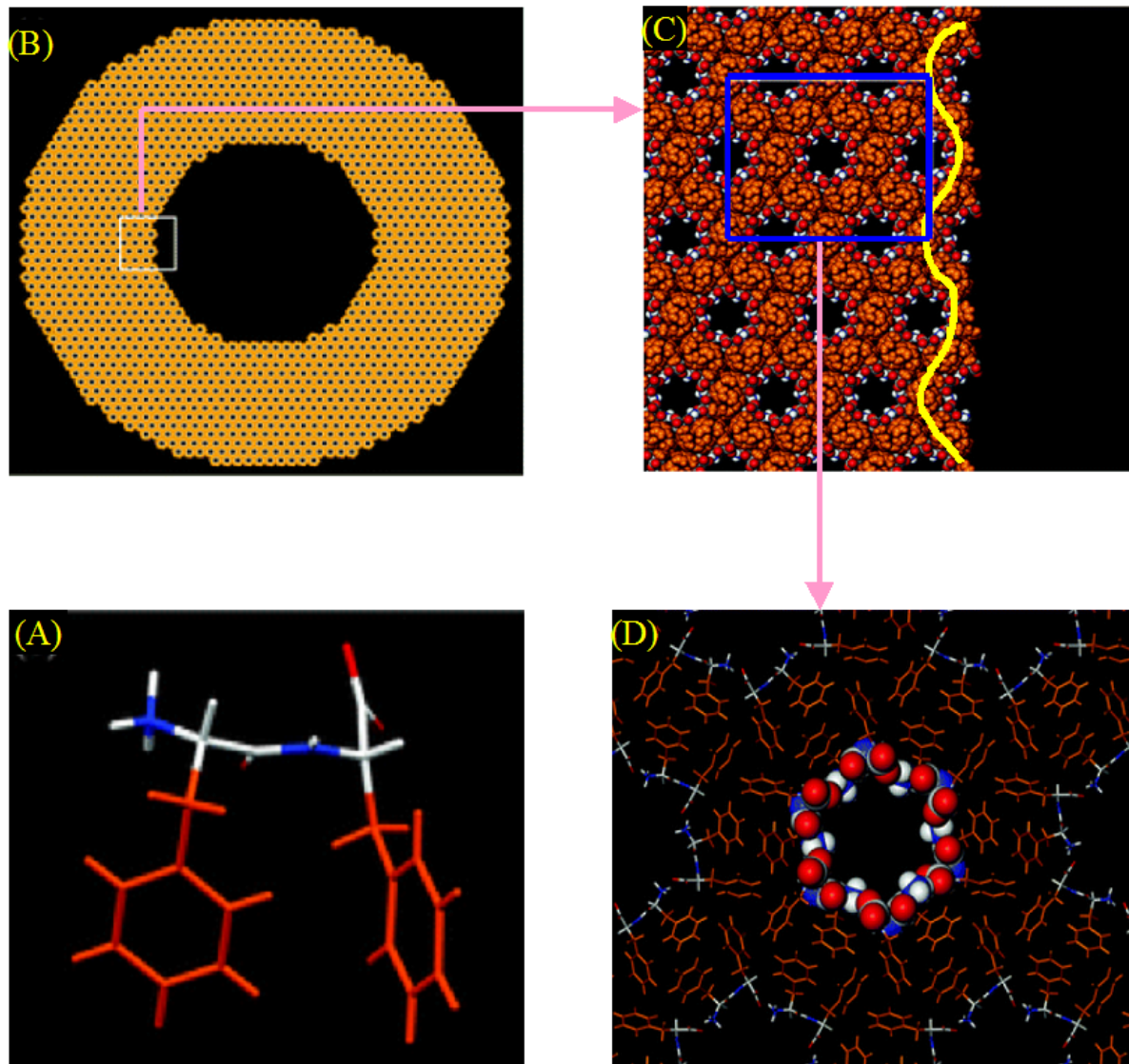


concentration ↑

↑
 η

Known: Phospholipids and spider silk fibroin

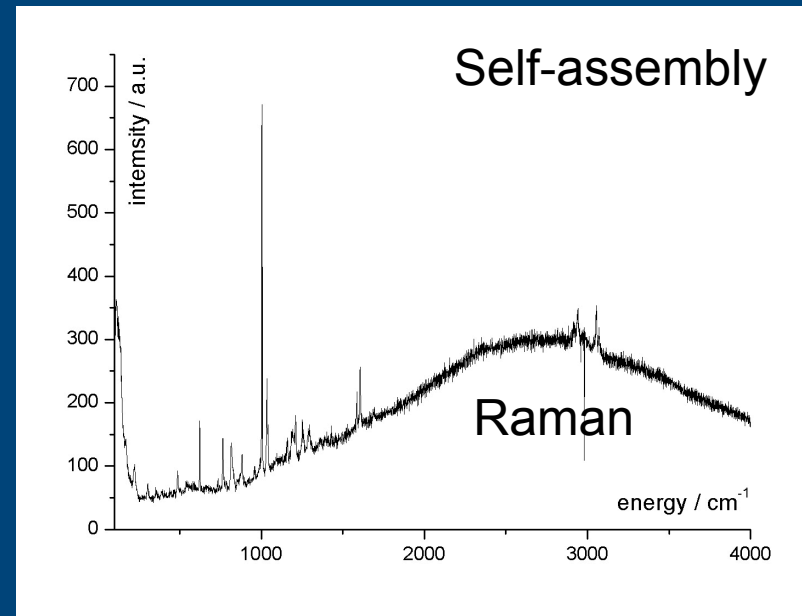
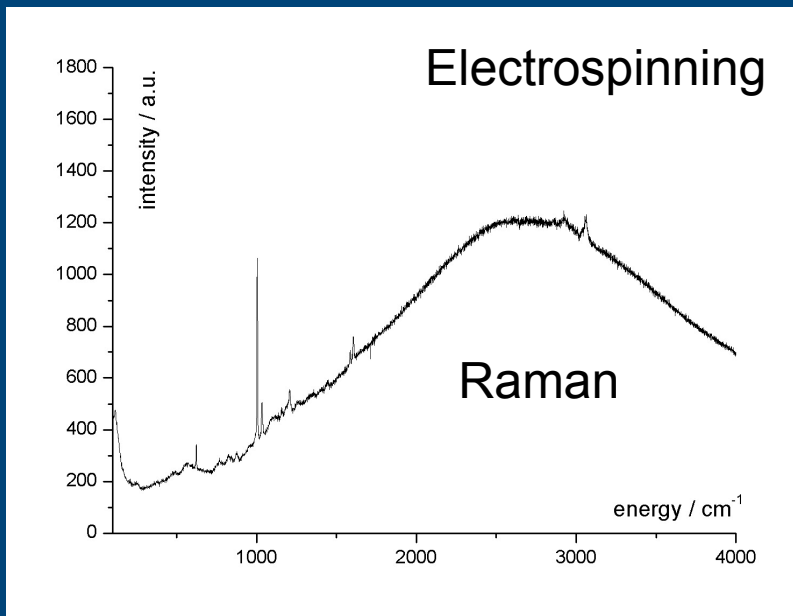
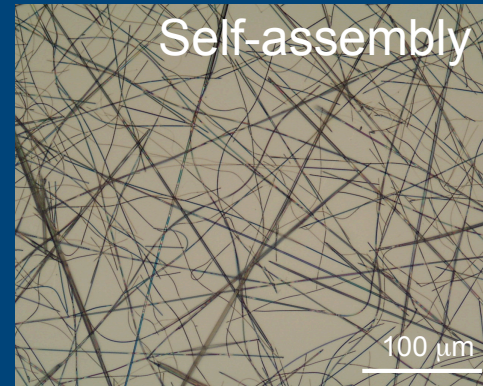
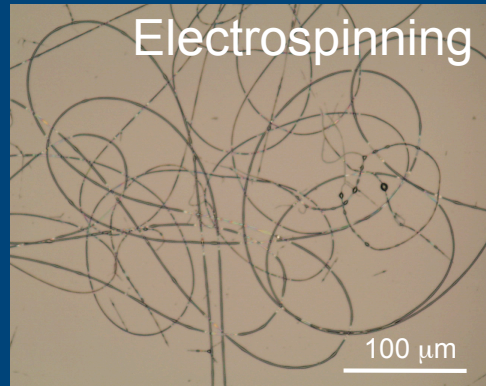
Di-phenylalanine (Phe-Phe, FF) self-assembly to tubes



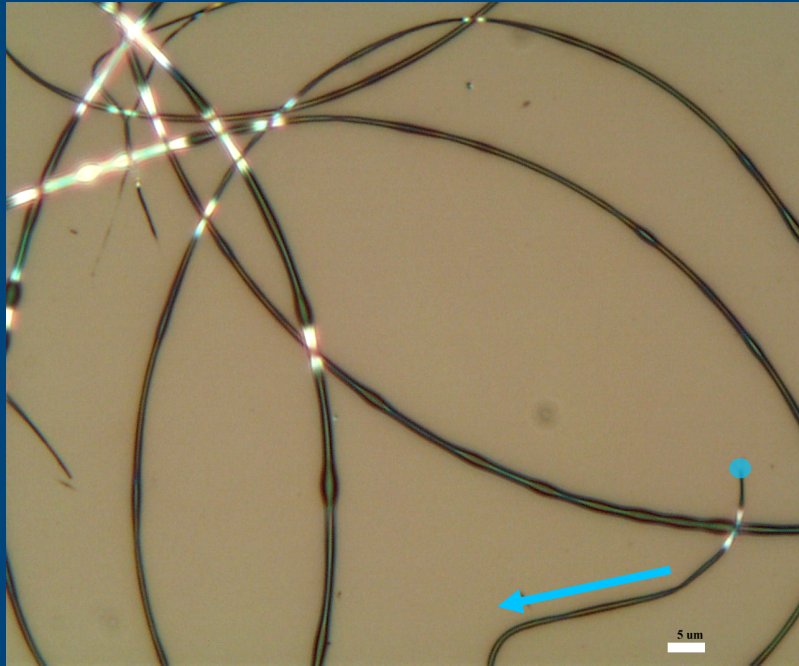
Potential for mineralisation:

1. Channel (templating by confinement)
2. Surface; carboxylic acid and amine, or phenyl?

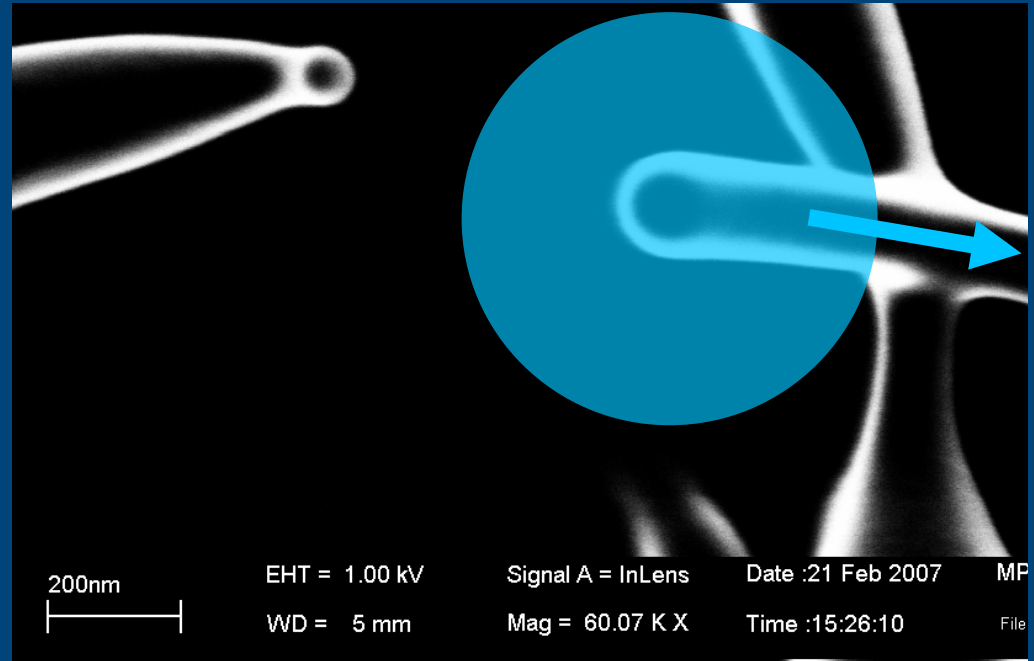
Electrospinning of self-assembling di-phenylalanine



Nanofluidics and materials synthesis in peptide channels?



Electrospun Phe-Phe, opt. micr.

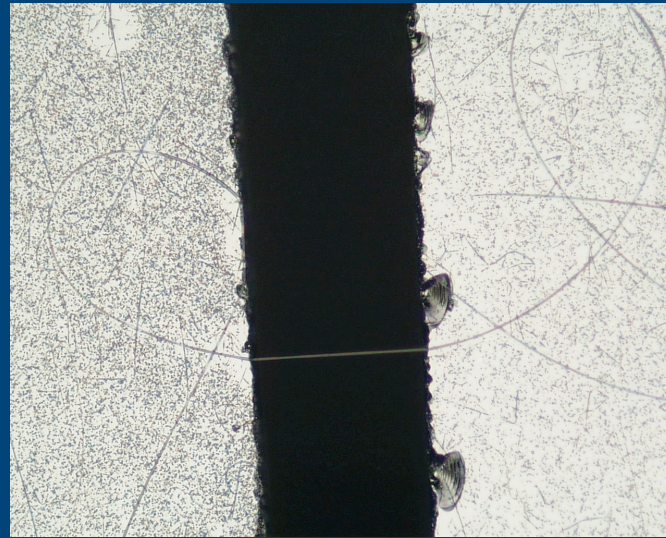


Electrospun Phe-Phe tubes, SEM

**Nanodispenser (AFM) → place droplets;
detect flow electrically or optically**

**Well known: Wet chemical deposition
of Ag in 20 nm Phe-Phe channels**

Controlling fibre collection



Stretching and bridging

~0.1 mm gaps

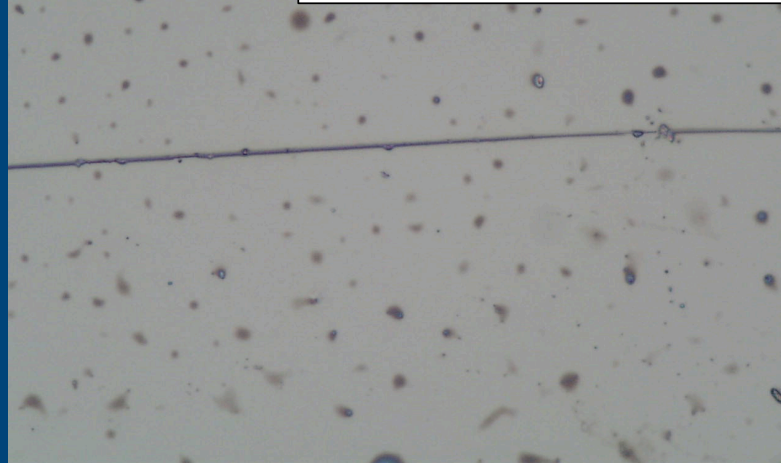
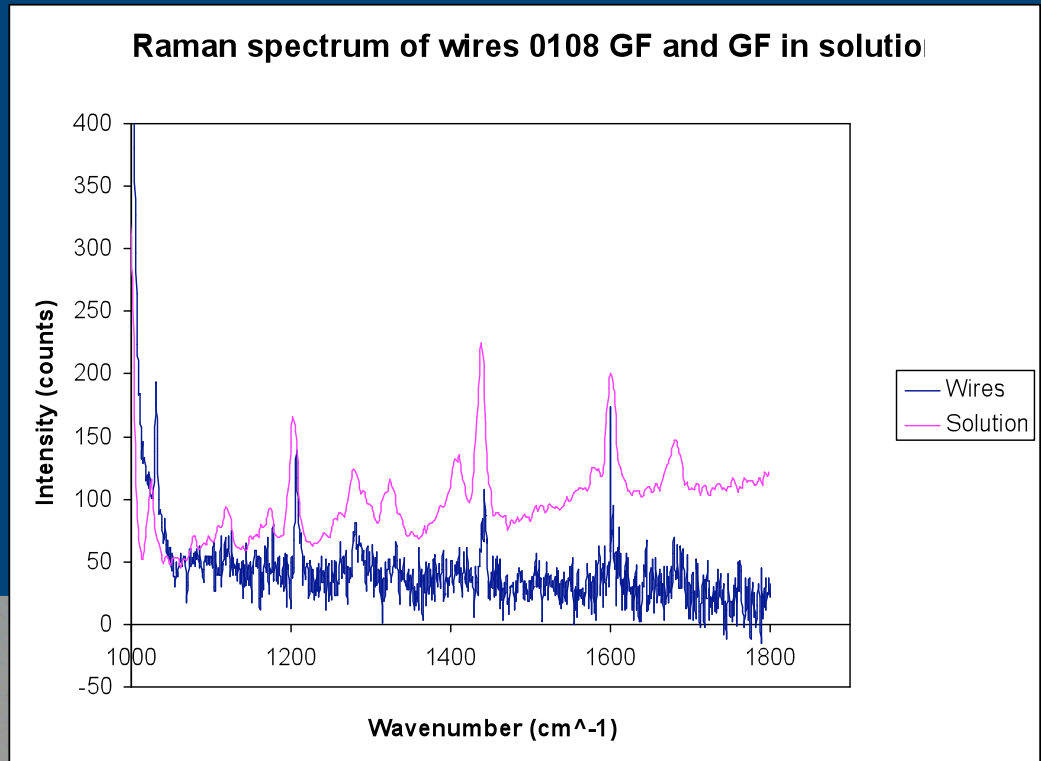
(two pieces of Si wafer)

**Substrate (collector) edges:
high electric fields!**

Electrospinning of Gly-Phe (GF) and Gly-Phe-Gly (GFG)

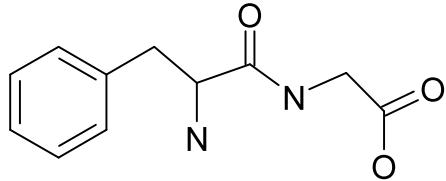


GF fibres
(85.5 x 68.4 μm)

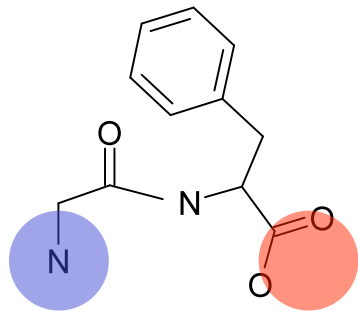


GFG fibre (85.5 x 68.4 μm)

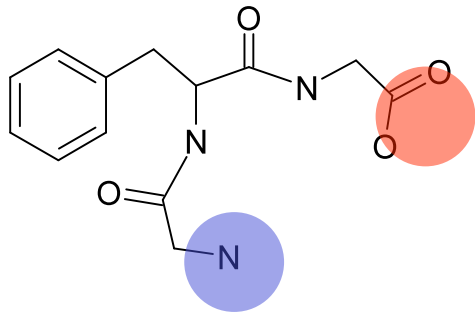
Peptide Electrospinning: Mimicking FG repeats in the Nuclear Pore Complex



Natural -Phe-Gly- (FG) replaced by



Gly-Phe ---> (GF) electrospun fibres!



Gly-Phe-Gly ---> (GFG) electrospun fibres!

Thanks

Plant virology group:

**Dr. Christina Wege
Prof. Hoger Jeske**

(Universität Stuttgart)

Group Klaus Kern:

**Dr. Gabriel Baralia
Dr. Nikola Malinowski
Mr. Sebastian Loscher
Mr. Gurvinder Singh
Mrs. Darya Amoli (Chalmers Univ.)
Mr. Guillaume Hupin**

Group Klaus von Klitzing

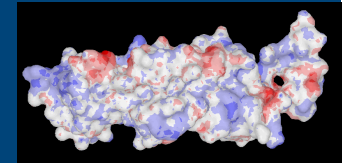
(MPI for Solid State Res., Stuttgart)

Outlook

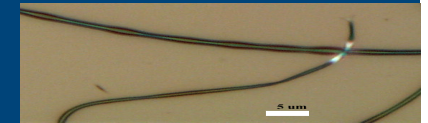
Peptide wires/tubes: Steering the assembly of biomolecules by electrospinning → **only tubes?**



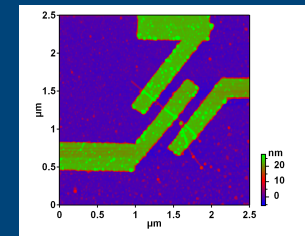
Complete proteins?



Nanofluidics: **Detection?** Hydrodynamics and MD simulations.



TMV: Wire synthesis, **magnetometry, nanofluidics.**



Tools: Confocal Raman spectromicroscopy, SEM, AFM, nanodispenser, electron beam lithography, magnetometry, ...