2nd MESA+ SPM Afternoon

Tuesday, Nov.24th, "Spiegel" room 4

14:00-14:20	G.J. Vancso Materials Science and Technology of Polymers *Introduction:* *SPM as enabling platform technology for MESA+*
14:20-14:40	Kim Sweers, Ine Segers-Nolten, Kees van der Werf, <u>Martin Bennink</u>, Vinod Subramaniam Biomedical Engineering *Mechanical characterization of alpha-synuclein fibrils using AFM imaging and force spectroscopy*
14:40-15:00	Harold J.W. Zandvliet Physical Aspects of NanoElectronics *Scanning tunneling microscopy & spectroscopy*
15:00-15:20	Frieder Mugele Physics of Complex Fluids *AFM spectroscopy methods for quantitative force measurements*
15:20-15:40	Coffee Break
15:40:16:00	<u>E. Sarajlic</u>, N.R. Tas, L. Abelmann SmartTip B.V; Transducers Science and Technology *BATCH FABRICATION OF SCANNING MICROSCOPY PROBES FOR THERMAL AND MAGNETIC IMAGING USING STANDARD MICROMACHINING*
16:00-16:30	Elevator Pitches (**<u>5 min</u>** maximum time) • Herek/Offerhaus • Tas/Abelmann • P.M. Schoen • G.J. Vancso • …(other candidates ?)
16:30-17:30	Open Discussion
17:30	Closing

Mechanical characterization of alpha-synuclein fibrils using AFM imaging and force spectroscopy

Kim Sweers, Ine Segers-Nolten, Kees van der Werf, Martin Bennink, Vinod Subramaniam

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The aggregation of different proteins into fibrillar amyloid structures is inherent to several serious neurodegenerative diseases. In Parkinson's disease, α-synuclein monomers assemble into amyloid fibrils with diameters of around 8 nm. These protein fibrils are the major component of inclusions (a.k.a Lewy bodies) found in the brain of Parkinson's patients.

Here, atomic force microscopy (AFM) imaging and force spectroscopy are used to study the mechanical characteristics of these α-synuclein fibrils, which can shed some light on the mechanism of how these fibrils are formed.. We used three different methods in this study to analyze the mechanical characteristics. First, we determined the bending rigidity of α-synuclein fibrils from AFM images by analyzing the 2D fibril contours using statistical mechanical theory of semi-flexible polymers. Second, using the AFM tip as indenter, we performed nano-indentation measurements on individual fibrils to obtain the stiffness of α-synuclein fibrils. The third and last method employed is Harmonic Force Microscopy (HarmoniX). This method uses a special cantilever that allows the measurement of stiffness, adhesion and energy dissipation during tapping-mode imaging, and thus without damaging the sample.

Typical bending rigidities found for these fibrils are $1.5\cdot10^{-24}$ Nm^2 which results in Young's moduli between 9 and 30 GPa, depending on the assumption of how the individual protein monomers are packed in the fibril. From this it is clear that α-synuclein fibrils are stiff structures. The nano-indentation and HarmoniX measurements gave Young's moduli around 1.3 and 1.1 GPa respectively. Even though, the packing model of individual monomers in a fibril is not fully known, the differences in results between the nano-indentation and statistical mechanical measurements clearly indicate that structure of α-synuclein fibrils is anisotropic.

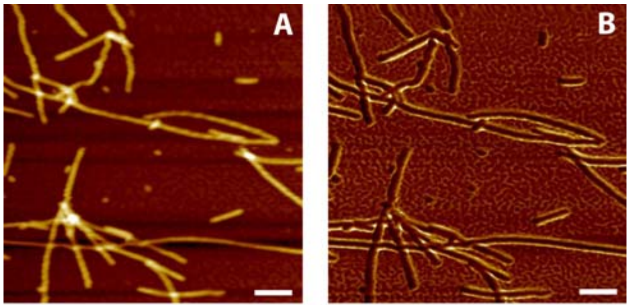

Figure 1; Typical HarmoniX images, panel A is AFM height image, panel B is a stiffness map of the fibrils, were the fibrils are less stiff (dark) compared to the mica substrate. Scale bars are 250 nm.

Scanning Tunneling Microscopy & Spectroscopy

Harold J.W. Zandvliet
Physical Aspects of NanoElectronics

The Scanning Tunneling Microscope (STM) has revolutionized our ability to explore, and manipulate, solid surfaces on the size scale of atoms. Besides its unparalleled spatial power, the STM is also capable of studying dynamical processes, such as molecular conformational changes, by recording current traces as a function of time. The STM can also be employed to measure the physical properties of molecules or nanostructures down to the atomic scale. Combining STM imaging with the measurement of current-voltage characteristics (*I-V*), i.e. Scanning Tunneling Spectroscopy (STS), at similar resolution makes it possible to obtain a detailed map of the electronic structure of the surface. For many years STMs lacked chemical specificity, requiring complementary spectroscopic tools to identify the chemical species being imaged. However, recently STM–IETS (STM Inelastic Electron Tunneling Spectroscopy) has been developed to measure the vibrational spectrum of a single molecule, allowing STMs to be used as a tool for chemical analysis of single molecules. This short talk does not aim to give a full overview of the field, but rather it aims to introduce and illustrate these recent developments with a few simple scholarly examples.

AFM spectroscopy methods for quantitative force measurements

Frieder Mugele
Physics of Complex Fluids

At PCF, we are interested in the properties of fluids on the nanometer scale, where molecular interactions play a significant role and give rise to deviations from the macroscopic bulk properties of fluids. In this context we contribute to the development of AFM spectroscopy and force inversion methods, focusing in particular on dynamic AFM in liquid environment. The latter is novel to the extent that most methods developed so far focus on applications in vacuum or air, where the resonances of the cantilevers are very sharp. The low Q-environments that we focus on are not only in the context of studying fluid properties, but in general for quantitative (oscillatory) force and dissipation measurement in fluid, such as typically the case for biological samples. Next to the experiments, we routinely perform numerical simulations of the AFM cantilever dynamics to provide a quantitative interpretation of our data. This – in principle straight forward – tool can be easily adapted to the needs of other dynamics AFM experiments in the institute.

BATCH FABRICATION OF SCANNING MICROSCOPY PROBES FOR THERMAL AND MAGNETIC IMAGING USING STANDARD MICROMACHINING

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Scanning thermal microscopy (SThM) and scanning Hall probe microscopy (SHPM) are widely applied techniques for the study of nanoscale thermal and magnetic phenomena. At the heart of these techniques is a modified scanning probe, which has a sharp tip with a nanometer-scale electrical cross junction integrated at its apex. We present a process for batch fabrication of a novel scanning microscopy probe for thermal and magnetic imaging by standard micromachining and conventional optical contact lithography. The probe, shown in Figure 1, features a force sensing cantilever with a sharp pyramidal tip composed of four freestanding silicon nitride nanowires coated by conductive material. The nanowires form an electrical cross junction at the apex of the tip, addressable through the electrodes integrated on the cantilever. The cross junction on the tip apex can be utilized to produce heat and detect local temperature changes or to serve as a miniaturized Hall magnetometer enabling, in principle, thermal and magnetic imaging by scanning the probe tip over a surface. We have successfully fabricated a first probe prototype with a nanowire tip composed of 140 nm thick and 11 μm long silicon nitride wires metallized by 6 nm Ti and 30 nm Au layers. We have experimentally characterized electrical and thermal properties of the probe demonstrating its proper functioning.

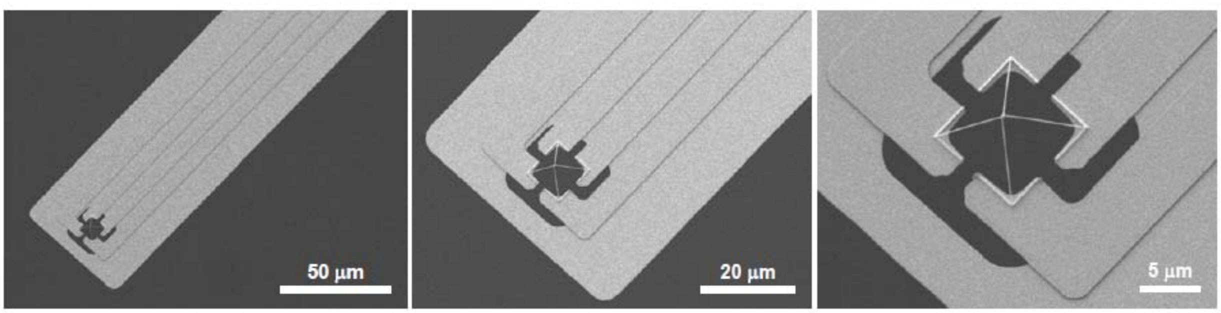

Figure 1: SEM micrographs of a novel scanning probe designed for thermal and magnetic imaging. The probe consists of a cantilever with a pyramidal tip composed of four freestanding nanowires. The nanowires, made of a 140 nm thick silicon nitride core coated by Ti/Au layers (6 nm/30 nm), form an electrical junction at the apex of the tip. The nanowire cross junction can be addressed through the electrodes integrated on the cantilever.