Parallel Session: “Enabling Technologies”

13:30-13:40 P. Schön, G.J. Vancso
Materials Science and Technology of Polymers

Introduction

13:40-14:00 Sissi de Beer, Dirk van den Ende, Frieder Mugele
Physics of Complex Fluids

Small amplitude AFM spectroscopy: A quantitative tool for studying nano-scale fluid flow

14:00-14:20 D. Wasserberg, F. Ungureanu, R. Verdoold, T. Brinkman, R. Molenaar, R.P.H. Kooyman
Biophysical Engineering

Functionalised Gold Nanoparticles:
Towards sensitive detection of biomolecules

14:20-14:40 Amirmehdi Saedi, Daan Kockmann and Harold J.W. Zandvliet
Physical Aspects of NanoElectronics

Time-resolved scanning tunneling microscopy

14:40-15:00 Raoul van Gastel, Gregor Hlawacek and Bene Poelsema
Solid State Physics

He Ion Spectromicroscopy

Small amplitude AFM spectroscopy: A quantitative tool for studying nano-scale fluid flow

Sissi de Beer, Dirk van den Ende, Frieder Mugele

Physics of Complex Fluids, Faculty of Science and Technology
University of Twente, P.O. Box 217, 7500 Enschede, the Netherlands

We present a method to extract distance dependent conservative and dissipative interaction forces in liquid from the amplitude and phase response of an atomic force microscope (AFM) cantilever. We show theoretically, experimentally, and numerically the possibilities, accuracy, limitations, and pitfalls of force inversion for AFM in liquid. As a model system for the experiments, we use a well-characterized non-polar fluid (octamethyltetrasiloxane) and atomically flat surfaces of highly oriented pyrolitic graphite. The system displays strongly oscillatory conservative tip-sample forces, which we recover consistently for measurements at various drive-frequencies of the AFM cantilever on and below its resonance frequency with free amplitudes below 1 Angstrom. The dissipative part of the tip-sample forces also displays oscillations, yet our analysis suggests that this behaviour is caused by imperfections in the modelling of the cantilever dynamics rather than true oscillatory dissipative forces of the few hundred molecules confined in the gap between the tip and the sample. We argue that present AFM measurement and analysis techniques are not sufficiently sensitive to detect potential oscillations in the dissipation and describe the limitations that have to be overcome.

Functionalised Gold Nanoparticles: Towards sensitive detection of biomolecules

D. Wasserberg, F. Ungureanu, R. Verdoold, T. Brinkman, R. Molenaar, R.P.H. Kooyman

Biophysical Engineering Group, Faculty of Science and Engineering, University of Twente, P.O. Box 217, 7500 AE, Enschede, the Netherlands
d.wasserberg@utwente.nl +31 (0)534893466

The light scattering and absorption properties of gold nanoparticles (GNPs) can be used for the detection of (bio-)molecules like proteins and oligonucleotides. The binding of these molecules changes the local refractive index around the GNP. This change results in a red-shift of the GNP's extinction maximum. This shift is proportional to the number of molecules bound to the GNP's surface.

We have observed a maximum red-shift of approximately 7 nm for the binding of 20mers of thiolated ssDNA to GNP of 60 nm diameter. From discrete dipole scattering simulations for 60 nm GNPs we estimated this to correspond to a monolayer of ~900 ssDNA strands. Such GNPs show a maximum red-shift of ~ 15 nm upon protein binding corresponding to a theoretically estimated coverage of a full monolayer.

We could prove that both DNA- and protein-GNP conjugates retain their biological activity using SPR and SEM in the case of protein conjugates and hybridisation assays in the case of DNA conjugates.

With this line of research we aim at the eventual realisation of a microfluidic sensor application based on the interaction of said GNP conjugates with specific analyte molecules. To this end we have carried out preliminary binding experiments of GNP conjugates in a microfluidic cell using a darkfield microscope with CCD camera for single particle detection. Current efforts are aimed at a detailed understanding of the binding behaviour of bioactive GNP conjugates using a.o. AFM, SEM and single particle spectroscopic techniques.

Time-resolved scanning tunneling microscopy

Amirmehdi Saedi, Daan Kockmann and Harold J.W. Zandvliet

Physical aspects of Nanoelectronics, MESA+ Institute for Nanotechnology, University of Twente, PO Box 217 7500AE Enschede, The Netherlands

Scanning tunneling microscopy has revolutionized our ability to image, study, and manipulate solid surfaces on the size scale of atoms. However, one important limitation of the scanning tunneling microscope (STM) is its poor time resolution. Recording a standard image with a STM typically takes about a fraction of a second for a fast scanning STM to several tens of seconds for a standard STM. The time resolution of a STM can, however, be significantly enhanced by several orders of magnitude by performing open-loop feedback experiments. In this talk we will illustrate this technique by giving several scholarly examples, such as the adsorption of hydrogen on a Ge(001) surface, the electrical transport through a single octanethiol molecule and the concerted motion of arrays of adatoms on a Ge(111) surface.

He Ion Spectromicroscopy

Raoul van Gastel[1], Gregor Hlawacek[1] and Bene Poelsema[1]

[1]University of Twente, MESA+ Institute for Nanotechnology,
P.O. Box 217, NL-7500AE Enschede, The Netherlands
email: R.vanGastel@tnw.utwente.nl

In this presentation I will detail the principles and possible applications of the Orion He Scanning Ion Microscope (SIM) [1]. A He Scanning Ion Microscope (SIM) is analogous to a Scanning Electron Microscope (SEM) but utilizes a beam of helium ions with an energy of 10 to 45 keV, instead of electrons. The He SIM technique has only become possible in the last few years after the development of a high brightness He ion source that is able to produce a subnanometer sized spot at the sample. Although the principles underlying the technique are at first sight similar to those found for SEM, the physics of how a He ion beam interacts with a specimen is fundamentally different from an electron beam. SIM potentially offers several advantages for the imaging of nanostructures. The combination of the reduced probe size and the enhanced secondary electron yield generated by the He ions allows for the imaging of surfaces in very fine detail. In addition, the He ion beam also generates a current of backscattered particles that can be detected and used to form an image. These images, referred to as Rutherford Backscattered Ion (RBI) images yield far fewer topographical contrast, but instead reveal a high degree of chemical contrast. By exploiting the details of the interaction of the He beam with the specimen and careful detection of the secondary particles it generates, the He SIM technique in principle allows for spectroscopic imaging on the nanometer scale and its capabilities can therefore be extended even further [2].

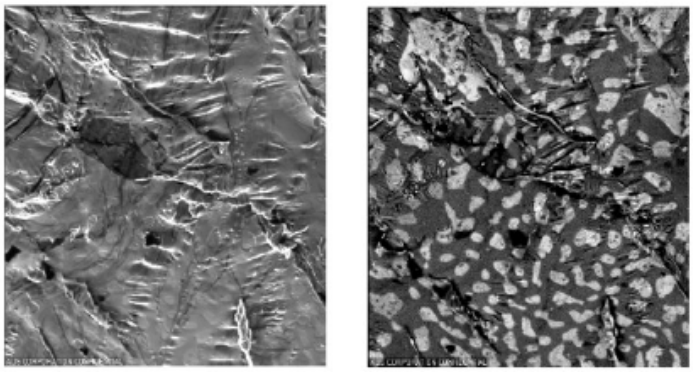

Figure: Secondary electron (SE) and backscattered ion (RBI) images of a piece of solder. The SE image yields a high level of topographic contrast, whereas the RBI image yields little topographic contrast, but instead allows to distinguish the Pb and Sn that the solder consists of.

[1] E.W. Ward, J. Notte and N.P. Economou, *Helium ion microscope: A new tool for nanoscale microscopy and metrology*, J. Vac. Sci. Technol. B **24** (2006), 2871.

[2] L. Scipioni, L.A. Stern, J. Notte, S. Sijbrandij and B. Griffin, *Helium ion microscope,* Advanced Materials & Processes **166** (2008), 27.