MI 8: Scanning Probe Microscopy (SPM)

Chair: Michael Hietschold (TU Chemnitz)

Time: Thursday 10:00–11:00 Location: MER 02

MI 8.1 Thu 10:00 MER 02

Machine Learning in Spectroscopic Scanning Probe Microscopy: a Magnetoelectric Composite Case Study — •Harsh Trivedi[1], Vladimir V. Shvartsman[1], Doru C. Lupascu[1], and Robert C. Pullar[2] — [1]Institute for Materials Science and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, 45141, Essen, Germany — [2]CICECO, University of Aveiro, 3810-193, Aveiro, Portugal

Recent years have seen a tremendous growth in the spectroscopic Scanning Probe Microscopy (SPM) modes, where spectra against various principle variables like voltage (Piezoresponse/Current), distance (force), frequency (amplitude) etc. are collected over a 2-dimensional grid. In certain cases however, the variable in concern is time dependent, and a point by point variation is not ideal. In such cases a convenient alternative is the sequential SPM, where a sequence of SPM images is generated as a function of the principle variable. However, such a method suffers from the absence of a concrete correlation between the consecutive images, and also the nature of each individual spectra differs with the spatial location. In the absence of a universal physical model that fits the data, a proper application of unsupervised machine-learning to such problems could lead to fast extraction of qualitative components of the spectra, which can conveniently be used to device the necessary physical models. Presented in this work is a case study of application of simple unsupervised machine-learning to variable magnetic field Piezoresponse Force Microscopy (PFM) of BaTiO3 based magnetoelectric composites.

MI 8.2 Thu 10:15 MER 02

Potential dependent tunneling barrier-height measurements at the interface of gold(111) in an ionic liquid — •Marcel Lang, Jeannette Lindner, and Rolf Schuster — Karlsruhe Institute of Technology, Germany

The behavior of ionic liquids at charged surfaces is fundamentally different from diluted electrolytes. For example ionic liquids form different multi-layered structures depending on the polarization of the gold electrode.

We employed distance-current spectroscopy in a room temperature electrochemical-STM under ambient atmosphere to study the tunneling barrier heights in [BMP][TFSA] on gold(111). We found that the tunneling barrier vanishes at moderately positive potentials. We attribute this to the formation of ion layers at the interface, which may exhibit high intrinsic conductance.

MI 8.3 Thu 10:30 MER 02

Scanning Microwave Microscopy and its application to nanoscale dopant density determination — •Arne Buchter[1], Johannes Hoffmann[1], Dimitri Hapiuk[2,3], Christophe Licitra[2,3], Kevin Louarn[4,5], Guilhem Almuneau[4], and Markus Zeier[1] — [1]Federal Institute of Metrology, METAS, Lindenweg 50, CH-3003 Bern-Wabern — [2]Univ. Grenoble Alpes, F-38000 Grenoble — [3]CEA, LETI, MINATEC Campus, F-38054 Grenoble — [4]LAAS-CNRS, Université de Toulouse, CNRS, UPS, Toulouse — [5]LNE, 29 avenue Roger Hennequin, F-78197, Trappes

In Scanning Microwave Microscopy (SMM) an atomic force microscope (AFM) is interfaced with a vector network analyzer (VNA) allowing to simultaneously measure topography and complex material properties on the nanoscale. Depending on the impedance forming at the tip-sample interface, a fraction of the microwaves is reflected and detected by the VNA in terms of scattering parameter S11. Operation in the microwave regime with fields confined to the tip's apex allows for spatial resolution down to 50 nm as well as subsurface sensing.

To enable extraction of dopant densities from semiconductor samples we present a fast and versatile algorithm based on classical VNA calibration. This algorithm models the influence of dopant density on tip-sample capacitance thus allowing nanoscale determination of dopant concentrations. As a proof-of-principle we present SMM results on an MBE-grown n-doped GaAs multilayer structure with dopant densities ranging from (1e16 - 6e18) cm^-3 which are then compared to Secondary Ion Mass Spectroscopy (SIMS) data.

MI 8.4 Thu 10:45 MER 02

A Quantitative Model for the Ion Current vs. Distance Behavior in Scanning Ion Conductance Microscopy — •Johannes Rheinlaender and Tilman E. Schäffer — Institute of Applied Physics, Eberhard Karls University Tübingen, Germany

Scanning ion conductance microscopy (SICM) is an emerging scanning probe microscopy technique in biophysical and electrochemical research. It is based on raster-scanning an electrolyte-filled nanopipette across the sample, while the ion current through the nanopipette serves as a measure for the tip-sample distance. However, so far there is no quantitatively validated model for the ion current vs. distance behavior in SICM, although it is the central functional principle of the technique. To quantitatively predict the ion current vs. distance behavior, we here provide two theoretical models: (1) an analytical model to investigate the dimensional dependencies and (2) a numerical model for even higher accuracy based on finite element modeling (FEM). We verified the models using experimental data recorded with nanopipettes of known geometry and opening radii between 30 and 300 nm. The new models therefore allow, for the first time, to quantify the tip-sample distance in SICM. Furthermore, as the ion current vs. distance behavior directly depends on the tip geometry of the nanopipette, the models can also vice versa be used to quantify the tip geometry from experimental ion current data. This provides a unique, non-destructive way of calibrating the nanopipettes tip geometry within the running SICM experiment.