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S E M I N A R
on
Semiconductor Physics and Nanotechnology

Mo, 05.06.2023, 11:15 Uhr,

Seminar in
person in the Physics lecture hall *or* via Zoom

"Quantitative Electrical Properties of nanostructured materials from DC to GHz frequencies"

Priv.-Doz. Dr. Georg Gramse
Institute for Biophysics, Johannes Kepler University Linz, Austria

The outstanding electrical properties of nanostructured materials are the key for many new applications ranging from quantum computing over 2D-material-based or organic electronics to electrochemical energy storage systems.

The Electrical SPM techniques Scanning Tunneling (STM), Scanning Microwave (SMM) and broadband Electrostatic Force Microscopy (EFM) developed in our lab allow us to visualize their material contrast with nm resolution. With calibration procedures quantitative values of the physically relevant, intrinsic material properties like dielectric permittivity [1], conductivity, carrier concentration and also electrochemical parameters can be extracted.

Based on the specific strength of the developed techniques, the overall focus of my interdisciplinary research is on elucidating local and dynamic electrical processes occurring at nanometric length scales in a quantitative way. Here, I will give an overview on the scientific results I obtained in various research fields in this still hardly explored domain. In particular, I will cover 3 applications:

1) Semiconductor physics where I show how to pinpoint non-invasively the precise 3D location of buried atomic scale n-type and p-type dopant structures for quantum devices with 1 nm vertical and 10 nm lateral resolution and determine their electrical characteristics by SMM [3] and bb-EFM [4].

2) Local dipole dynamics in protein membranes and its interplay with surface water where I investigated the nanoscale dipole mobility of proteins in a wide frequency range from 3 kHz to 10 GHz. Measurements on bacteriorhodopsin reveal Debye relaxations with time constants being characteristic for the dipole moments of the bR retinal, the α-helices and the entire molecule, respectively [2].

3) High frequency nano-electrochemistry where we did first steps for investigation of fast electrochemical processes of electron transfer through metallo-organic SAMs, showing new potentials for research on catalysis and future battery surfaces [5, 6].

Zoom – Link:
https://zoom.us/j/96375934537?pwd=RTlKTWhSdzRHU211YTY1bGFxTUtpZz09
Meeting-ID: 963 7593 4537
Kenncode: =r=4YQ

[1] Gramse G*, Kasper M, Fumagalli L, Gomila G, Hinterdorfer P and Kienberger F 2014 Calibrated complex impedance and permittivity measurements with scanning microwave microscopy Nanotechnology 25 145703 (8pp)

[2] Gramse G*, Schönhals A, Kienberger F, 2019 Nanoscale dipole dynamics of protein membranes studied by broadband dielectric microscopy Nanoscale 11, 4303-4309

[3] Gramse G*, Kölker A, Lim T, Stock TJZ, Solanki H, Schofield SR, Brinciotti E, Aeppli G, Kienberger F and Curson NJ, 2017 Nondestructive imaging of atomically thin nanostructures buried in silicon Science Advances 3, 6 (9pp)

[4] Gramse G*, Kölker A, Skeren T, Stock T, Aeppli G, Kienberger F, Fuhrer A, Curson N, 2020, Nanoscale imaging of mobile carriers and trapped charges in delta doped silicon p–n junctions. Nature Electronics 3, 531–538 Cover paper

[5] S Grall, I Alić, E Pavoni, T Fujii, S Müllegger, M Farina, N Clément and Gramse G* 2021 Attoampere Nanoelectrochemistry, Small 17 (29), 2170148 Cover paper

[6] M. Awadein, et al. 2022, Nanoscale Adv., 2023,5, 659-667