MM 48: Topical session: In-situ Microscopy with Electrons, X-Rays and Scanning Probes in Materials Science V - Biological and Electronic Materials

Time: Thursday 10:15–11:45 Location: H38

Topical Talk MM 48.1 Thu 10:15 H38

In-situ TEM Switching of Non-volatile Memory Devices — •Sang Ho Oh — POSTECH, 77 Cheongam-Ro. Pohang 37673, Republic of Korea

In this talk I will present two case studies illustrating how in-situ TEM is used to visualize the switching processes of non-volatile memory devices and to reveal the switching mechanisms. In the first example, the 180° polarization switching process of an epitaxial PbZr0.2Ti0.8O3 (PZT) thin film capacitor is presented. The preferential, but asymmetric, nucleation and forward growth of switched c-domains were observed at the PZT/electrode interfaces, arising due to the built-in electric field induced at each interface. It was found that the preexisting a-domains split into fine a- and c-domains constituting a 90° stripe domain pattern during the 180° polarization switching process, revealing that these domains also actively participated in the out-of-plane polarization switching. In the second example, as a model resistive random access memory (ReRAM), I will show in-situ TEM observation of the multi-level switching of a TiN/Pr0.7Ca0.3MnO3 (PCMO)-based ReRAM which utilizes the resistance change as the two materials goes through reversible redox reactions at the interface. Based on the direct observations of the microstructural evolution and correlated I-V characteristics, a resistive switching model for TiN/PCMO devices will be presented.

MM 48.2 Thu 10:45 H38

In situ studies of structural biological materials with X-ray microdiffraction — •Martin Müller — Helmholtz-Zentrum Geesthacht, Germany

The structural biological material silk combines high extensibility and high mechanical strength. The key to those unique mechanical properties lies in the hierarchically organised micro- and nanostructure with nanocrystals embedded in a softer, disordered matrix in the fashion of a composite material. Position-resolved in situ X-ray diffraction experiments play a central role in the development of new mechanical models, which also include the influence of humidity on the mechanical performance of silk. Based on our findings, native silk fibres were functionalised with chromophores in order to make them optically switchable; again, the mechanical switching effect is readily visible in X-ray microdiffraction experiments.

Further examples include the mechanical properties of wood and the attachment mechanism of adhesive spider hairs. Similarities with in situ experiments on engineering materials will be highlighted.

MM 48.3 Thu 11:15 H38

Microspectroscopic Insights into Electronic Switching — Benedikt Rösner[1], Xiaoyan Du[1], Ke Ran[2], Erdmann Spiecker[2], Marat M. Khusniyarov[3], and •Rainer H. Fink[1] — [1]Physikalische Chemie II, FAU Erlangen-Nürnberg — [2]CENEM, FAU Erlangen-Nürnberg — [3]Anorganische Chemie II, FAU Erlangen-Nürnberg

Controlling the electronic switching in metal-organic semiconductors is crucial for implementation of these materials into functional devices. We report on in-situ investigations of electronic switching with different microspectroscopic methods using electrons, X-rays and scanning probes. Bipolar resistivity switching in Ag-TCNQ nanocrystals is investigated using TEM, Raman-, and scanning X-ray transmission microspectroscopy. Reverse charge transfer within the charge transfer salt is demonstrated qualitatively and quanitified [1]. In organic field-effect transistors, spatially resolved Raman spectroscopy proofs modifications of the polarizability tensor in the organic semiconductor upon operation, visualizing charge trapping [2]. Light-induced switching in our Fe(II) spin-crossover complex between a paramagnetic high-spin state and a diamagnetic low-spin state is proven using X-ray absorption and XPS. NEXAFS spectroscopy is thereby ideally suited to probe the d-orbital occupation and thus to quantify the fractions of the respective spin states [3]. This work is funded within the GRK 1896 (In-situ Microscopy with Electrons, X-rays and Scanning Probes). [1] B. Rösner et al., PCCP (2015), 17, p. 18278. [2] B. Rösner et al., Organic Electronics (2014), 15, p. 435. [3] B. Rösner et al., Angew. Chemie (2015) 54, p. 12976.

MM 48.4 Thu 11:30 H38

Natural silk made optically switchable — •Igor Krasnov[1], Nicolai R. Krekiehn[1], Christina Krywka[2], Urlich Jung[1], Ahnaf U. Zllohu[3], Thomas Strunskus[3], Mady Elbahri[2,3], Olaf M. Magnussen[1], and Martin Müller[1,2] — [1]IEAP, Universität Kiel — [2]Institute of Materials Research, HZG Geesthact — [3]Institut für Materialwissenschaft, Universität Kiel

An optically active bio-material is created by blending natural silk fibers with photoisomerizable chromophore molecules-azobenzenebromide (AzBr). The material converts the energy of unpolarized light directly into mechanical work with a well-defined direction of action. The feasibility of the idea to produce optically driven microsized actuators on the basis of bio-material (silk) is proven. [1] The switching behavior of the embedded AzBr molecules was studied in terms of UV/Vis spectroscopy. To test the opto-mechanical properties of the modified fibers and the structural changes they undergo upon optically induced switching, single fiber X-ray diffraction with a micron-sized synchrotron radiation beam was combined *in situ* with optical switching as well as with mechanical testing and monitoring. The crystalline regions of silk are not modified by the presence of the guest molecules, hence occupy only the amorphous part of the fibers. It is shown that chromophore molecules embedded into fibers can be reversibly switched between the *trans* and *cis* conformation by illumination with light of defined wavelengths.

[1] I. Krasnov et al., Applied Physics Letters, 106, 093702 (2015)