

MM 44: Topical Session: TEM-Symposium - In-Situ II

Time: Wednesday 16:30–17:45

Location: H25

MM 44.1 Wed 16:30 H25

Nanoscale investigation of metal-induced crystallization (MIC) and related mass transport by in-situ TEM/STEM

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The MIC process enables fabrication of thin polycrystalline Si films at relatively low temperature (< 450°C) making it highly promising for thin film photovoltaics. The microscopic mechanism of materials transport during the layer exchange is still largely unknown. Here the microstructure of a-Si/metal/Quartz stacks, in-situ annealed at 450–530 °C, have been investigated at different length scales by combining optical microscopy and analytical TEM/STEM [1]. In particular Ag metal layer was used to directly visualize the material transport by Z-contrast imaging in STEM due to the large difference in atomic numbers of Ag and Si. Like in Al induced crystallization, Si grains are nucleated in the original Ag layer and grow dendritically as the smaller Ag grains were preferentially replaced by Si. The replaced Ag was observed to concentrate over the larger Ag grains replacing the a-Si which appears to diffuse out. Thus in contrast to Al induced crystallization a continuous Si film could not be formed, indicating the importance of Ag grain size distribution. [1] B. Birajdar, T. Antesberger, M. Stutzmann, E. Spiecker, Scripta Mater. 66, 550 (2012).

Topical Talk

MM 44.2 Wed 16:45 H25

In-situ environmental TEM studies of oxide electro-catalysts

— •CHRISTIAN JOOSS¹, STEPHANIE RAABE¹, DANIEL MIERWALDT¹, JIM CISTON², MATTHÉ UIJTTEWAAL³, JÖRG HOFFMANN¹, PETER BLÖCHL³, and YIMEI ZHU⁴ — ¹Inst. of Materials Physics, University of Goettingen, Germany — ²National Center for Electron Microscopy, Lawrence Berkeley National Laboratory, USA — ³Inst. of Theoretical Physics, Technical University of Clausthal, Germany — ⁴Dep. of Cond. Mat. Phys., Brookhaven National Laboratory, USA

In-situ studies of catalysts under operation conditions are of high scientific interest since their atomic and electronic structure in their active state may fundamentally differ from that in equilibrium. In addition, reactions in the vapor phase can hardly be observed. We present an in-situ ETEM study of electro-catalytic O₂ evolution during H₂O splitting based on Pr-doped CaMnO₃ perovskite catalysts. This materials system offer the opportunity for studies of the role of correlation effects and mixed valence physics in multi-charge transfer catalysis. We observe changes in surface and subsurface structure as well as in Mn valence in the active state during O₂ evolution. The electro-chemical processes can be controlled by application of a bias. For validation of the obtained results, the ETEM studies are complemented by in-situ X-ray absorption spectroscopy (XANES) and ex-situ cyclic voltammetry studies. This allows for deriving conclusions about the opportunities and challenges for controlled electro-chemical experiments in the ETEM. S. Raabe et al. Adv. Funct. Mater. 2012, DOI: 10.1002/adfm.201103173

MM 44.3 Wed 17:15 H25

Dynamic atomic-scale observation of catalysts in their functional state by aberration-corrected environmental transmission electron microscopy (ETEM) — •JOERG JINSCHKEK — FEI Company, Eindhoven, The Netherlands

Currently the strong focus on energy producing and environmental protecting technologies relies on the advancement of new functional catalysts. Characterization of the state and properties as well as catalyst*’s performance demands detailed dynamic atomic-scale insights while in operation conditions [1]. The implementation of differential pumping apertures in an aberration corrected TEM (FEI Titan ETEM) enables to maintain high-resolution imaging and analytical capabilities, while confining a gas environment in the close vicinity of the catalyst specimen. Atomic-scale imaging in ETEM has opened up a unique possibility to monitor heterogeneous catalysts during exposure to reactive gas environments and temperatures [2]. As an example, a catalyst composed of Au nanoparticles supported on CeO₂, active for the oxidation of carbon monoxide (CO) even below room temperature, has been examined utilizing Titan ETEM [3]. The results of in situ HRTEM experiments depict that adsorbed CO molecules cause the Au{100} facets of a gold nanoparticle to reconstruct to Au{100}-hex. The energetic favorability of this reconstructed structure has been confirmed by ab initio calculations [3]. [1] P. L. Hansen et al. Science 295, 2053 (2002); [2] J.R. Jinschek, S Helveg. Micron 43, 1156 (2012); [3] H. Yoshida, et al. Science 335, 317 (2012)

MM 44.4 Wed 17:30 H25

Electron-beam-stimulated mechanical engineering of nanoscaled amorphous silica — •MIRZA MACKOVIC and ERDMANN SPIECKER — Center for Nanoanalysis and Electron Microscopy, Cauerstr. 6, 91058 Erlangen, Germany

Oxide glasses are widely used as structural and functional materials in electronic, optical, and nanoelectromechanical devices. Since amorphous silica does not show ductility at room temperature, complications arise if one considers its application in functional devices, because no shaping or re-shaping is possible without significantly rising the temperature. However, using electron-beam-assisted deformation just recently it has been demonstrated that enormous ductility and superplasticity can be achieved for nanoscaled amorphous silica, at or near room temperature [1]. This material behavior is related to the electron-beam-induced generation of structural and bonding defects, facilitating bond-switching events in the silica network and accommodating viscous flow. Using in-situ nanomechanical testing in a transmission electron microscope, we show that this electron-beam-stimulated viscous flow and shape change of nanoscaled silica is even reversible and can thus be considered for re-shaping not only once, but multiple times. Furthermore, we demonstrate that this phenomenological reversibility can be exploited for generating anisotropic glass topology by specific electron-beam-stimulated quenching under mechanical load. This offers new opportunities for fundamental studies on structure-property relations of nanoscaled glass, which have remained unexplored till now. [1] K. Zheng et al., Nature Comm. 1:24, DOI: 10.1038/ncomms1021.