MM 40: Topical Session: TEM-Symposium - In-Situ I

Time: Wednesday 15:00–16:15 Location: H25

Topical Talk MM 40.1 Wed 15:00 H25

The kinetics of nanowire growth as seen by ultra-high vacuum transmission electron microscopy — •Frances M. Ross — IBM T. J. Watson Research Center, Yorktown Heights, NY, USA

Nanowires formed from semiconducting materials have exciting applications in electronics and optoelectronics, solid state lighting, sensing, and energy storage and conversion. These applications arise from the ability to control crystal structure and composition with great precision, for example to form abrupt heterointerfaces or specific polytypes. Here we show how direct, in situ observations using ultra-high vacuum transmission electron microscopy can help us understand the mechanisms of nanowire growth. Nanowires are formed by flowing precursor gases onto a heated sample containing catalytic particles. For Si and Ge nanowires, this allows us to visualise the ledge-flow growth mechanism directly and explore the relationship between catalyst phase and interface formation. Here, we focus on III-V nanowires, specifically GaP, where in situ measurements show unexpected changes in growth rate from one atomic layer to the next that depend on local defects. We can understand the differences in kinetics by considering the pathways and chemical potentials of the species involved. In situ microscopy therefore provides a unique view into growth and structural control in these complex and versatile nanomaterials.

MM 40.2 Wed 15:30 H25

Birth, motion, interaction, and annihilation of dislocations in graphene at the atomic scale — •Ossi Lehtinen[1,2], Simon Kurasch[1], Arkady V. Krasheninnikov[2,3], and Ute Kaiser[1] — [1]Central Facility for Electron Microscopy, Group of Electron Microscopy of Materials Science, University of Ulm — [2]Department of Physics, University of Helsinki, Finland — [3]Department of Applied Physics, Aalto University

Dislocations, one of the key concepts in materials science, govern the mechanical properties of any material. Thus, understanding their life cycle, from creation to annihilation via motion and interaction with other dislocations, point defects, and surfaces is of fundamental importance. Unfortunately, atomic scale investigations of dislocation evolution in a bulk object are well beyond the spatial and temporal resolution limits of current characterization techniques, and therefore such studies have long been reserved for computer simulations and analytical theory. Here, we overcome the experimental limits by investigating a two-dimensional material, graphene, in an aberration-corrected transmission electron microscope, exploiting the impinging energetic electrons both to image and stimulate atomic scale morphological changes in the material. The resulting transformations are followed *in-situ*, showing the full life cycle of a dislocation from birth to annihilation. Our experiment, combined with atomistic simulations, reveals the underlying mechanism of interaction to be out-of-plane buckling, which leads to markedly long-range interactions of the defects.

MM 40.3 Wed 15:45 H25

Superdislocation characterization by means of large angle convergent beam electron diffraction (LACBED) — •Julian Müller and Erdmann Spiecker — Center for Nanoanalysis and Electron Microscopy (CENEM), Department Werkstoffwissenschaften, Universität Erlangen-Nürnberg

Superdislocations (SD) play an important role for the mechanical properties of ordered intermetallic compounds. For instance, in Ni base superalloys the formation of SDs and their glide/climb across the ordered γ' phase are key elementary processes in high-temperature creep. A key step of the microscopic characterization of dislocations in the transmission electron microscope is the determination of the Burgers vector (BV) which is typically performed by identifying two-beam conditions for which the dislocation is invisible. However, in the case of SDs difficulties in the conventional BV analysis often arise due to pronounced residual contrast. In this work we demonstrate that LACBED is well suited for reliable BV analysis of SDs even in cases where the conventional analysis fails. We confirm that SDs with BVs of type a<110> and a<100> coexist in high temperature crept Ni-base superalloys, which means that the SDs are composed of partials with identical or different BVs of type a/2<110>, respectively. We use weak-beam dark field imaging and STEM tomography to reveal the corresponding splitting of the SDs into partials.

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MM 40.4 Wed 16:00 H25

Real-time observation of grain boundary migration in graphene with atomic resolution — •Carl Krill[1], Simon Kurasch[2], Dana Zöllner[3], Ossi Lehtinen[4], Jani Kotakoski[4], Arkady Krasheninnikov[4,5], and Ute Kaiser[2] — [1]Institute of Micro and Nanomaterials, Ulm University, Germany — [2]Group of Electron Microscopy of Materials Science, Ulm University, Germany — [3]Institute of Experimental Physics, University of Magdeburg, Germany — [4]Department of Physics, University of Helsinki, Finland — [5]Department of Applied Physics, Aalto University, Finland

Grain growth in polycrystalline solids is a materials science manifestation of survival of the fittest, with individual grains seizing every opportunity to steal atoms away from their neighbors. What fate befalls an atom caught in this bitter struggle, subject to the nefarious desires of two or even three neighboring grains? Until now, it has been impossible to answer this question definitively, as experimental techniques lack the spatial and temporal resolution needed to capture atomic-level dynamics during grain growth. By irradiating polycrystalline graphene with electrons in an aberration-corrected TEM, however, we show that grain growth can be studied for the first time experimentally on an atom-by-atom basis. We can watch configurational fluctuations in the boundary core region average out over time, resulting in mesoscopic translation in the direction of local curvature. The extreme case of a small graphene grain completely embedded within a larger one represents an ideal model system for testing the validity of atomic-scale computational models for grain growth.