MI 3: Analytical Transmission Electron Microscopy and Atom Probe Tomography

Chair: Hartmut S. Leipner (Martin-Luther-Universität Halle-Wittenberg)

Time: Tuesday 9:30–11:00 Location: MER 02

Invited Talk MI 3.1 Tue 9:30 MER 02

***In situ* transmission electron microscopy studies of one-dimensional materials** — •Vadim Migunov[1], Zi-An Li[2], Spasova Marina[2], Michael Farle[2], and Rafal E. Dunin-Borkowski[1] — [1]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Gruenberg Institute, Research Centre Juelich, Juelich, Germany — [2]Faculty of Physics and CeNIDE, University of Duisburg-Essen, Duisburg, Germany

As a result of recent progress in *in situ* transmission electron microscopy (TEM), the mechanical, electronic and magnetic properties of nanoscale materials and devices can now be investigated directly and correlated with their local three-dimensional morphologies, atomic structures and chemical compositions.

We have studied the mechanical, electronic and field emission properties of a variety of different nanostructures, including InAs nanowires and CdS nanocomb-like structures, using methods based on scanning probe microscopy (SPM) *in situ* in the TEM. In particular, we have used a combination of SPM and off-axis electron holography in the TEM to measure electrostatic potential and charge density distributions inside and outside materials with nm precision, both in projection and in three dimensions. Such information about local functional properties is important both for fundamental research and for the design of novel nanoscale devices.

The first author gratefully acknowledges the award of a Heinz-Bethge-Nachwuchspreis for part of this work.

MI 3.2 Tue 10:00 MER 02

New Applications in Atom Probe Tomography — •H.-Ulrich Ehrke — CAMECA, München

Atom probe tomography (APT) is known as a method for element and isotope analysis with sub-nm resolution in 3D. Innovations in APT and focused ion beam based sample preparation have enabled new applications including semiconductors and insulating materials.

Variability in metal-oxide-semiconductor (MOS) transistors has substantially increased due to continuous decreasing feature size. APT can provide elemental mapping in MOS transistors, and correlate such electrical performance with dopant concentration, showing that threshold voltage in 65 nm-node n-MOS transistors is positively correlated with the channel dopant concentration.

In geological materials, APT is now providing unique information for understanding the thermal history and mechanisms of mineral reaction, mineral exchange and radiation damage. In zircon crystals, $^{207}Pb/^{206}Pb$ ratios for nm-scale domains ($< 20\,000$ atoms Pb) average 0.17 ± 0.04 for a 2.4 Ga zircon and 0.43 ± 0.14 for a 4.0 Ga zircon in agreement with the ratios measured by SIMS over much larger volumes (100's μm^3) 0.1684 and 0.4269, respectively).

In metallic glass research, the glass forming ability of high Fe-content glasses for low-cost transformer applications is improved by small copper additions. $Fe_{76-x}C_{7.0}Si_{3.3}B_{5.0}P_{8.7}Cu_{0.7}$ glass phase-separates into α-Fe precipitates, ultrafine spheroidal ϵ-Cu-rich precipitates, silicon-depleted Fe_3(P,B,C), and Fe_3C after thermal annealing for 30 min. at 729K.

MI 3.3 Tue 10:30 MER 02

Stapelfehler als Ursache für Degradation von Si-Solarzellen — •Volker Naumann[1], Dominik Lausch[1], Andreas Graff[2], Jan Bauer[3], Angelika Hähnel[3], Otwin Breitenstein[3], Stephan Grosser[1] und Christian Hagendorf[1] — [1]Fraunhofer-Center für Silizium-Photovoltaik CSP, Halle (Saale) — [2]Fraunhofer-Institut für Werkstoffmechanik IWM, Halle (Saale) — [3]Max-Planck-Institut für Mikrostrukturphysik, Halle (Saale)

In Solarmodulen können bei Reihenschaltung hohe Spannungen gegen Erdpotenzial auftreten. Diese führen bei bestimmten klimatischen Bedingungen zur sogenannten potenzialinduzierten Degradation (PID), was mit teils dramatischen Leistungsverlusten der betroffenen Solarmodule durch Kurzschließen der kristallinen Si-Solarzellen einher geht.

Die physikalische Ursache der Kurzschlüsse wird mit elektronenmikroskopischen Methoden untersucht. Zum Auffinden der Defekte wurde REM/EBIC angewendet. An mittels FIB erzeugten Querschnitten sind die PID-Kurzschlussdefekte mit EBIC als zweidimensionale Defekte in {111}-Ebenen erkennbar. TEM-Untersuchungen ergeben, dass es sich bei den Defekten um Stapelfehler handelt. Mit STEM/EDX lässt sich eine Dekoration der Stapelfehler mit Na nachweisen. Die Dichte von Na in der Stapelfehlerebene wurde zu 10^{14} bis 10^{15} Atome pro cm^2 bestimmt. Es wird vermutet, dass Natriumatome in Stapelfehlern eine große Dichte elektronischer Zustände erzeugen. Die Kurzschlüsse, die bei PID entstehen, werden folglich darauf zurückgeführt, dass die Stapelfehler im Siliziumkristall durch das Eindringen von Na elektrisch leitend werden und den pn-Übergang kurzschließen.

MI 3.4 Tue 10:45 MER 02

Microstructural Investigation of Recombination Active Defects in Multicrystalline Silicon Solar Cells — •Dominik Lausch[1], Angelika Hähnel[2], Martina Werner[1], Jan Bauer[2], Otwin Breitenstein[2], and Christian Hagendorf[1] — [1]Fraunhofer Center for Silicon Photovoltaics, Walter-Hülse-Str. 1, 06120 Halle, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany

The focus of this work will be on the microstructural investigation of different types of defects in mc-Si solar cells introduced in a previous publication. It is shown that defect types observed on a macroscopic scale could be directly related to structures on a microscopic scale by using advanced and newly applied microstructural microscopy methods. One defect type could be clearly correlated to iron precipitates located at defect structures of the underlying wafer by TEM analysis. To discuss the physical behaviour at the different defect classes temperature dependent EBIC measurements have been performed. Based on these results a model for the different classified types will be proposed explaining the observed recombination and prebreakdown behavior.The knowledge obtained can be reversibly interconnected to the macroscopic investigation on an industrial level to work on a solution to avoid these problems.