MI 2: Analytical Electron Microscopy: SEM and TEM-based Material Analysis

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

Time: Tuesday 11:15–13:15 Location: H5

Invited Talk MI 2.1 Tue 11:15 H5

Nanocharacterisation of the structural and luminescence properties of materials in the scanning electron microscope — •Carol Trager-Cowan[1], G. Naresh-Kumar[1], N. Allehiani[1], S. Kraeusel[1], B. Hourahine[1], S. Vespucci[1], D. Thomson[1], E. Pascal[1], R. Johnston[1], M. Morrison[1], A. Alasmari[1], J. Bruckbauer[1], G. Kusch[1], P. R. Edwards[1], R. W. Martin[1], A. P. Day[2], A. Winkelmann[3], A. Vilalta-Clemente[4], A. J. Wilkinson[4], P. J. Parbrook[5], D. Maneuski[6], V. O'Shea[6], and K. P. Mingard[7] — [1]Dept of Physics, SUPA, University of Strathclyde, Glasgow G4 0NG, UK — [2]Aunt Daisy Scientific Ltd, Claremont House, High St, Lydney, Gloucestershire, GL15 5DX, UK — [3]Bruker Nano GmbH, Am Studio 2D, 12489 Berlin, Germany — [4]Department of Materials, University of Oxford, Oxford OX1 3PH, UK — [5]Tyndall National Institute, University College Cork, Lee Maltings, Cork, Ireland — [6]School of Physics and Astronomy, SUPA, University of Glasgow, Glasgow, G12 8QQ, UK — [7]National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK

The performance requirements for next-generation materials, with applications spanning the aerospace, automotive, oil and gas, electronics and lighting industries, demand pioneering manufacturing techniques combined with innovative characterisation tools. The structural properties of materials play a vital role in the performance of critical components and it is important to understand such properties down to the sub-micron scale. For example high temperature operation of gas turbines is affected by the crystal orientation of the nickel-based single-crystal super alloys from which they are made; the optical efficiency and lifetime of UV LEDs is strongly dependent on the type and density of structural defects such as dislocations present in AlGaN thin films.

The novel scanning electron microscopy techniques of electron backscatter diffraction (EBSD); electron channelling contrast imaging (ECCI) and hyperspectral cathodoluminescence imaging (CL) can provide complementary information on the structural and luminescence properties of materials rapidly and non-destructively with a spatial resolution of tens of nanometres. EBSD provides orientation, phase and strain analysis, whilst ECCI is used to determine the planar distribution of extended structural defects such as threading dislocations and stacking faults over a large area of a given sample. CL provides information on the influence of crystallographic defects on light emission, either specific defect-related luminescence or dark spot features where carrier recombination at defects is non-radiative. CL can also provide information on the composition of alloy thin films used in the manufacture of light emitting devices, e.g., the AlN content in AlGaN thin films.

In this talk I will describe the EBSD, ECCI and CL techniques and give some examples of their application to real material problems. In particular I will illustrate the advantages of acquiring coincident EBSD/ECCI/CL data to the understanding of nitride semiconductor structures. For example electron channelling contrast images and hyperspectral CL intensity maps of the UV emission from approximately the same region of a $Al_{0.8}Ga_{0.2}N$:Si thin film were shown. The presence of dislocations (black-white spots), revealed by ECCI, lead to a reduction in the luminescence. In particular dislocations with a screw component appear as dark spots in the CL image.

I will also describe how advances in instrumentation, e.g., digital direct electron imaging detectors, can provide exciting opportunities for new applications for these techniques.

Invited Talk MI 2.2 Tue 12:00 H5

Highly spatially resolved cathodoluminescence of III-Nitride based nanostructures directly performed in a Scanning Transmission Electron Microscope at liquid He temperatures — •Juergen Christen, Gordon Schmidt, Frank Bertram, Marcus Mueller, and Peter Veit — Otto-von-Guericke-Universität Magdeburg, Germany

For a detailed understanding of complex semiconductor heterostructures and the physics of devices based on them, a systematic determination and correlation of the structural, chemical, electronic, and optical properties on a nanometer scale is essential. Luminescence techniques belong to the most sensitive, non-destructive methods of semiconductor research. The combination of luminescence spectroscopy - in particular at liquid He temperatures - with the high spatial resolution of a scanning transmission electron microscope (STEM) (dx < 1 nm at RT, dx < 5 nm at 10 K), as realized by the technique of low temperature scanning transmission electron microscopy cathodoluminescence microscopy (STEM-CL), provides a unique, extremely powerful tool for the optical nano-characterization of semiconductors, their heterostructures as well as their interfaces. Typical results, which will be presented, include nm-scale correlation of the optical properties with the crystalline real structure of GaN/AlN quantum dots. In particular, we will show the preferential nucleation of GaN/AlN quantum dots at threading dislocation without inhibition of very sharp emission lines with line width below 0.5 meV.

MI 2.3 Tue 12:45 H5

Quantifying the magnetism of individual nanomagnets: EMCD on FePt nanoparticles — •Sebastian Schneider[1,2], Darius Pohl[1], Stefan Löffler[3], Deepa Kasinathan[5], Jan Rusz[6], Peter Schattschneider[3,4], Schultz Ludwig[1,2], and Bernd Rellinghaus[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany — [2]TU Dresden, Institut fur Festkörperphysik, D-01062 Dresden, Germany — [3]Vienna University of Technology, USTEM, A-1040 Vienna, Austria — [4]Vienna University of Technology, Institute of Solid State Physics, A-1040 Vienna, Austria — [5]Max-Planck Institute for Chemical Physics of Solids, D-01187 Dresden, Germany — [6]Uppsala University, S-75105 Uppsala, Sweden

Electron magnetic chiral dichroism (EMCD) is the electron wave analogue of X-ray magnetic circular dichroism (XMCD). It offers the possibility to study magnetic properties at the nanoscale in a transmission electron microscope (TEM). In a 'classical' EMCD setup, the sample is illuminated with an electron plane wave and acts as a beam splitter. Although it is meanwhile established that EMCD allows for the measurement of magnetic dichroism, only few examples are available that present quantitative results. We report on EMCD measurements on individual FePt nanoparticles with a thickness of roughly 10 nm and compare our experimental findings with simulations. From the experimental spectra, a ratio of angular to spin magnetic moment $m_l/m_s = 0.084 \pm 0.076$ is for the first time quantitatively derived for individual FePt nanoparticles.

MI 2.4 Tue 13:00 H5

Ein Experimenteller Standpunkt zur Informationstiefe von EBSD — •Wolfgang Wisniewski — Otto-Schott-Institut Jena

Bisher beruht die weit verbreitete Auffassung bezüglich der Informationstiefe von EBSD auf einer Abschätzung der Bandbreite und Simulationen bei denen nur Elektronen mit einem Energieverlust von ca. 4% oder weniger berücksichtigt wurden. Dieser Beitrag liefert eine kritische Diskussion der bestehenden Literatur, experimentelle Ansätze sowie erste Ergebnisse die darauf hin deuten, dass die Informationstiefe von EBSD mehr als doppelt so tief reicht als bisher angenommen.