



GASTKOLLOQUIUM
Zentrum für Oberflächen- und Nanoanalytik
Johannes Kepler Universität Linz



*Im Rahmen der Eröffnung des Christian Doppler Labors für
Nanoskalige Phasenumwandlungen spricht*

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über

Spectroscopic STEM imaging in 2D and 3D

Atomic-resolution imaging with a spherical aberration-corrected scanning transmission electron microscope (STEM) is now widely used for the study of interesting, complex material systems. This is owed both to the flexibility in detecting the electrons scattered off from matter, but also to the improved efficiency in collecting spectroscopic signals. High-angle annular dark-field imaging is routine and has become a quantitative technique [1]. Developments like high-brightness guns and monochromators, improved electron energy-loss spectrometers (EELS) or X-ray (EDXS) detector concepts, have enabled elemental-specific imaging at that scale, and allow for a correlation of structural and chemical information [2,3,4]. The simultaneous collection of all these signals at various tilt angles even, defining the technique of STEM-EELS/EDXS tomography, has given unprecedented insight into the 2D and 3D structural and physico-chemical make-up of TEM specimens [5,6,7,8].

While the principal acquisition of large multi-modal data sets has become more straightforward, the data processing and the interpretation of the spectroscopic intensities now appear rather challenging. Monochromated low-loss EELS for instance is now widely accepted for probing and mapping the evanescent fields of particle plasmons [9,10,11,12,13], and early issues of interpretation could be overcome. Recently, a novel tomography scheme lifted some of the restrictive conditions for nano-particles and opened up new ways for the computation of the photonic local density of states in three dimensions [14,15,16].

Classical compositional analysis with core-loss EELS and EDXS signals, when executed accurately, still suffers from a multitude of ill-defined parameters and intensity conversions into concentrations for a particular quantification scheme often rely on “best-guess”

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quantities, such as sample densities, absolute thicknesses, theoretical ionization cross-sections, solid and take-off angles etc [17]. A recently described analysis concept tries connecting EDX and EELS signals in a common analysis framework helping to reduce the need for estimates [18]. Secondly, the complex physics of scattering of the electron probe along aligned atomic columns produces a nonlinear relation between signal and composition and there is no longer a simple relationship between the observed analytical intensities from the projected atomic positions. Different approaches to recover the true concentrations from inelastic images, taken under strong channeling conditions, have been proposed [19, 20,21]. Often image simulations and a calculation of the underlying scattering dynamics are required to “correct” the experiment. Alternatively, acquisition schemes to reduce the effects of channeling by tilting or precessing the beam [22] have been suggested.

Overall, the STEM represents a quantitative instrument which is capable of providing numerical data on the properties of thin specimens. The talk aims to give an overview to spectroscopic imaging in the mentioned areas.

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