Low-energy electron microscopy for functional materials characterization

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In the nearly six decades after its original invention and experimental realization in 1962, low-energy electron microscopy (LEEM) [1] has matured into a powerful and reliable experimental technique for structural characterization of crystalline surfaces. The inherent full-field imaging principle of LEEM provides unprecedented insights into the morphology of surfaces at nanometer resolution and video rates, enabling the monitoring of an ever-expanding variety of dynamical phenomena at surfaces, such as, e.g., thin-film growth and etching, structural phase transitions, and surface-chemical reactions. Owing to its intimate relation to (very)-low-energy electron diffraction ((V)LEED), both sample morphology and local atomic structure may be probed simultaneously, making it possible to assess surface structure across many different length scales [2]. In their newest variant, aberration-corrected instruments even offer a lateral resolution of 2 nm and below in favorable circumstances [3].

When combined with intense, tunable, monochromatic, ultraviolet or X-ray sources and a suitable energy filter, the full-field imaging approach facilitates photoemission electron microscopy (PEEM) and related techniques, allowing detailed spectroscopic investigations of individual nanosized objects and elucidating its individual chemical, electronic, or magnetic properties and structure [4].

In this presentation, I will start from the fundamental physical principles of low-energy electron microscopy and sequentially introduce the major contrast mechanisms that can be exploited for sample characterization [5]. Examples of increasing complexity will include metal-on-metal growth, transition metal oxidation, growth of 2D materials as well as chemical reactions at oxide surfaces [6].

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