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High-Resolution STEM and EELS as Tools to Study Structure and Bonding of Oxides

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Due to the developments of aberration correctors, bright electron sources, stable microscopes and electron monochromators, electron microscopy has dramatically evolved in the recent years. The current microscopes provide structural, chemical and spectroscopic information with sub-angstrom resolution and with synchrotron-quality spectroscopic performance ranging from the mid-infrared to the hard X-ray regime. Using a combination of scanning transmission electron microscopy (STEM) and electron energy loss spectroscopy (EELS) with better than 0.1eV energy resolution (down to 10meV), we provide here a review of recent studies where EELS and STEM have allowed us to probe the structure, the local chemistry and the nature of the local electronic structure of a range of complex oxides. These studies show that it is possible to determine the location of particular atomic species used as dopants in a crystal [1], the local coordination and valence of atoms in crystals and at surfaces [2,3], and also the nature of the hybridization and valence in perovskites [4] and superconductors [5,6]. These applications show that EELS and STEM can be used to resolve ambiguities in structure refinements of oxides by deducing the site preference of transition metal atoms and their coordination. We also show that it is possible to extract valence information and localization of electron charge in a range of materials, thus providing essential information on termination at interfaces [7]. With these techniques, we explore defects in materials and the nature of the electronic structure at interfaces.

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