EELS mapping, a key component for the exploration of the nanoworld

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EELS (Electron Energy Loss Spectroscopy) now constitutes a major component in any new electron microscope, in particular for the characterization of solid specimens. It is commonly used for elemental mapping, in which case atomic resolution and single atom sensitivity have been demonstrated, and it has found wide areas of applications in many scientific domains.

Recent progress in instrumentation (spectrometers, monochromators, detectors) and in methodology (data processing) now provide access to increased performance, to upgraded accuracy and precision and also to unconventional domains lying out of the main stream. They are all associated to spatially-resolved EELS (as offered, for instance, in the spectrum-imaging mode), which intimately combines an electron spectroscopy over a very broad spectral domain (from 1 eV up to a few thousands of eV) and with high spectral resolution (typically 0.2 to 0.5 eV), and an imaging microscopy with unique spatial resolution. However, the huge amount and the quality of the recorded data require a parallel development in processing tools for an optimized information extraction and in theoretical background support for improved interpretation.

5^{th}-order aberration corrected STEM instruments delivering a sub-angström incident electron beam probe on the specimen surface, have already proved their capacity to generate atomic-scale maps of the interface chemistry in perovskite-based systems for spintronic applications. Some examples in this domain will be shown and discussed. The abruptness of the interfaces at the atomic-scale is demonstrated, along with some initial analysis of the oxidation states for the metal ions as it can be deduced from the spatial variations of the fine EELS structures on characteristic core-edges (ELNES).

In the low energy-loss part of an EELS spectrum, new routes are now opened to disentangle the local electronic response of the material in terms of band structure (band gap, interband transitions, excitons) from the long-range response of the neighbouring architecture, encompassing the electromagnetic fields generated by surface and interface plasmons. In particular, when applied to individual metallic nanoparticles, it has been demonstrated that the measured EELS signal is closely related to the electromagnetic modes density of states (EMDOS) defined by the shapes and dimensions of the investigated nanostructure, thus opening extended access to the comprehension of plasmon physics and to the conception of new structures and devices of interest in nanophotonics.

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