Enlarging the field of mapping at the (sub)-nm level with STEM-EELS

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Recent progresses in instrumentation and methodology have opened to STEM-EELS at the ultimate level, bright new fields of research in materials, and in particular in nano- sciences. New channels of information, typically down to the atom-size in space and to 10 meV in energy resolution (see figure below), have become accessible in the different EELS energy domains to the latest generation of instruments. They also provide a more efficient collection of the signals which therefore exhibit increased S/N ratios and become prone to more refined statistical analysis.

Consequently, beyond the well-established use of the characteristic core-losses EELS signals for elemental mapping at the single atom and/or single atomic column level, their fine structures are now used to extend the information to their bonding state and coordination. In particular, the position in energy of well-defined structures can be determined with a very high level of accuracy, so that minute shifts of the position of transition metal white lines can be used to quantify small electron doping changes with unit cell resolution. In the low-loss energy domain (from UV to IR), EELS spectra exhibit on the surface of metallic nanoparticles plasmon peaks which are related to collective electron excitations associated to electro-magnetic fields, whose spatial distributions critically depend on shape, size and environment. With the introduction of monochromators, these features are now mapped well below 1 eV in the IR domain. Very recently, the bulk plasmons have also gained a spectacular revival of interest, as it has been demonstrated that the analysis of their position change with electron density is sufficiently sensitive to "take the temperature" at the nanoscale. Pushing further down in the EELS spectral domain (typically around 100 meV), the implementation of monochromators has spectacularly demonstrated the access to local vibrational spectroscopy. It has even been suggested that the signal associated to the impact scattering on nuclei could be used to map masses and isotopes with atomic resolution. The bright rich future for these established or potential EELS-based techniques in the spectrum imaging mode will be discussed in this presentation.