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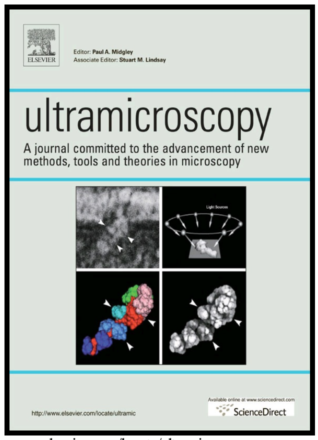

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Electron Energy Loss Spectroscopy imaging of surface plasmons at the nanometer scale

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Abstract

Since their first realization, electron microscopes have demonstrated their unique ability to map with highest spatial resolution (sub-atomic in most recent instruments) the position of atoms as a consequence of the strong scattering of the incident high energy electrons by the nuclei of the material under investigation. When interacting with the electron clouds either on atomic orbitals or delocalized over the specimen, the associated energy transfer, measured and analyzed as an energy loss (Electron Energy Loss Spectroscopy) gives access to analytical properties (atom identification, electron states symmetry and localization). In the moderate energy-loss domain (corresponding to an optical spectral domain from the infra-red (IR) to the rather far ultra violet (UV), EELS spectra exhibit characteristic collective excitations of the rather-free electron gas, known as plasmons. Boundary conditions, such as surfaces and/or interfaces between metallic and dielectric media, generate localized surface charge oscillations, surface plasmons (SP), which are associated with confined electric fields. This domain of research has been extraordinarily revived over the past few years as a consequence of the burst of interest for structures and devices guiding, enhancing and controlling light at the sub-wavelength scale.

The present review focuses on the study of these surface plasmons with an electron microscopy-based approach which associates spectroscopy and mapping at the level of a single and well-defined nano-object, typically at the nanometer scale i.e. much improved with respect to standard, and even near-field, optical techniques. After calling to mind some early studies, we will briefly mention a few basic aspects of the required instrumentation and associated theoretical tools to interpret the very rich data sets recorded with the latest generation of (Scanning)TEM microscopes. The following paragraphs will review in more detail the results obtained on simple planar and spherical surfaces (or interfaces), extending then to more complex geometries isolated and in interaction, thus establishing basic rules from the classical to the quantum domain. A few hints towards application domains and prospective fields rich of interest will finally be indicated, confirming the demonstrated key role of electron-beam nanoplasmonics, the more as an yet-enhanced energy resolution down to the 10 meV comes on the verge of current access.