Surface plasmon standing waves on Ag nanorods: observations of finite size effects and size dependency

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Silver nanoparticles were synthesized via polyol synthesis and then deposited on a 30 nm thick silicon nitride membrane. STEM-EELS-SI measurements were carried out using a monochromated FEI Titan TEM operated at 120 kV. Surface plasmon (SP) resonances on silver nanorods, mapped via STEM-EELS-SI, were observed to have clear configuration of standing waves of the nanorod. The nm resolution of the electron probe allowed important physical information about the formation of SP waves to be obtained directly from the STEM-EELS-SI maps. In particular, we extracted information about the effects of retardation and substrate interaction on the value of the energy of a given mode, by modelling theoretically the STEM-EELS-SI results, solving explicitly Maxwell's equations for the system under consideration. Also, we measured directly the value of the 'skin depth' of the SP resonances and its dependence on the dimension of the nanorod (diameter) and we measured an exponential decay of the amplitude of the different modes at the ends (tips) of the nanorod. Furthermore, we observed that in contrast to the behaviour of a classical standing wave on a string with fixed ends, we observed that the wavelength of the SP standing wave on a nanorod, for a given mode, is not constant throughout the length of the nanorod. In particular, the wavelength has a natural or 'relaxed' value in the central region of the nanorod, and becomes compressed to lower values as the wave approaches the tip (or end) of the nanorod.