TEMPERATURE-DEPENDENT OPTICAL PROPERTIES OF PLASMONIC NANOSYSTEMS

Michele Magnozzi[a], Marzia Ferrera[a], Francesco Bisio[b], Maurizio Canepa[a]

[a] OPTMATLAB, Dipartimento di Fisica, via Dodecaneso 33, Università di Genova, Genova, Italy
[b] CNR-SPIN, corso Perrone 24, Genova, Italy

The variation of optical properties of metals with temperature is becoming an increasingly relevant issue in fields like thermoplasmonics, particle-mediated hyperthermia or heat transfer at the nanoscale. Indeed, when light-induced heating of metallic nanoparticles is performed, the systems' properties are modified, dramatically altering the heating process itself.
Whereas temperature dependencies of bulk materials are relatively well investigated, much less is known about the same phenomenon for metallic nanoparticles, where surface effects and finite-size constraints may contribute to strongly affect the temperature-dependent system response. For example, it is known that for thin Au films there is an increase of more than 100% of the imaginary part of the Au permittivity going from room temperature to 500 °C [1]. For particles, it could be in principle significantly different.
In typical laser-heating experiments on nanoparticle systems, the actual system temperature at the nanoscale is often determined *ex-post* by means of simulations that, at their best, employ the temperature-dependent permittivity of the corresponding bulk systems. Here we attempt to reverse this paradigm by measuring the optical response of a system of nanoparticles heated at a well-defined temperature, and retrieving the actual temperature-dependent system response.
We present a spectroscopic-ellipsometry study of 2D arrays of gold nanoparticles [2] at variable temperatures in the 245-1700 nm spectral range and in the 25 °C to 350 °C temperature interval. The ellipsometric spectra were acquired in-situ, under high-vacuum conditions, employing a custom-built roll-on/roll-off mini-vacuum chamber fitted to a J.A. Woollam M-2000 ellipsometer [3]. Using a dedicated effective medium approximation developed for this kind of systems [2], we are able to reproduce the SE spectra at different temperatures, noticing that contributions from surface softening or melting may play a key role as the temperature is increased.

Keywords: gold nanoparticles; in situ ellipsometry

References

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