Physics of two photon luminescence imaging in nanoplasmonics

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Since the eighties, a tremendous interest has been devoted to the original near-field optical properties of nano-objects (either dielectric or metallic) deposited on surfaces [1]. To investigate these properties, near-field experimental methods such as PSTM and SNOM were initially developed [2]. They however need to accurately locate a near-field detector (tip) in the vicinity of the sample, making the system difficult to describe theoretically since the detector has an influence on the system itself. Recently, an alternative method based on two photon luminescence (TPL) has been developed to give access to near field informations through a far field measurement [3-4]. This technique can be advantageously coupled to optical absorption measurements of isolated nano-objects [5,6].

We investigate here lithographically fabricated gold nanoprisms. Both TPL and scattering by dark-field microspectroscopy were performed on isolated nanoprisms. The signals provided by these experiments are then compared and investigated theoretically.

In a first step, the nanostructure is represented by a single gold nanosphere deposited on a glass substrate and excited by an incident electric field. By using the field susceptibility theory, a simple analytical expression of the scattering signal generated by this nanoparticle is extracted as a function of the experimental parameters (incident wavelength and power, numerical aperture). In a second step, we describe the two photon luminescence signal in this simple configuration. This allows to discuss the origin of the spectral shift of the surface plasmon resonance during the propagation towards the far-field.

Finally we generalize this analytical scheme to realistic gold nanoparticles to simulate our experimental results. This comparison enables us to extract the order of magnitude of the non-linear response function of the nano-object as function of the incident wavelength.

References

[1] C. Girard, and A. Dereux, Rep. Prog Phys. **59** (1996) 657
[2] P. Dawson, F. de Fornel, and J-P. Goudonnet, Phys. Rev. Lett. **72** (1994) 2927
[3] P. Ghenuche, S. Cherukulappurath, T. H. Taminiau, N. F. van Hulst, and R. Quidant, Phys. Rev. Lett. **101** (2008) 116805
[4] K. Imura, T. Nagahara, and H. Okamoto, J. Phys. Chem. B **109** (2005) 13214
[5] A. Arbouet, D. Christofilos, N. Del Fatti, F. Vallee, J. R. Huntzinger, L. Arnaud, P. Billaud, and M. Broyer, Phys. Rev. Lett. **93** (2004) 127401
[6] M. W. Knight, J. Fan, F. Capasso, and N. J. Halas, Optics Express **18** (2010) 2580.

Figures :

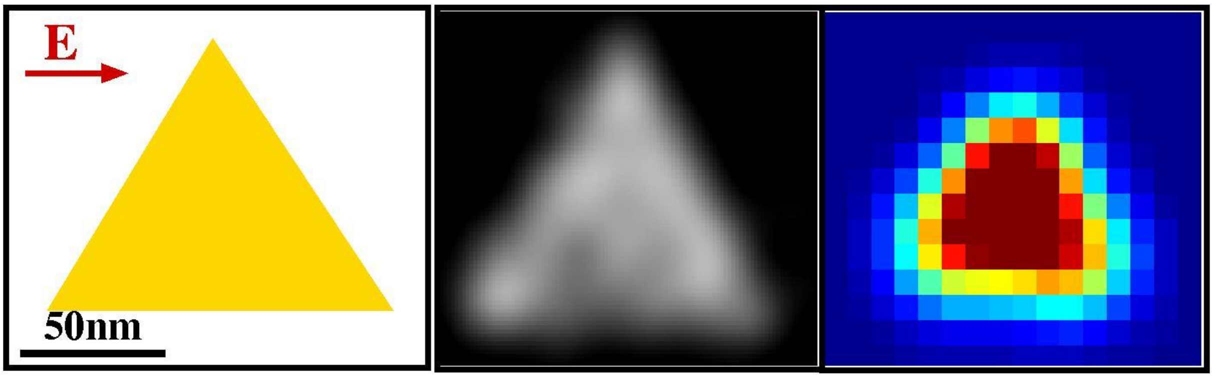

Figure 1 : (a) Investigated configuration : the electric field is parallel to the side of the nanoprism and the propagation of the beam is perpendicular to the triangle (and to the substrate). (b) SEM image of the considered gold nanoprism. The length of its side is 120nm. (c) TPL map of the nanotriangle performed at λ=822nm.