Ultrafast transient optical response of gold decorated silica nanowires

T. O. Otomalo1*, F. Martelli2, P. O’Keeffe4, D. Cantone3, T. Lin2, S. Turchini2, L. Di Mario2, and B. Palpant1

(1) Laboratoire de Photonique Quantique et Moléculaire, CentraleSupélec, Ecole Normale Supérieure Paris-Saclay, Université Paris Saclay, CNRS UMR 8537, 3 rue Joliot Curie, F-91190 Gif-sur-Yvette, France
(2) Istituto per la Microelettronica e i Microsistemi (IMM), CNR, Via del Fosso del Cavaliere 100, 00133 Rome, Italy
(3) Istituto di Struttura della Materia (ISM), CNR, Division of Ultrafast Processes in Materials (FLASHit), Via del Fosso del Cavaliere 100, 00133 Rome, Italy
(4) Istituto di Struttura della Materia (ISM) CNR, Division of Ultrafast Processes in Materials (FLASHit), 00016 Monterotondo Scalo, Italy

The so-called localized surface plasmon resonance (LSPR) phenomenon in gold nanoparticles (AuNPs), caused by the collective oscillation of its conduction electrons upon light excitation, has raised a remarkable interest for its applicability in multiple fields. Beyond, shining AuNPs with ultrashort laser pulses tuned to their LSPR induces a series of energy exchange phenomena which modulates the optical properties of the material where they are dispersed on a very short timescale [1,2]. In the present communication, we study both the stationary and transient optical properties of gold decorated silica nanowires (NWs) [3]. Disordered silicon NWs have been grown on a transparent quartz substrate by vapor–liquid–solid method and then transformed into silica NWs under thermal oxidation at 900°C. After evaporating a thin (5 nm) layer of gold onto the silica NWs and dewetting it at 500°C, every NW is covered by a distribution of AuNPs on all over its surface (Figure). The spectral dependence of the ultrafast transient optical absorption of this sample has been studied by broadband pump-probe spectroscopy [4]. This transient response stems from the modulation of the dielectric function of gold, following the photo-induced dynamics of the electron distribution [1,5]. Hence, in order to support the experimental results, we have developed a two-step model which calculates the transient optical response of the AuNPs-decorated SiO₂ NWs after ultrashort laser pulse absorption. It provides a spectral dependence of the transient absorption profile in agreement with the one obtained experimentally, except that the experimental spectral signature is broader, which can be attributed to the non-uniform shape distribution of the nanoparticles in the real sample. The influence of such a distribution on the theoretical results is finally demonstrated.

References

Corresponding author email: tadele.otomalo@centralesupelec.fr