HOT CARRIERS ULTRAFAST DYNAMICS IN ADIABATIC PLASMON FOCUSING

M. Berthel[1], O. Lozan[1], B. Ea-Kim[2], J.-M. Rampnoux[1], P. Lalanne[3] and S. Dilhaire[1]

[1]Laboratoire Ondes et Matière d'Aquitaine, Université Bordeaux, CNRS, 33405 Talence, France.
[2]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris-Sud, France
[3]Laboratoire Photonique Numérique et Nanosciences, Université Bordeaux, Institut d'Optique d'Aquitaine, CNRS, France
stefan.dilhaire@u-bordeaux.fr

The initial decay of surface plasmons-polaritons (SPPs) occurs mainly via the creation of electron-hole pairs. This rapid process is detrimental for most plasmonic applications and devices, since it destroys the coherence of the collective electron oscillations, limits the lifetime and propagation length of SPPs and prevents the realization of drastic local field enhancements. Conversely and positively, one may rather consider how to make use of the generated hot electrons to study new physical effects and to design new devices. In this frame, we will present our recent advances in the new area of ultrafast plasmonics.

Absorption-loss measurement in nanostructured films with hot electrons. The knowledge of the absorption losses (the local heat source term in the thermal diffusion equation) in devices using metal films is crucial for most components. The local heat generated by SPP decays cannot be directly measured with classical low-temporal resolution techniques [1] because they provide temporally- and spatially-broadened versions of the local heat source (after heat diffusion in the metal). We have used the permittivity changes induced by hot electrons to measure the absorption losses in metal films incorporating subwavelength apertures. The measurements performed in a temporal scale of 500 fs, much smaller than the characteristic diffusion times of electrons and phonons, shows quantitative agreement with theoretical results [2].

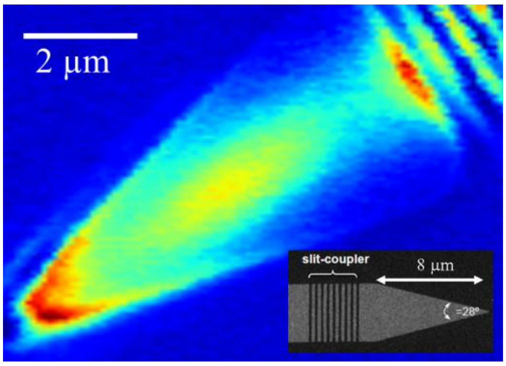

Fig. 1: Reflectance-variation image of a taper by a raster-scanned probe beam @532nm ≈1ps after the plasmon excitation by a pump beam @800nm (fixed on the coupler).
Inset: SEM image of the taper.

Generation of hot electrons in plasmonic tapers. Devices capable of generating hot electrons with good efficiencies in nano-scale spots are likely to be highly desirable [1] for future prospects in the emerging field of SPP-induced hot carrier generation. Consequently, we show measurements of the permittivity variations induced by the hot-electron energy relaxation in the electron gas of adiabatic nano-focusing SPP tapers (see Fig. 1). The strong focusing of the SPPs, clearly noticeable on Fig. 1, leads to very high temperatures and increasing of thermalization time of the hot electrons at the tip apex, which is confirmed by our theoretical study, using a two-temperature model.

[1] C. Clavero, "Plasmon-induced hot-electron generation at nanoparticle/metal-oxide interfaces for photovoltaic and photocatalytic devices" Nature. Photon, **8**, 95–103 (2014).
[2] O. Lozan, M. Perrin, B. Ea-Kim, J.M. Rampnoux, S. Dilhaire and P. Lalanne, "Anomalous light absorption around tiny apertures in metal films", Phys. Rev. Lett. **112**, 193903 (2014). editor selection and focus in physics, http://physics.aps.org/articles/v7/52.