Femtosecond spectroscopy of the electron thermalization in gold in the vicinity of Tamm plasmon resonance

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Tamm plasmon-polaritons (TPPs) have attracted huge interest since their first experimental observation in 2008. TPPs are surface states which arise at the boundary of 1D photonic crystal and metal film [1]. They are greatly analogous to the well-known surface electromagnetic waves and surface plasmon-polaritons, yet have distinctive features. TPPs exist for both s and p polarizations of the incoming light and do not require satisfaction of in-plane phase-matching conditions, thus they can be excited at any angle of incidence. Experimentally, TPP can be detected as a narrow absorption resonance in reflectance spectrum of a PC/metal structure. Electromagnetic field localization [2, 3] in the TPP mode leads to the enhancement of the nonlinear-optical phenomena, as it was demonstrated recently [4, 5].

Studied sample of one-dimensional PC consists of 6 pairs of ZrO_2/SiO_2 layers (average thicknesses 110 nm and 145 nm, respectively) covered with a semitransparent 30-nm-thick gold film. Measurements of the reflectivity change were performed in a conventional cross-polarized pump-probe scheme with a Ti:Sa laser as a source of radiation (fig.1a). Pump pulses had an energy of 60 pJ, while probe pulses were approximately 25 times weaker. Pump and probe beams were independently focused into the 40-μm wide spots on the sample. Wavelength was tuned in the range of 700–820 nm.

Figure 1b shows measurements of the time-dependent change in reflectivity of the Au/PC sample. Before the pump pulse have illuminated the sample (time less than zero) no change in reflectivity was observed. When probe pulse reflected from them pump-illuminated sample, the change in reflectivity appeared, reaching its maximum at approximately 250 fs after the zero time, and decaying for approximately 4 ps (not shown). Arrow indicate point where data was acquired for a spectroscopic measurements.

Figure 1b shows reflectance spectrum of the Au/PC sample with a solid line. A TPP-associated resonance is observed with a minimum at 765 nm. Spectrum of the relative change in reflectivity $\Delta R/R$ is shown with black dots. It exhibits a derivative-like shape in the vicinity of the TPP resonance. Maximal absolute values of the $\Delta R/R$ are observed at 760 and 770 nm at the falling and rising edges of the TPP resonance respectively. Corresponding values of the reflectivity change are in the order of $3{\cdot}10^{-3}$, which is approximately 10 times larger than the previously reported $\Delta R/R$ values for a bare gold film [6].

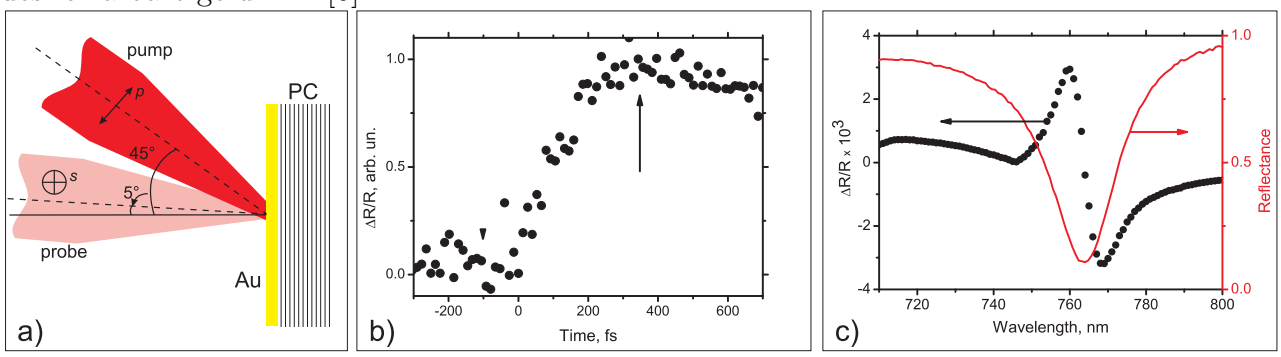

Fig. 1: (Color online) (a) Sketch of the experiment. (b) Transient reflectivity measured in the Au/PC sample at 760 nm. (c) Dots — experimental spectrum of the relative change in reflectivity of the Au/PC sample. Solid red curve — experimental reflectance spectrum of the Au/PC sample.

References

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