Strong Coupling between Localized and Propagating Surface Plasmon Modes Revealed in the Near Field from Spectral and Temporal Domains

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We investigate the strong coupling between the localized surface plasmon resonance (LSPR) mode and surface plasmon polariton (SPP) Bloch wave based on the multilayer structures as shown in Fig. 1a [1]. The strong coupling can occur when the energy of the LSPR and SPP Bloch wave is close to each other so that two hybrid modes can be formed (Fig. 1b). The far-field spectra clearly give the anti-crossing dispersion curves (Fig. 1c). Furthermore, the near-field properties of strong coupling are investigated by photoemission electron microscopy (PEEM), which has been demonstrated as a power tool in access the near field and dynamics of the plasmonic structures [2-4]. In the spectral domain, the wavelength-dependent photoemission (PE) intensity curves can exhibit the modal splitting and the extent of coupling visually (Fig. 1d, e). In the temporal domain, we obtain the ultrafast dephasing time of coupled modes (Fig. 1f). Importantly, the dependence of the dephasing time against the detuning ($E_{SPP}-E_{LSPR}$) reveals the evolution of mode dissipation. The investigation of the near-field and dynamical properties can be applied to various strong coupling systems and supplements the research of strong coupling from the viewpoint of near field in both spectral and temporal domains. The results also provide insights of manipulating the dephasing time of surface plasmons within the plasmonic frame.

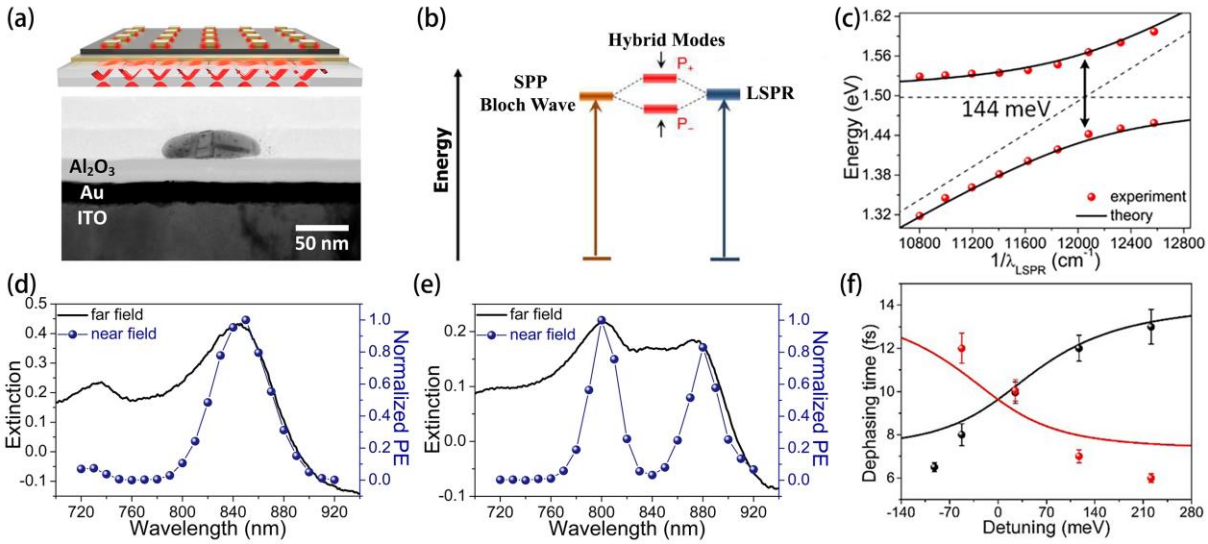

Figure 1. (a) The schematic and TEM image of the multiple-layer structure. (b) The energy diagram of the coupled system. (c) The dispersion curves of the two coupled hybrid modes. (c, d) Far-field spectra and near-field photoemission (PE) intensity curves for different detuning: (d) large detuning and (e) small detuning. (f) Dephasing time of the two coupled modes as a function of the detuning energy. [1]

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