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Program Title (English)　: Multidimensional characterization of strong coupling between localized and propagating plasmon modes by photoemission electron microscopy
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1. 概要（Summary）

Surface plasmons can be classified into two main categories: Surface plasmon polariton (SPP) and localized surface plasmon resonance (LSPR). In this work, we investigate the strong coupling between the LSPR mode and SPP-Bloch wave in multiple dimensions. In particular, near-field spectral and ultfrafast dephasing properties were elucidated by time-resolved multi-photon photoemission electron microscopy (PEEM).

2. 実験（Experimental）

【Main utilized facilities】

TR-PEEM (Elmitec); Electron beam lithography (EBL, ELS-F125, Elionix); Sputtering (MPS-4000, ULVAC); Atomic Layer Deposition (ALD, Sunnale-R150, Picosun); FE-SEM (JSM-6700FT, JEOL).

【Method】

Ordered arrays of multiple layer metallic nanostructures were fabricated by ALD, EBL and lift-off techniques. Near-field and dynamics properties of structures were explored by multi-photon photoemission electron microscopy (MP-PEEM).

3. 結果と考察（Results and Discussion）

The structure designed to realize the strong coupling is shown in Fig. 1 (a). A 20-nm-thick gold film was deposited on an indium-tin-oxide (ITO) coated glass substrate to support the SPP-Bloch wave. Then a 25-nm-thick Al_2O_3 spacer was deposited by ALD. The gold square nanoblock arrays were fabricated on the Al_2O_3 spacer by EBL to support the LSPR modes. In the strong coupling regime, the original uncoupled modes would be reconstructed into new modes exhibiting disparate characteristic owing to the reversible energy exchange between different uncoupled modes. Here, an anticrossing behavior with the Rabi spitting of 144 meV (Fig. 1(b)) observed from the far-field spectra verifies the strong coupling between the LSPR mode and SPP-Bloch wave. In addition, the excitation wavelength-dependent photoemission (PE) intensity curves measured by PEEM (Fig. 1(d)) exhibit the Rabi splitting visually in the near-field frequency domain, which is contrast to that in a control experiments in case of uncoupled LSPR and SPP Bloch wave (Fig. 1(c)). In the time domain, we can obtain the dephasing time of coupled modes from the oscillation of the photoemission (PE) signal. Furthermore, it was found that the variation of the dephasing time against the detuning reveals the evolution of mode dissipation. The near-field manifestation in both frequency and time domain would benefit to explore the strong coupling systematically.

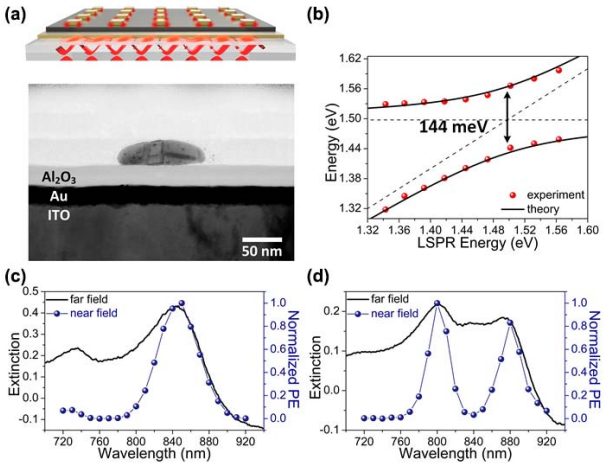

Fig. 1 (a) The geometry of the sample. (b) The dispersion of two branches against the uncoupled LSPR energy. Far-field spectra and near-field photoemission intensity curves for a uncoupled structure (c) and strongly coupled structure (d).

4. その他・特記事項（Others）

Collaborators: Quan Sun, Kosei Ueno, and Hiroaki Misawa

5. 論文・学会発表（Publication/Presentation）

1) J. Yang and Q. Sun *et al.*, Annual Meeting on Photochemistry 2017.09.06, Sendai, Japan.

2) J. Yang and Q. Sun *et al.*, The 10th Asian Symposium on Intense Laser Science, 2018.3.11, Sharjah, UAE.

6. 関連特許（Patent）

N/A