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利用形態　:共同研究
利用課題名（日本語）　:
Program Title (English)　:Manipulation of the dephasing time of coupled plasmon modes
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1. 概要（Summary）

We have studied the on near-field properties of strong coupling between localized surface plasmon resonance (LSPR) and surface plasmon polariton (SPP) in both frequency and time domains using photoemission electron microscopy (PEEM). We find that the near-field spectral can reflect the strong coupling between two plasmon modes visually. More importantly, we explore that the dephasing time of the coupled modes can be controlled by tuning the detuning energy.

2. 実験（Experimental）

【利用した主な装置】
PEEM (Elmitec); High-resolution electron beam lithography (EBL, ELS-F125-U, Elionix); Sputtering (MPS-4000, ULVAC); Atomic Layer Deposition (ALD, Sunnale-R150, Picosun); FE-SEM (JSM-6700FT, JEOL).
【実験方法】
The multiple layer nanostructures were fabricated by sputtering, atomatic layer deposition (ALD), electron beam lithography (EBL) techniques. The resonance wavelength (energy) of the LSPR and SPP can be tuned by changing the size and period of the Au nanoblock array on the top layer. The near-field spectral and dynamics properties of the structures were investigated by wavelength dependent PEEM measurements and time-resolved PEEM measurements, respectively.

3. 結果と考察（Results and Discussion）

We investigate the strong coupling between the LSPR mode and the SPP Bloch wave based on the multilayer structures as shown in Fig. 1a. 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. The far-field spectra clearly give the anti-crossing dispersion curves. 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. In the spectral (frequency) domain, the wavelength-dependent photoemission (PE) intensity curves can exhibit the modal splitting and the extent of coupling visually. In the temporal domain, we obtain the ultrafast dephasing time of coupled modes (Fig. 1b). Importantly, the dependence of the dephasing time against the detuning energy (ESPP−ELSPR) reveals the evolution of mode dissipation, also demonstrating that the dephasing time of the coupled modes can be controlled by changing the detuning energy. 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.

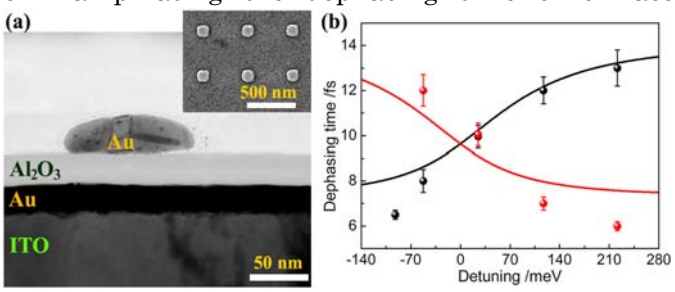

Fig. 1 (a) Sectional view of sample imaged by scanning transmission electron microscope, inset shows top view of sample imaged by scanning electron microscope; (b) evolution of dephasing time against detuning between two modes.

4. その他・特記事項（Others）

Collaborators: Quan Sun, Shuai Zu, Kosei Ueno, and Hiroaki Misawa (RIES-Hokkaido University).

5. 論文・学会発表（Publication/Presentation）

1) J. Yang, Q. Sun, K. Ueno, X. Shi, T. Oshikiri, H. Misawa, Q. Gong, Nature Commun., 9, 4858 (2018).
2) J. Yang and Q. Sun *et al.*, The 11th LEEM/PEEM workshop, October 31, 2018, Chongqing, China.
3) Q. Sun *et al.*, 第 66 回応用物理学会春季学術演講会, March 9, 2019, Tokyo, Japan. (9p-W331-8)

6. 関連特許（Patent）

N/A