

課題番号 : F-13-HK-0026
 利用形態 : 共同研究
 利用課題名 (日本語) :
 Program Title (English) : Dynamics study of plasmon-exciton strong coupling in a hybrid system of silver nanostructures and cyanine dye
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1. 概要 (Summary)

Metallic nanostructures showing localized surface plasmon (LSP) resonance have attracted much attention because it allows the interaction between photons and molecules to be enhanced. Recently, strong coupling between LSP and excitons have been studied in hybrid systems of metallic nanostructures and dye J-aggregates. In the hybrid system, stronger field enhancement effect is expected due to extended dephasing time of LSP resonance. In this study, strong coupling was induced in hybrid systems of silver nanostructures and metal-free phthalocyanine and its spectral properties were elucidated. Furthermore, ultrafast dynamics of these hybrid-states were studied by using a femtosecond transient absorption measurement system, under resonant excitation at around near-infrared region.

2. 実験 (Experimental)

Planar patterns of square-shaped silver nanoblocks with thickness of 40 nm (sputtered by using ULVAC, ACS-4000-C3-HS) were fabricated on glass substrates by high-resolution electron beam lithography (Elionix, ELS-F125) and lift-off technique. Then, the silver nanoblocks were sulfidative protected with alumina layer with thickness of 2 nm by atomic layer deposition (Picosun, SUNALE-R) and coated with metal-free phthalocyanine (Pc) by using thermal evaporation and extinction spectra of the hybrid films were measured at various thicknesses of Pc layer. Then, transient absorption spectra of the hybrid system were measured by a femtosecond pump & probe system.

3. 結果と考察 (Results and Discussion)

Silver nanoblocks with desired sizes were fabricated at various controlled block sizes and α -phased Pc films were deposited uniformly on the silver nanoblocks at various film thickness. A typical extinction spectrum of a silver-Pc hybrid film under strong overlapping condition is shown in Fig. 1(a). Rabi splitting due to strong coupling was induced and the Rabi splitting energy of the hybrid states was 670 meV with Pc thickness of 90 nm.

Fig. 1(b) shows kinetic traces of transient absorption at

800 nm wavelength in the hybrid system. At the pumping wavelength of 400 nm, decay of transient absorption derived from electron-phonon relaxation is several pico-second in lifetime. In the case of 550 nm pumping at around resonant wavelength of a hybrid state, however, decay of absorption due to not only electron-phonon relaxation but another process with time constant of 280 fs which may be lifetime of the hybrid-state. In this work, ultrafast dynamics of the hybrid states were studied and possibility of increase in LSP lifetime from sub-10 fs to several hundred femtoseconds. For further work, it is necessary to study more detail about dynamics and an electromagnetic field enhancement effect derived from localized surface plasmon will be discussed in the hybrid-system.

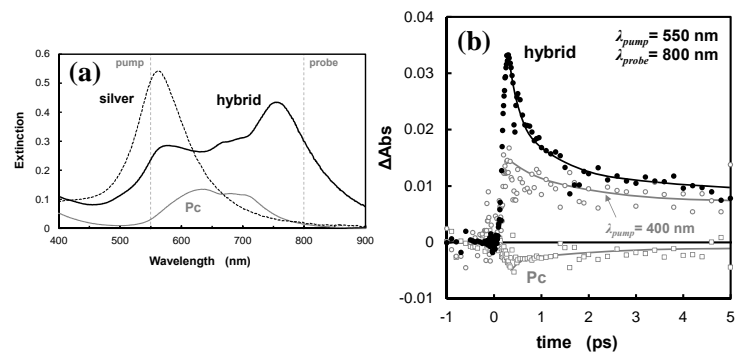


Fig.1 (a) Extinction spectra of hybrid system of phthalocyanine-silver, naked-silver nanostructure and phthalocyanine molecules. (b) Kinetics traces of transient absorption at 800 nm wavelength in hybrid system and Pc film (excitation wavelength: 550, 400 nm).

4. その他・特記事項 (Others)

・共同研究者等 (Coauthor) : H. Uehara, T. Oshikiri, K. Ueno, H. Misawa

5. 論文・学会発表 (Publication/Presentation)

なし。

6. 関連特許 (Patent)

なし。