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Program Title (English)	:Effect of detuning on near-field spectral properties of plasmonic hetero-trimer
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1. 概要（Summary）

We previously studied the plasmonic properties of gold hetero-trimer from both far field and near field. We found that the dipolar mode of the middle nanorod in the trimer system is greatly suppressed. Here, we further find that the mid-mode suppression is very sensitive to detuning of the three nanorods. With a larger detuning, the mid-mode suppression becomes less pronounced.

2. 実験（Experimental）

【利用した主な装置】

PEEM (Elmitec); Electron beam lithography (ELS-F125-U, Elionix); Sputtering system (MPS-4000C1/HC1, ULVAC); FE-SEM (JSM- 6700FT, JEOL).

【実験方法】

The gold hetero-trimer structures were fabricated through a standard electron beam lithography (EBL) technique followed by sputtering and lift-off process. The structures are arranged on a 2-D square array in a 75×75 μm^2 area with pitch size 1 μm to avoid near-field interaction of adjacent units. The thickness of gold is 30 nm with an additional 2 nm Titanium as the adhesion layer. The width of the three nanorods in a hetero-trimer is kept the same as 100 nm, while the lengths are different (180 nm, 150 nm, 120 nm). The near-field and far-field spectra were measured by a Fourier transform infrared spectrometer and photoemission electron microscopy (PEEM), respectively.

3. 結果と考察（Results and Discussion）

In our previous studies, we found when the detuning of the nanorods in the hetero-trimer is small (the lengths are 170 nm, 150 nm, 130 nm) the longitudinal dipole mode of the middle rod is greatly suppressed in both far-field and near-field spectra. In this study, we enlarge the detuning length from 20 nm to 30 nm, that is, the length of the three nanorods are 180 nm, 150 nm, and 120nm. Surprisingly, we find that the dipole mode of the middle rod becomes obvious in both far-field and near-field spectra as seen in Fig. 1 (a). If we integrate the photoemission (PE) intensity from the region ad one end of each rod, we reveal the selectively excitation of each rod (Fig. 1 (b)). Such selective excitation can also be clearly observed in the PEEM images taken at three peak wavelengths as shown in Fig. 1 (c-e). We further propose an analytical model considering both the near-field-mediated direct coupling and radiative-field-mediated indirect coupling. We determine that the radiative field coupling, which is stronger in the trimer system with smaller detuning, takes an essential role in mode suppression in the near field. In the case of large detuning, radiative field coupling becomes weaker, leading to less pronounced mode suppression.

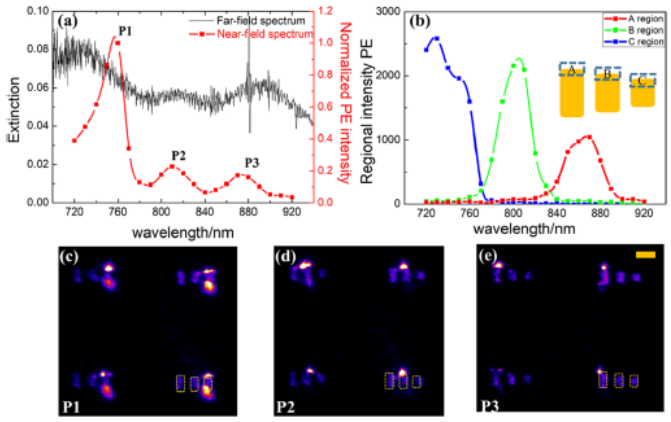

Fig. 1 (a) Far- and near-field spectra with polarization along the long axis of the nanorods. (b) Integrated photoemission intensity at different regions, as indicated in the inset. (c)–(e) PEEM images excited using laser and mercury lamp simultaneously. The laser wavelengths are selected at three near-field peak wavelengths in (a). The scale bar in is 200 nm.

4. その他・特記事項（Others）

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

5. 論文・学会発表（Publication/Presentation）

H. Song, Q. Sun et al., J. Phy. Chem. C 123, 1398-1405 (2019).

6. 関連特許（Patent）

N/A