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Observation of a Plasmon Induced Magnetic Resonance in a Gold Sphere Dimer-on-Film Nanocavity

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Abstract:

We experimentally and theoretically reveal that a gold nanosphere-dimer-on-film nanocavity supports a strong in-plane magnetic dipolar resonance in a deep sub-wavelength region, induced by a current loop in the nanometer thick dimer-film gap.

Optical responses of plasmonic nanoparticles have attracted substantial interest in recent years owing to extreme light localization and enhanced optical fields. The plasmonic coupling of the gold nanosphere-monomer to its image charges in metal-substrate-coupled gold nanoparticle systems support highly tunable electric resonance in the visible spectrum [1,2,3]. Compared to monomer, the gold nanosphere-dimer exhibits peculiar modes that are different from those of monomer.

Here, we have revealed a strong in-plan magnetic dipolar resonance in gold nanosphere-dimer-on-film system induced by a current loop enclosed by the dimer and the metal film. Full-wave electromagnetic simulations reveal that such magnetic dipolar mode has strongly enhanced local magnetic field and is highly sensitive to the gap and the sizes, offering a straightforward method for tuning the magnetic resonances to span the visible and infrared frequencies. Based on the advanced synthetic technique, the gold nanoparticles were coated by an extremely thin (1~2 nm) SiO2 layer to precisely control the distances between the particles and those between the particles and the metal film. By utilizing the home-built polarization dependent oblique illumination dark field spectroscopy, we are able to “visualize” and distinguish unambiguously the magnetic resonance from other electric resonance modes such as electric horizontal bonding mode and vertical gap mode. Fig.1a,b show the simulation scattering spectra of dimers on gold

film under incident polarization along or vertical the dimer axis respectively. The blue arrows in Fig.1a,b depict the narrow magnetic dipolar resonance.

The corresponding experimental data is depicted in Fig. 2c,d, approximately agree with the simulation results. Note that the SiO2 coated gold nanosphere used in experiment cause the resonance red-shift compared to the simulations, which are performed without SiO2 coating. The plasmon-induced magnetic resonance have shown great potentials in optical metamaterials, chemical (bio)-sensing, and surface-enhanced spectroscopies, etc.

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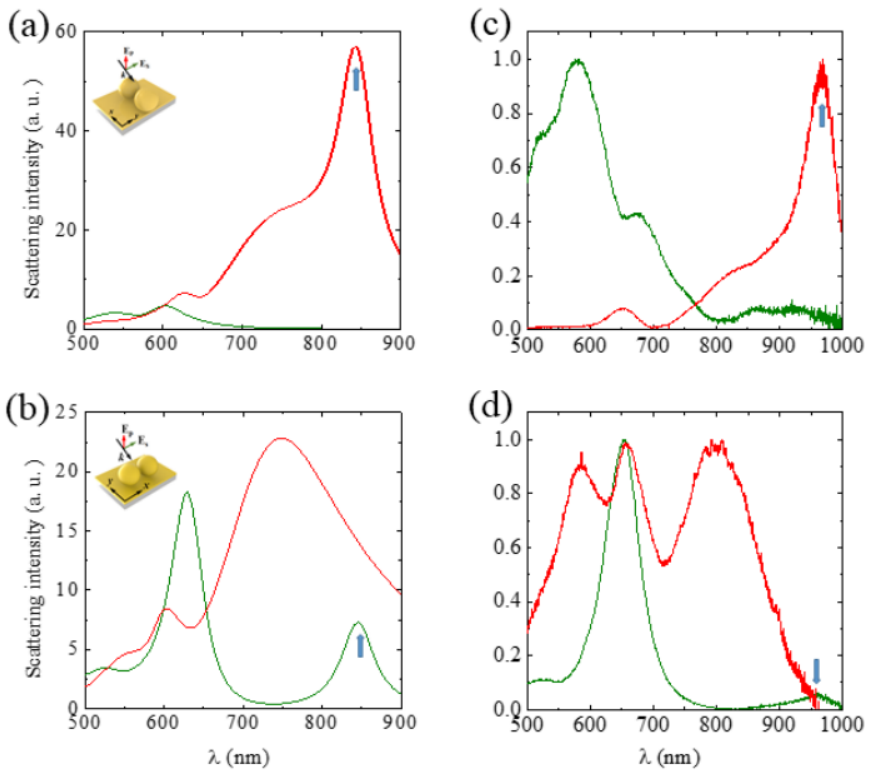

Fig. 1. Simulated (a,b) and measured (c,d) polarization-resolved scattering spectra of the gold nanosphere dimers on the gold film. The insets depict schematically the excitation configurations used in the respective measurements