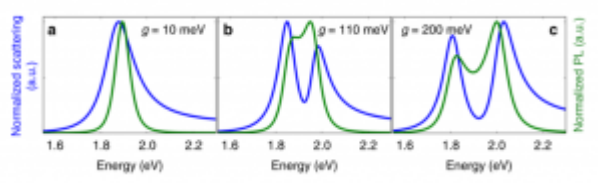
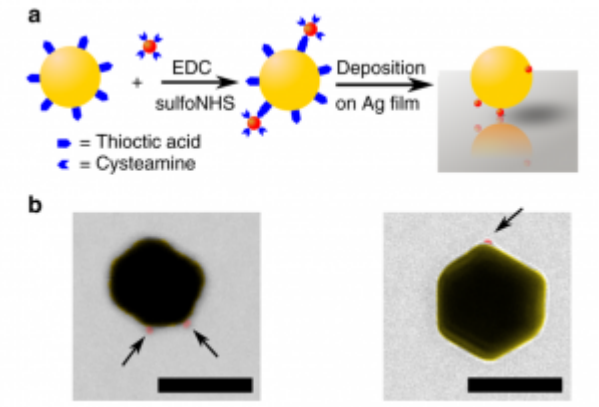
Strong coupling and induced transparency at room temperature with single quantum dots and gap plasmons

Coherent coupling between plasmons and transition dipole moments in emitters can lead to two distinct spectral effects: vacuum Rabi splitting at strong coupling strengths, and induced transparency (also known as Fano interference) at intermediate coupling strengths. Achieving either strong or intermediate coupling between a single emitter and a localized plasmon resonance has the potential to enable single-photon nonlinearities and other extreme light–matter interactions, at room temperature and on the nanometer scale. Both effects produce two peaks in the spectrum of scattering from the plasmon resonance, and can thus be confused if scattering measurements alone are performed. Here we report measurements of scattering and photoluminescence from individual coupled plasmon–emitter systems that consist of a single colloidal quantum dot in the gap between a gold nanoparticle and a silver film. The measurements unambiguously demonstrate weak coupling (the Purcell effect), intermediate coupling (Fano interference), and strong coupling (Rabi splitting) at room temperature.



As shown in Fig. , however, a measurement of the photoluminescence (PL) spectrum can distinguish between the two regimes. Unlike scattering, PL is an incoherent process, and thus does not display Fano interference. Splitting in the

PL spectrum thus occurs only in the strong-coupling regime, and has therefore been recognized as the definitive signature of Rabi splitting. So far, there has been only one report of PL splitting for a single emitter (a QD) coupled to a plasmonic metal nanostructure, but the PL spectrum showed an unexpected four-peak structure.



Fabrication of coupled quantum-dot / gap-plasmon systems. **a** Illustration of the synthesis process. Quantum dots (red) are linked to gold nanoparticles (yellow) through their capping molecules. The linked assemblies are then deposited on a silver film. **b** Electron-microscope images of linked assemblies. Quantum dots are colored in red and indicated by arrows. The left image was obtained by scanning transmission electron microscopy, and the right image was obtained by transmission electron microscopy. The scale bars are 100 nm

For more information: https://www.nature.com/articles/s41467-018-06450-4