Robust and consistent single-quantum-dot plasmonic-nanocavity strong coupling at room temperature

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Strong coupling between a single quantum emitter and an optical cavity (at rate Ω) reveals the quantum nature of light and provides an essential building block for photonic quantum technologies. However, the limiting mode volume ($\Omega \propto 1/\sqrt{V}$) of conventional dielectric cavities restricts their operation to cryogenic temperature for strong coupling.[1] Here we harness reliable self-assembly to make deterministic strong coupling at room temperature using CdSe quantum dots (QDs) in nanoparticle-on-mirror (NPoM) plasmonic nanocavities.

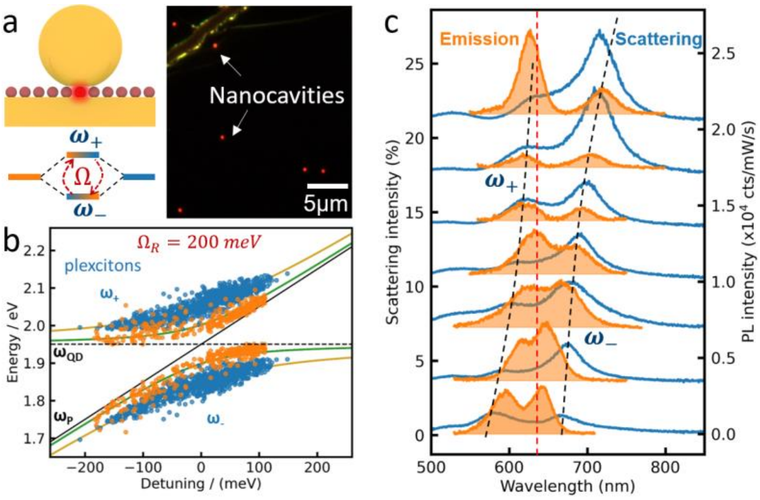

Figure 1. a, Quantum dot monolayer integrated into NPoM nanocavities. **b,** Plexciton anti-crossing of hundreds of NPoMs. Plexciton energies extracted from splitting in scattering (blue) and photoluminescence (orange) spectra. **c,** Individual scattering and photoluminescence spectra of NPoMs at various detunings.

Plasmonic nanocavities provide extreme light confinement at sub-wavelength scales,[2] making them a promising platform for delivering single-QD strong coupling at room temperature. Although several plasmonic geometries have been devised to achieve strong coupling with single QDs, their yield and consistency are very far from useful applications (<5%).[3] More importantly, evidencing the strong coupling by observing two peaks in the scattering spectra of plasmonic nanocavities is not rigorous. In this work, we integrate QD superlattices inside nanoparticle-on-mirror (NPoM) plasmonic nanocavities (Fig. 1a). We achieve high yields ~70% in single QD strong coupling by optimizing their size and spacing (Fig. 1b). A clear and reliable Rabi splitting is observed both in the scattering of each nanocavity and the QD photoluminescence (Fig. 1c).[4] Our advance provides a straightforward way to now achieve practical devices at room temperature, and opens up exploration of their nonlinear, electrical, and quantum correlation properties.

References

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