Full control of plasmonic nanocavities using gold decahedra-on-mirror constructs with monodisperse facets

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Extreme light confinement in plasmonic nanocavities has opened up a wide range of nanophotonics science and technology. The nanoparticle-on-mirror (NPoM) nanocavity has become an outstanding platform, able to control the inter-metal gap with subnanometer precision. However, geometrical variations in spherical Au nanoparticles[1] prevent full control. Here we use instead gold nanodecahedra[2] with identical monodisperse facets to create nanodecahedra-on-mirror (NDoM) nanocavities with ultra-precise optical modes and ultrahigh consistency.[3]

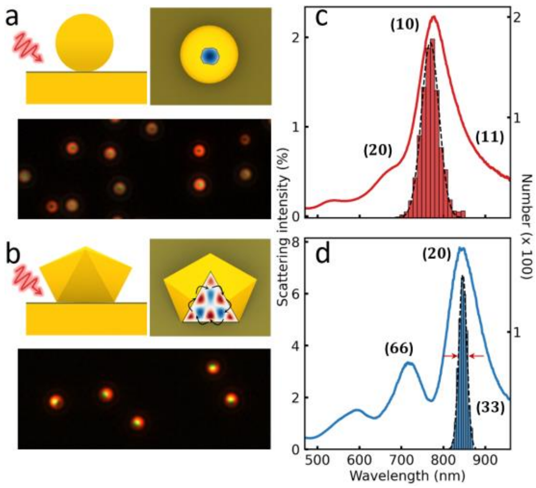

Figure 1. a,b, Schematic and dark field images of (a) spherical NPoM and (b) decahedral NDoM nanocavities. **c,d,** Statistics of scattering spectra from >1000 (c) NPoMs and (d) NDoM nanocavities, with dominant spectra for each.

We suppress the variability in optical modes when using NDoMs as a result of this facet control (Fig. 1)[3]. A set of robust higher-order plasmonic whispering gallery modes are obtained, which are uniquely localized at the edges of the bottom triangular facet (Fig. 1b). To understand the variability of light in/output coupling, we characterize 20,000 individual nanocavities and evaluate the effect of laser polarization, chirality, and diameter. Implementing a further systematic elaboration based on quasi-normal mode simulations, produces a further hundred-fold enhancement in radiative efficiencies. This develops a novel metallic nanocavity system that will have broad applications across nanophotonic devices, optomechanics, catalysis, molecular electronics, and surface science.

References

[1] JJ Baumberg *et al*., Extreme nanophotonics from ultrathin metallic gaps. *Nat. Mater.* 2019, 18, 668.

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[3] S Hu *et al.*, Full Control of Plasmonic Nanocavities Using Gold Decahedra-on-Mirror Constructs with Monodisperse Facets. *Adv. Sci.* 2023, 2207178.