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Single molecule plasmonics, strong coupling, and nanochemistry

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Coupling between plasmonic nano-components generates strongly red-shifted resonances combined with intense local field amplification on the nanoscale. This allows directly seeing molecules as well as excitations in semiconductors. We have recently explored plasmonic coupling which can be tuned dynamically, through reliable bottom-up self-assembly using the nanoparticle-on-mirror geometry (NPoM) [1-14]. We recently demonstrated how individual molecules can be strongly coupled to these ultralow volume plasmonic cavities [13] as well as how they act as optomechanical constructs with enormously enhanced couploing.[14]

We also demonstrate the possibility to track few molecules using the extreme enhancements. We find that changing just a single atom on each molecule of a self-assembled monolayer can shift the plasmon by over 50nm, and produce surprising vibrational signatures.[4-7] These have encouraging prospective applications in (bio)molecular sensing as well as fundamental science.[8-14] The ability to track and watch molecules interact and react opens up the ability to study chemistry molecule-by-molecule.

[1] Nature 491, 574 (2012); Revealing the quantum regime in tunnelling plasmonics,
[2] ACS Nano 5, 3878 (2011); Precise sub-nm plasmonic junctions within Au NP assemblies,
[3] Nano Lett 13, 5033 (2013); Controlling sub-nm plasmonic gaps using graphene
[4] ACS Nano 9, 825 (2014); Monitoring Morphological Changes in 2D Monolayer Semiconductors …
[5] Nano Letters 15, 669 (2015); Nano-optics of molecular-shunted plasmonic nanojunctions
[6] Science Reports 4, 5490 (2014); Watching individual molecules flex within lipid membranes using SERS
[7] Nature Comm. 5, 3448 (2014); DNA origami based assembly of gold nanoparticle dimers for SERS detection
[8] Scientific Reports 4, 6785 (2014); Quantitative multiplexing with nano-self-assemblies in SERS
[9] Nano Lett 13, 5985 (2013); In-situ SERS monitoring of photochemistry within a nano-junction reactor
[10] Nano Lett 15, 2600 (2015); Demonstrating PL from Au is Electronic Inelastic Light Scattering …
[11] Sci.Rep. 5, 16660 (2015); Size Dept Plasmonic Effect on BiVO4 Photoanodes for Solar Water Splitting
[12] Nano Letters 15, 7452 (2015); Controlling Nanowire Growth by Light
[13] Nature 535, 127 (2016); Single-molecule strong coupling at room temperature in

plasmonic nanocavities
[14] Science 354, 726 (2016); Single-molecule optomechanics in picocavities