Research activities at Nanophotonics group at UAHuntsville

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Research topics

- Optics of nanostructure materials
- Plasmonic effects in hybrid semiconductor quantum dot-metallic nanoparticle systems
- Nanodevice applications
- Photonic devices

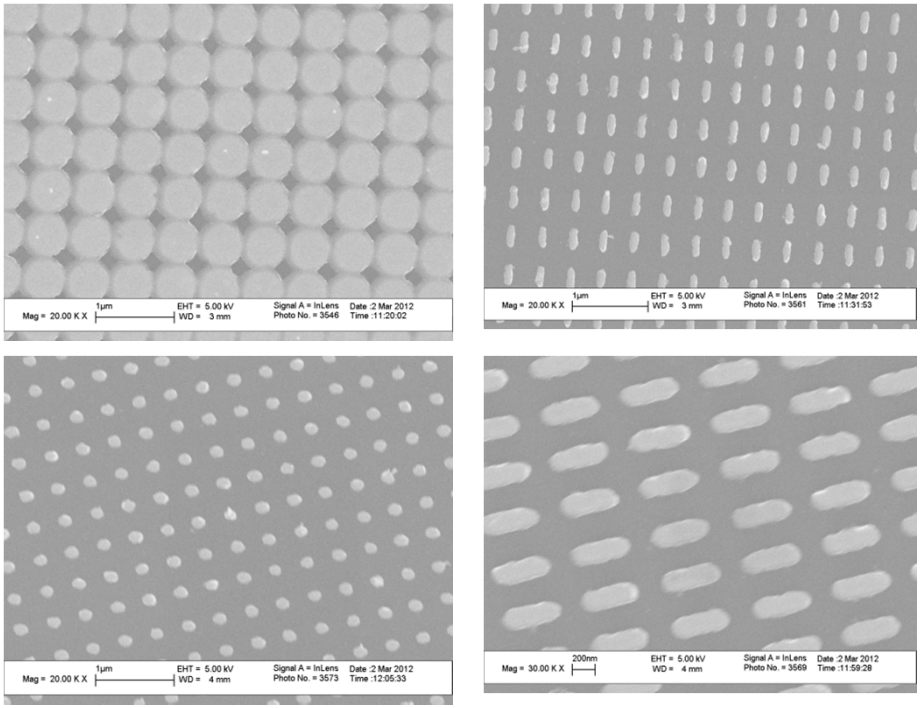
- Plasmonic enhancement of quantum dot fluorescence:

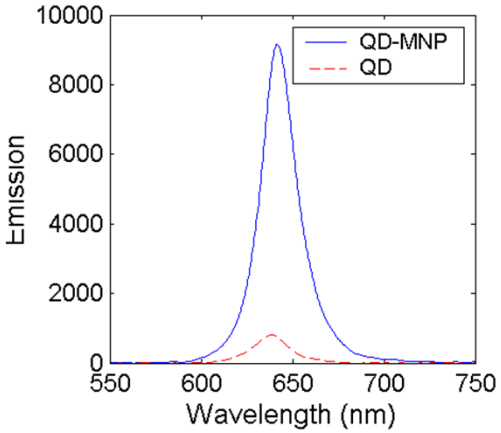
Red dashed line: fluorescence of QDs (no MNPs)

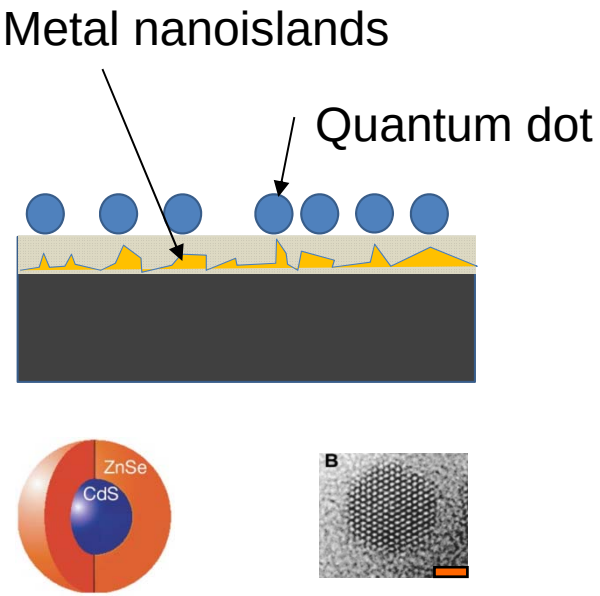
Blue solid line: fluorescence of QD+MNP

– Utilizing near fields of MNPs

– Investigating the impacts of shapes and sizes of MNPs

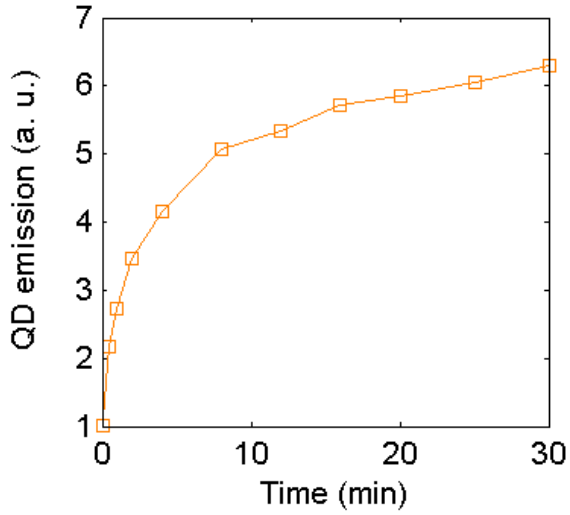


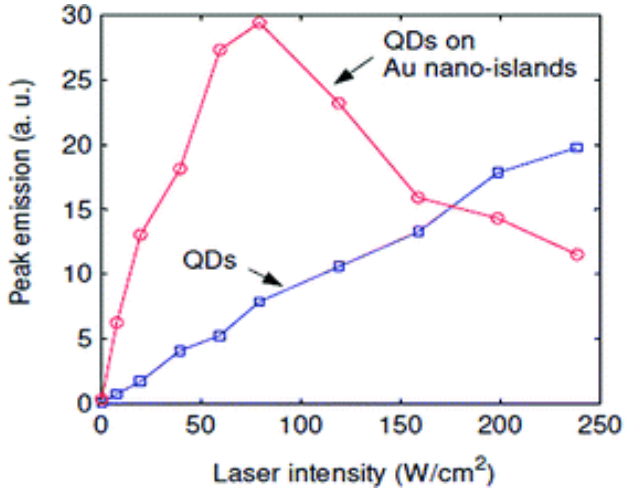


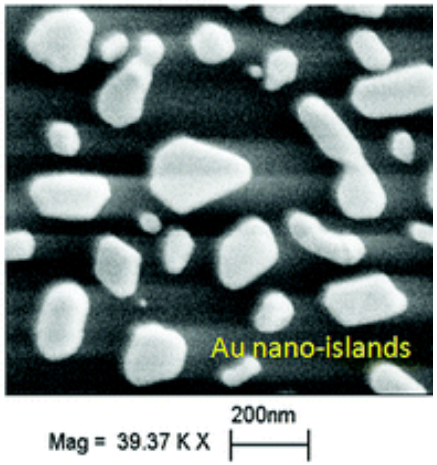


Plasmonic effects on photo-induced fluorescence enhancement of QDs (PFE):

- How metallic nanoparticles influence PFE
- Governing processes in PFE
- QD solids v.s. single QDs
- Forster energy transfer
- Photoionization, photo-oxidation, etc.
- Emission stability of QDs

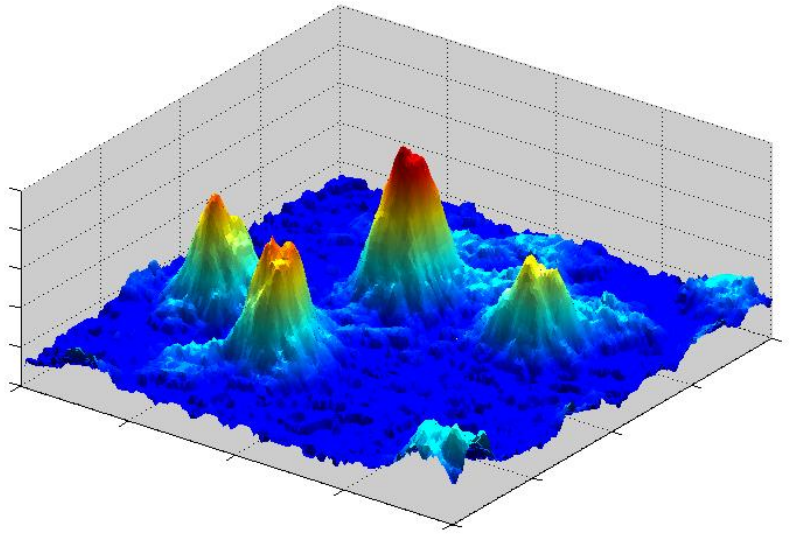




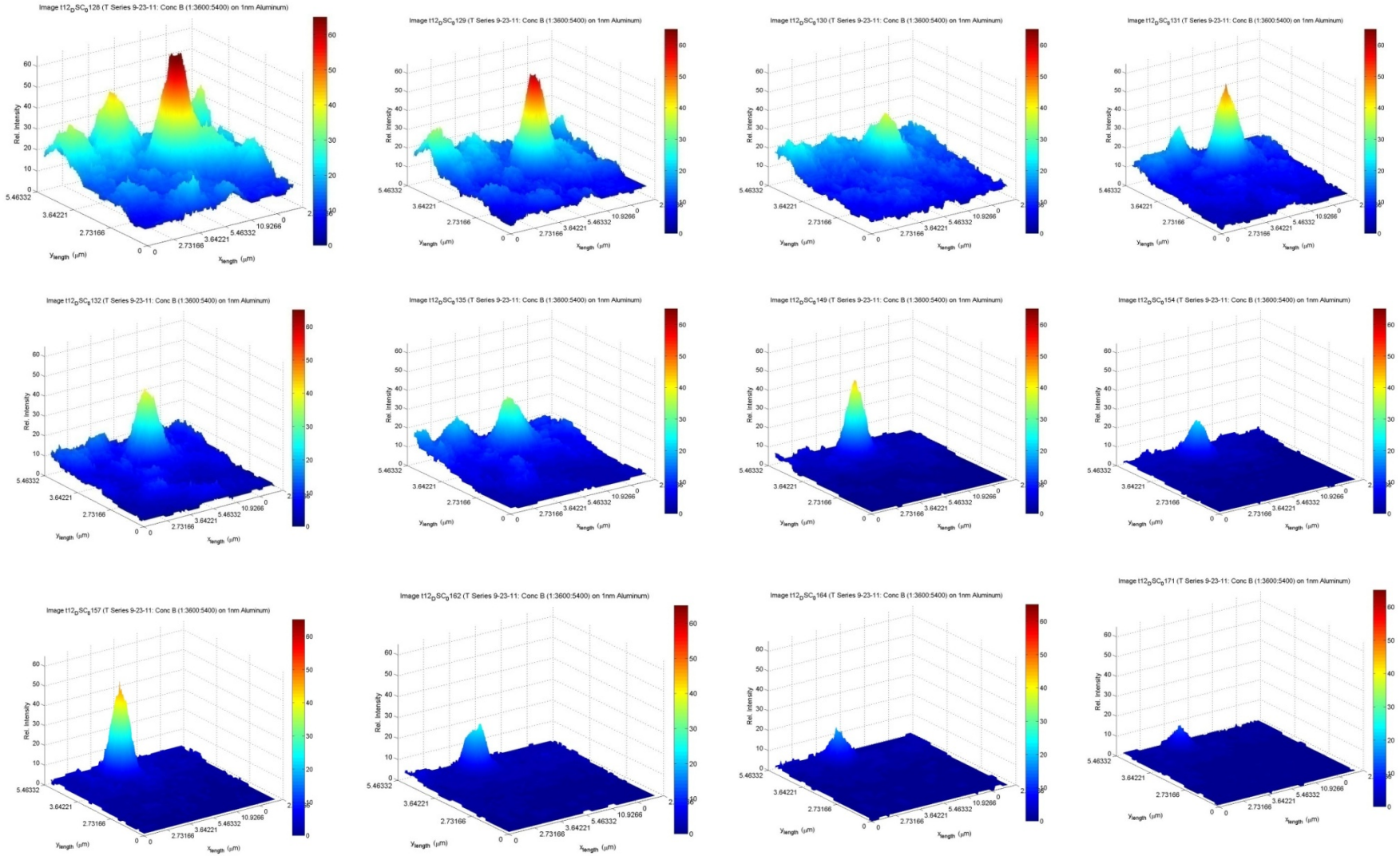


Single quantum dot optics

- Single QD spectroscopy
  - Study how emission of single QDs are influenced by the environment, metallic nanoparticles, and irradiation.
  - How QDs interact with each other, interaction of single QD-MNP systems with coherent light sources, etc.



Photophysics/photochemistry of single QDs: effects of irradiation



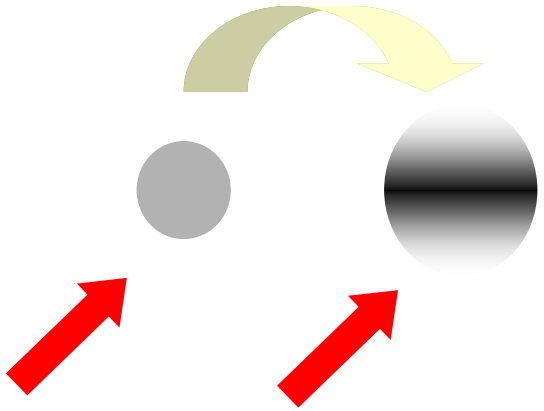
Hybrid nanostructure systems:

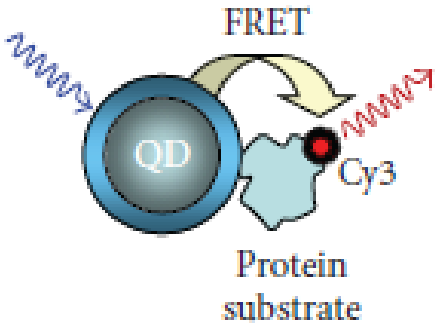
1-Control of energy transfer between nanoparticles

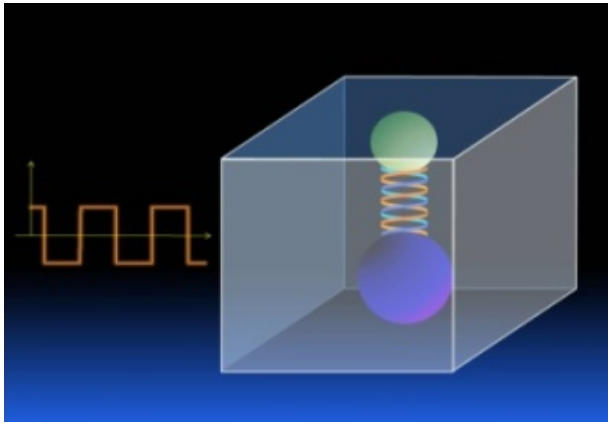
- We use plasmons to turn off or on the flow of energy from one nanoparticle to another.
- We manipulate transfer of energy from a quantum dot to a metallic nanoparticle.

2-Control of plasmonic fields of metallic nanoparticles using quantum dots.

- We use quantum dot to remove the near fields of metallic nanoparticle or enhance them.







Applications

We study applications (theory/exp):

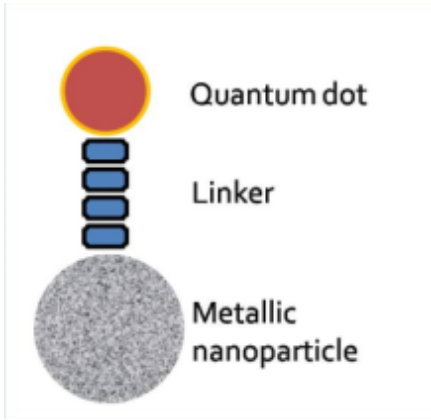
- Optical modulators and filters
- Nanoswitches
- Single QD-MNP devices
- Sensoring devices
- Quantum optics (plasmonic quantum optics)

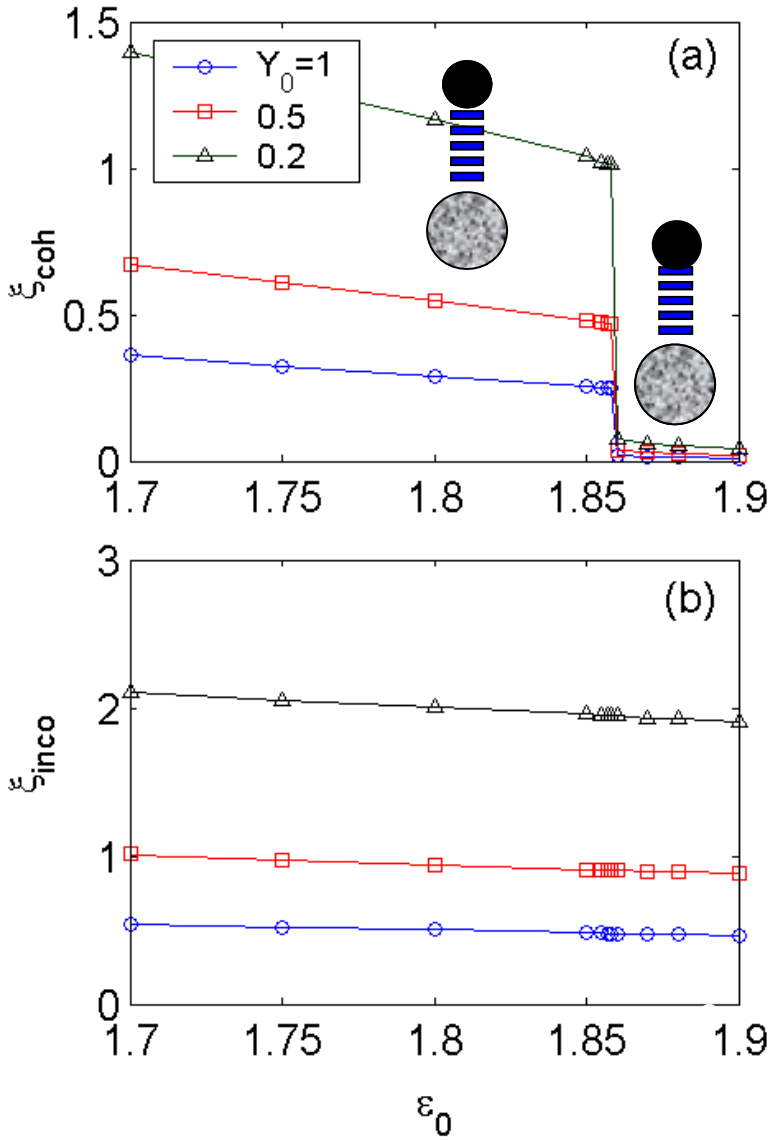
  Using metallic nanoparticles to generate optical nonlinear effects.

Example: Nanoswitch

Define emission enhancement:

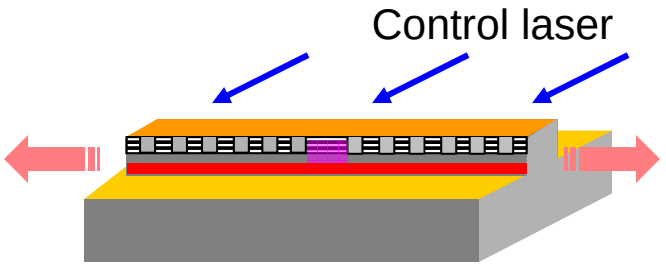
$$\zeta = \frac{\text{emission of the QD in QD - MNP}}{\text{emission of the QD by itself}}$$

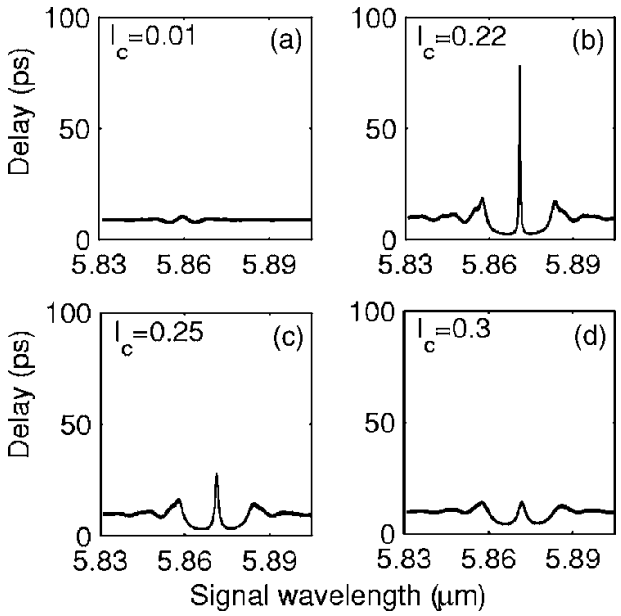


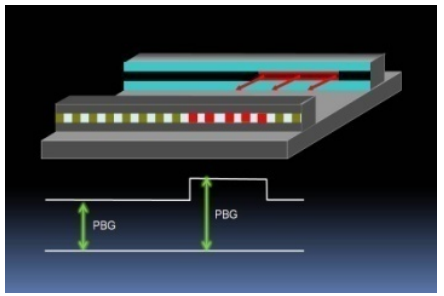


Photonics (simulation):

1. Development of novel lasers systems
   - Tunable mid-infrared lasers
   - Intrinsically single lasers
2. Development of time delay lines based on nonlinear optical processes in semiconductors
   - We design waveguide structures that allow us to use a laser to slow down the speed of propagation of the signal light passing through a waveguide in a controlled way.
3. Active photonic band gaps:
   - We develop photonic structures that can become photonic gap structure when activated with a laser beam in a reversible wavy







Concluding remarks

- Investigating materials and optical properties and hybrid nanostructure systems (QD and MNP conjugated biologically or using assembled using dielectric materials)
- Controlling near fields of metallic nanoparticles, energy transfer between quantum dots and metallic nanoparticles, etc.
- Their unique device applications