

Antenna-Enhanced Light Emission from Quantum Dots

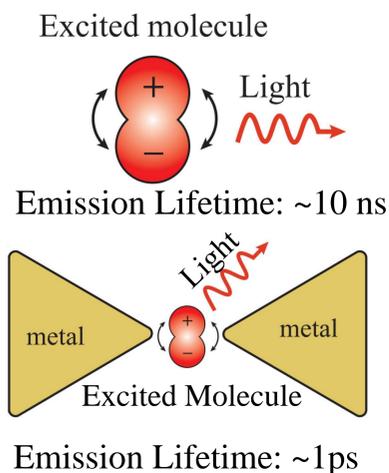
Abstract We designed an optical antenna with light emitting quantum dots tightly coupled to the antenna mode. We used surface functionalization and conjugation techniques to demonstrate deposition of the quantum dots to a selective area in the antenna feed gap.

Background

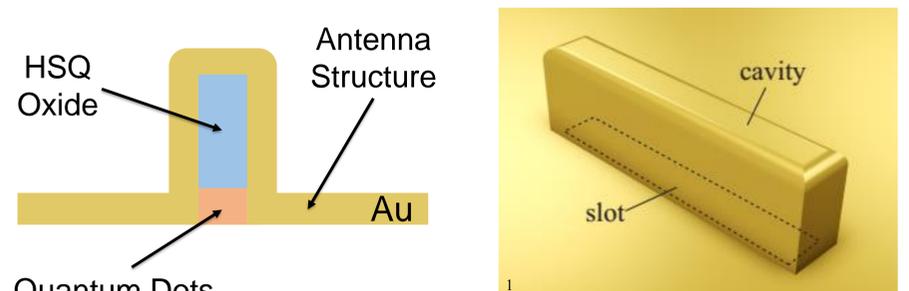
- Quantum dots (QDs) can be coupled to antenna structures¹
- Spontaneous emission lifetime can be reduced¹

Applications:

- Replace metal conductors with optical interconnects on computer chips¹
- Potential for high speed efficient data transfer¹
- Emerging display technology



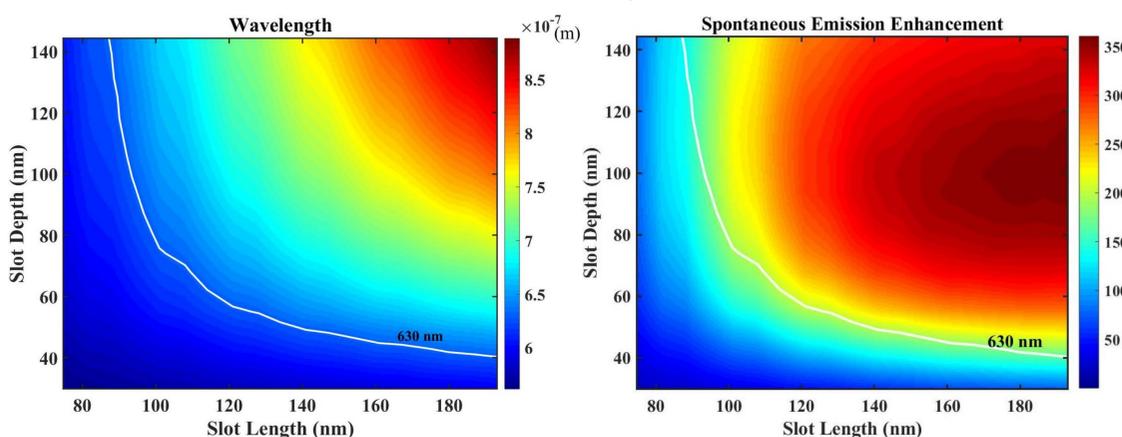
Cavity-Backed Slot Antenna



- HSQ (oxide) allows for selective bonding of QDs to antenna feed gaps

Simulating the Antennas

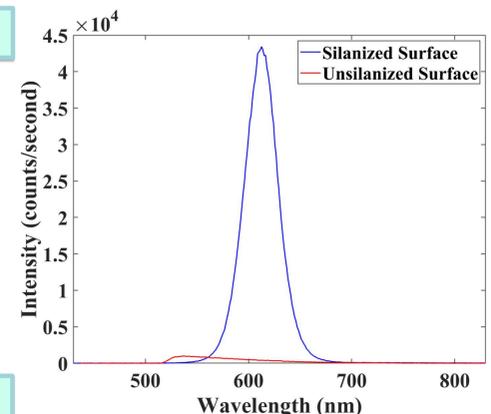
- Antenna resonance wavelength at 30nm width designed to overlap with quantum dot emission wavelength ($\lambda = 630\text{nm}$)
- Predict ~200-fold enhancement of spontaneous emission rate



Experimental Results

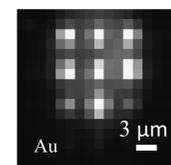
Photoluminescence

- Quantum dots were bonded to silanized surface
- Quantum dots did not bond to unsilanized surface, as expected



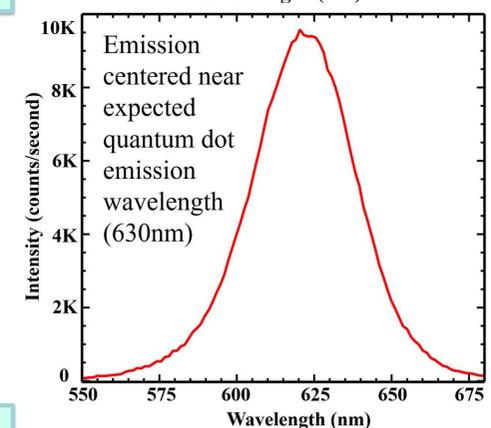
Selective Bonding to HSQ

Photoluminescence image



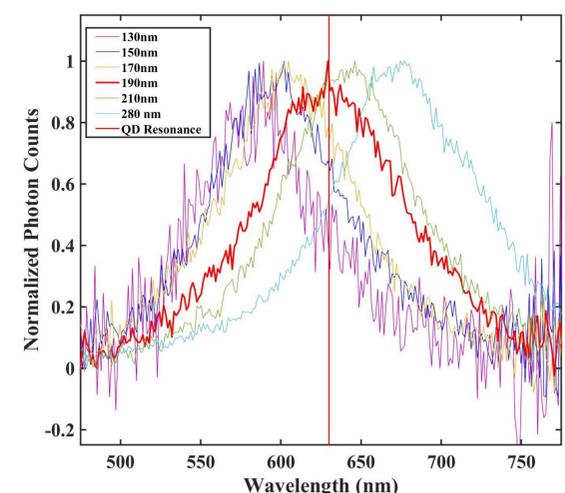
HSQ oxide ridges (w/QDs)

- A spectrum was taken to confirm the emission came from the QDs



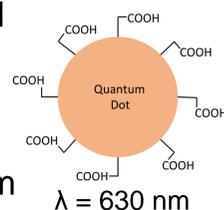
Array of Nano Antennas

- Antenna structures at 72nm HSQ depth with an 8nm airgap, 80nm width
- Resonant wavelength increases with cavity length as expected
- 190nm cavity length overlaps with the QD emission wavelength

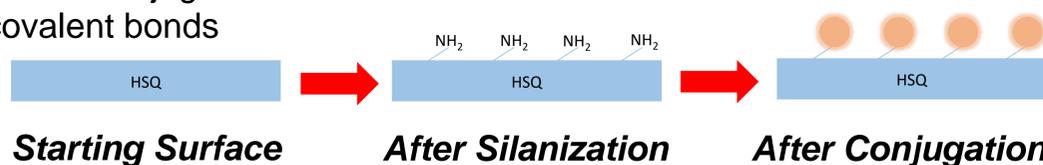


Bonding Quantum Dots to Oxide Regions

- Quantum dots functionalized with carboxyl groups
- Hydrogen silsesquioxane (HSQ) with silanization for selective bonding of quantum dots
- Use of conjugation to form covalent bonds



Spectrum of emissions for various QD sizes



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References

[1] S.A. Fortuna, Integrated Nanoscale Antenna-LED for On-Chip Optical Communication, Berkeley, USA: Electrical Engineering and Computer Sciences University of California at Berkeley, 2017, Technical Report No. UCB/EECS-2017-144 .
[2] "Quantum Dots", https://commons.wikimedia.org/wiki/File:CdSe_Quantum_Dots.jpg

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