Metal surface enhanced emission from CdTe Quantum dots

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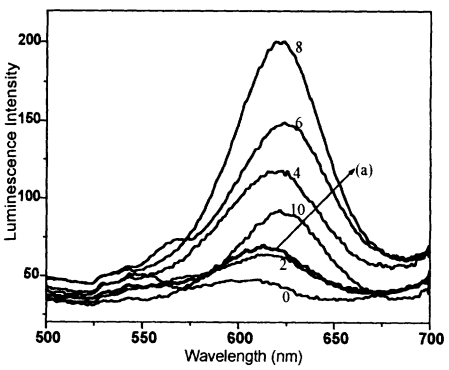
Interface of semiconductor quantum dots (QDs) with metal surface plasmons enhances the light-matter interaction and modifies QDs emission properties, the most striking change of emission properties of QDs occurs when the metal islands serve as a resonant amplifiers for both the incident and scattered radiation. Emission lifetime of excited QDs sensibly depends on the distance to the nearby metal surface. In this paper we report the enhancement in emission from CdTe QDs on Au island film as a function of CdTe-Au distance.

Using a layer-by-layer (LBL) electrostatic deposition technique CdTe monolayers and polyelectrolyte spacer layers between gold film and CdTe QDs are deposited by dipping sequentially in CdTe, PDDA and PSS solution. Au films are deposited using pulse laser deposition technique. The absorption spectrum of gold films shows the surface plasmon at 550 nm, which is a typical signature of the small isolated Au islands. Water-soluble CdTe QDs are synthesized using thioglycolic acid as a short-chain stabilizer; its luminescence band is centered around 600 nm. Room temperature PL spectra of sample are recorded using Perkin-Elmer Fluorescence spectrometer.



In the figure luminescence spectra of 2 monolayers of CdTe QDs are shown; Curve (a) is CdTe QDs on glass, the remaining curves are QDs on Au film. The numbers on spectra indicate the polyelectrolyte spacer layers between Au film and CdTe. One spacer layer consists of PDDA/PSS with thickness around 1.4 nm. Due to long-range resonance energy transfer from small to large QDs, the PL spectra of CdTe QD solids are red shifted compared to the isolated QDs. Luminescence of QDs is quenched after placing directly on Au film due to the non-radiative energy transfer from CdTe to Au particles though several decay channels. With increasing the spacer layer thickness between the Au and CdTe the luminescence is increasing by suppressing the non-radiative energy transfer process; it is very much sensitive to the distance between QDs and Au islands. The 5-fold enhancement in luminescence has been observed for the distance grater than 10 nm (8 spacer layers) between QDs and Au film, then after there is again a reduction in PL.

From one hand the observed enhancement can be partially explained by increased absorption cross section for QDs on metal islands; QDs near metal illuminated by both direct and a reflected beam, which increase the incident intensity. However the major enhancement is due to the increase in the electric field at QDs when the incident field excites the transverse collective resonances of metal islands. When the frequency of the incident light is resonant with surface plasmon of metal, the electromagnetic fields will be strongly modified near metal surface, the local electric field induced by an incident wave is much stronger than the free space as well as scattered field from metal cluster is more than the incident field. The increase of radiative lifetime of excitons near metal proximity can be further confirmed using time-resolved luminescence spectroscopy.

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