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Electronic Supplementary Information (ESI)

Surface Plasmon Enhanced Energy Transfer in Metal–Semiconductor Hybrid Nanostructures

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1. Photoluminescence of QDs-Ag with different Ag nanoprism concentrations

Figure S1 shows the photoluminescence (PL) emission spectra of CdSe/ZnS QDs in QD-Ag structures with different Ag nanoprism concentrations. The wavelength of the excitation light is 396 nm. Compared to the PL intensity from QDs without Ag, the PL intensity from QDs with Ag (i.e. in QDs-Ag structures) decreases slightly at an Ag prism concentration of 3×10^{-9} M. When the Ag prism concentration increased to 5×10^{-8} M, the PL intensity increases. However, when the Ag concentration increased to 1×10^{-7} M, the corresponding PL intensity will decrease.

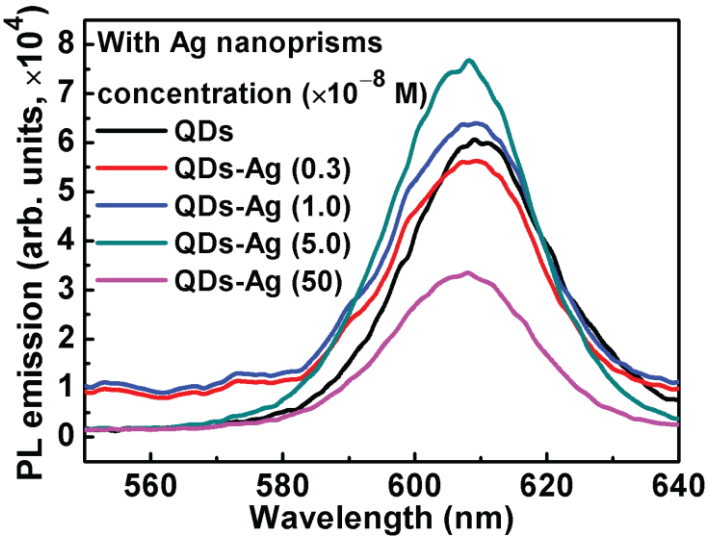

Figure S1. PL emission spectra of QDs in QDs-Ag with different Ag nanoprism concentrations in the wavelength region of 550–640 nm. The wavelength of the excitation light is 396 nm.

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2. Influence of different layer structure on the energy transfer

A series of layer by layer self-assembled multi-layer films were fabricated by the spin-coating method to study the influence of different layer structure on the energy transfer and PL enhancement (Figure S2a). To minimize electromagnetic coupling between nanoprisms, the deposited volume of solution was optimized to achieve an average interparticle distance approaching single uniform dispersed nanoparticles. Figure S2b and c show the PL emission spectra of the layer by layer self-assemble muti-layer film with different layer orders under the same excitation condition. It shows that the PL emission peaks from the ZnO nanoparticles are appeared at 379 nm without shift and broadening for the different layer orders, but the PL peak intensity is varied for different layer structures. The ZnO/Ag/QDs has the strongest ZnO band edge PL emission, and the Ag/QDs/ZnO has the weakest PL emission. The weak PL emission indicates the existence of enhanced energy transfer from the ZnO nanoparticles to the QDs. The PL peak of the QDs at 609 nm did not shift and broaden indicating that the band structure of the QDs is not affected by the layer by layer self-assemble techniques. On the contrary, the PL emission from the ZnO nanoparticles decreases while the PL emission from the QDs increases in sequence with the order of the ZnO/Ag/QDs, ZnO/QDs/Ag, and Ag/QDs/ZnO. This behavior can be easily understood according to the FRET theory. The FRET strongly depends on the local optical field and the donor-acceptor distance. For the ZnO/Ag/QDs, the Ag nanoprisms are in the middle layer between the QDs and the ZnO nanoparticles layers. The ZnO layer closes to the Ag nanoprisms, so the PL emission from the ZnO is strong. While the QDs and the ZnO layer were separated by the Ag nanoprisms layer that increases the donor-acceptor distance, so the PL emission of the QDs is relatively weak. For the ZnO/QDs/Ag, the Ag nanoprisms is in the upper layer, the fluorescence emission is partly absorbed by the Ag nanoprisms, but the donor-acceptor distance is shorter than the ZnO/Ag/QDs system, therefore, the SP-enhanced fluorescence emission and the energy transfer is relatively stronger than that of the ZnO/Ag/QDs system. For the Ag/QDs/ZnO, the Ag nanoprisms is in the bottom layer and the donor-acceptor distant is short, so the SP-enhanced fluorescence induced emission from the QDs and the energy transfer are strongest in the three system.

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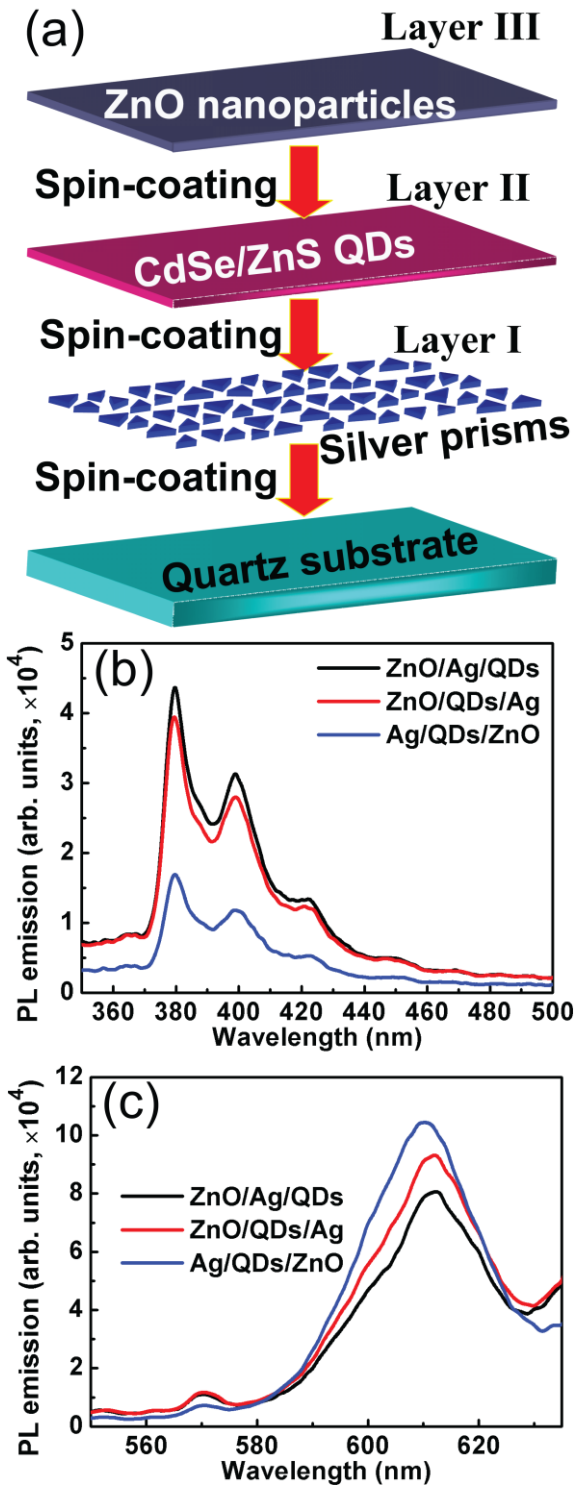

Figure S2. Schematic diagram of the fabrication process and PL emission spectra of layer by layer self-assembled multi-layer films. (a) Representative fabrication process of the Ag/QDs/ZnO layer by layer self-assembled multi-layer films. (b) PL emission spectra of the layer by layer self-assemble muti-layer films with different layer orders in the wavelength region of 350–500 nm. (c) PL emission spectra of the layer by layer self-assemble muti-layer films with different layer orders in the wavelength region of 550–640 nm.