Custom Designed Fluorescence Enhancing Hot Spot

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Application Note

Introduction

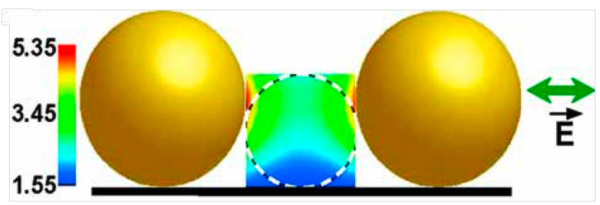

Figure 1: Calculated electric field enhancement (532 nm) for E-field polarization parallel to the dimer axis.

Spontaneous emission of fluorescence can be modified by the resonant coupling of the emitter to the external electromagnetic environment. It has been shown that two gold spheres (dimer) form a hot spot of strong field enhancement (compare figure 1). Depending on the exact distance of the two gold spheres not only the intensity, but also the spectral shape of the emitter can be changed [1]. The paired gold nanospheres can be fabricated with various techniques and a survey about how the fluorescence enhancement and shaping depends on the relative distance is in principle possible. However, it would require a time-consuming sample preparation for each specific distance, the fluorescent object would not be identical on each sample and it is hard to vary the distance in a continuous way. To circumvent this problem, we have designed an experimental setup which combines an atomic force microscope (AFM) with a confocal microscope.

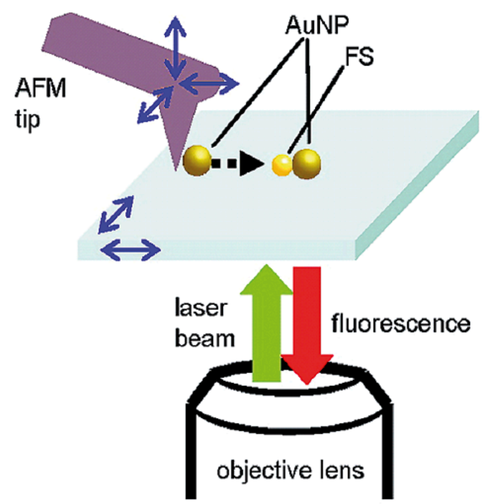

Figure 2: Experimental setup.

Experimental Setup

An AFM is placed on top of a confocal inverted microscope. The AFM is used in noncontact mode for acquiring height images and in contact mode to mechanically push the gold nanoparticles (AuNPs) towards an emitter. A 532 nm CW laser source is used to excite the emitter. AFM images are recorded by raster-scanning the sample while the closed-loop, three-axis scan stage of the AFM head is used to align the AFM tip with the optical axis. The fluorescence is spectrally resolved and detected with an Andor Newton EMCCD (DU971N-UVB). With this experimental setup we mechanically address single emitters like semiconductor quantum dots and simultaneously characterize their fluorescence spectrum. A typical spectrum of a CdSe colloidal quantum dot is given in figure 3.

Results

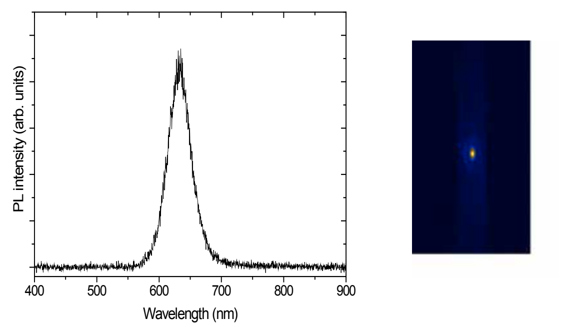

Figure 3: Spectrum of a CdSe quantum dot acquired with the described setup. The inset shows the corresponding CCD image.

With the combination of an AFM and confocal microscope we observe an enhancement of fluorescence from emitters sandwiched between two individual gold nanoparticles, forming a hot spot of strong field enhancement. The fluorescence enhancing hot spot is custom-designed by the deliberate assembly of gold nanoparticles with an atomic force microscope cantilever. The fluorescence intensity is monitored while the separation between the two gold nanoparticles is reduced by gradually pushing the gold nanoparticles closer to the fluorescent emitter. The fluorescence enhancement is maximal when the distance between the two gold nanoparticles is smallest, when the excitation polarization is parallel to the axis of the sandwich, and when the fluorescent sphere is positioned exactly on the axis connecting the two gold nanoparticles [2].

References

[1] M. Ringler, A. Schwemer, M. Wunderlich et al., "Shaping emission spectra of fluorescent molecules with single plasmonic nanoresonators," Physical Review Letters **100** (20), 4 (2008).

[2] A. Bek, R. Jansen, M. Ringler et al., "Fluorescence Enhancement in Hot Spots of AFM-Designed Gold Nanoparticle Sandwiches," Nano Letters **8** (2), 485-490 (2008).

Further Information

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