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Emission Enhancement and Strong Light-Matter Coupling in the Near-Infrared using Plasmonic Antennas and Plasmonic Crystals

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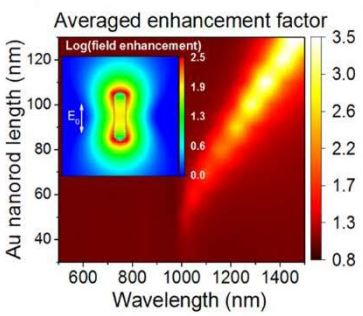
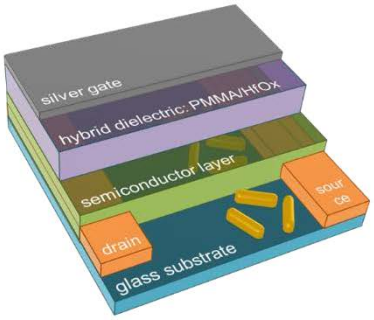
There are very few efficient carbon-based emitters in the near-infrared and even fewer that combine fast charge transport with good photoluminescence quantum yields (PLQY) for electroluminescent devices. Among the relatively poor emitters are narrow bandgap conjugated polymers and semiconducting carbon nanotubes with emission wavelengths >1000 nm. One possible way of increasing the radiative decay rate (via the Purcell effect) and thus the effective PLQY of these materials is the use of plasmonic nanoantennas that create local electric fields that are orders of magnitude higher than in the plain thin film. However, the enhancement effect is highly localized and these antennas also enhance absorption, making the interpretation more difficult. Typically, lifetime measurements in diluted samples are necessary to corroborate enhanced radiative decay.

Here, I will present a number of examples where plasmonic nanoantennas [1] and plasmonic crystals were directly integrated in the active channels of light-emitting field-effect transistors (LEFET) based on conjugated polymers or carbon nanotubes [2,3]. The LEFET structure enables a controlled number of injected holes and electrons and their recombination away from the electrodes and thus facilitates decoupling of charge transport and plasmonic enhancement effects. A clear increase of electroluminescence depending on resonance wavelength and detection angle is observed that points toward the role of the Purcell effect. Aside from weak coupling, also strong light-matter coupling and the formation and propagation of plasmon-exciton-polaritons (plexcitons) was observed and characterized in plasmonic crystals with (6,5) carbon nanotubes [4,5].

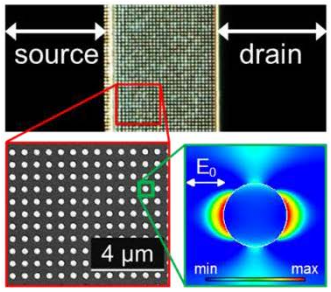
Colloidal Nanorod Antennas



Light-emitting Transistor Structure



Integrated Plasmonic Crystals



[1] *ACS Photonics* **2016,** *3* (1), 1–7.
[2] *ACS Photonics* **2016,** *3* (12), 2225-2230.
[3] *Opt. Express* **2017,** *25* (15), 18092-18106.
[4] *Nano Lett.* **2016,** *16* (10), 6504-6510.
[5] *Nano Lett.* **2018,** *18* (8), 4927–4933