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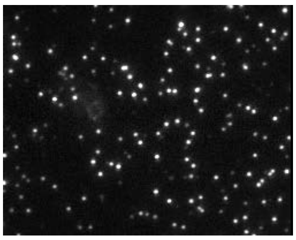
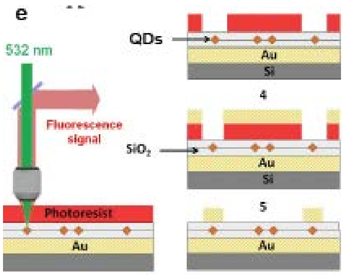
Coupling a single fluorescent nanocrystal to a micropillar

The PhD will take place at the INSP, in a group which studies the effect of a **photonic or plasmonic structure** (photonic crystal, optical cavity, nano-antenna…) on the **fluorescence of a single nano-emitter**. The principle of these studies is that the fluorescence properties of a nano-emitter are not only a function of its intrinsic characteristics, but also of its environment and its density of available photonic states (Fermi's golden rule). The nano-emitters in consideration are **nanocrystals**, CdSe spheres of a few nm, obtained by chemical synthesis. These nanocrystals are very bright and versatile ; their emission wavelength is determined by their size (quantum confinement) and tunable over the whole visible spectrum. By fluorescence microscopy, it is possible to image single nanocrystals deposited on a substrate (fig. a : each spot corresponds to a 5-nm nanocrystal). The emission of a single nanocrystal then exhibits statistical properties ("**single photons**") specific to quantum optics: two photons are never generated exactly at the same time, as opposed to a classical or laser beam.

A technical challenge in coupling a single nano-emitter to a specific nano-photonic environment is the need to **control the position and the emission wavelength of the emitter with respect to the photonic structure**, or vice versa. We are presently implementing, in collaboration with the Laboratoire de Photonique et Nanostructures (LPN), a **photolithography protocol** to fabricate a metallic disk nano-antenna on top of a nanocrystal : on a substrate, nanocrystals are deposited and covered by a photosensitive resist ; by fluorescence microscopy, the sample is mapped and a single nanocrystal is found ; then a stronger laser beam is sent into the microscope in order to expose a disk in the photoresist. The sample is then developed and gold is deposited in a micrometer-sized disk centered on the nanocrystal (fig. b). This technique will be adapted to **fabricate a dielectric micropillar centered on a single nanocrystal**. Such a structure (preliminary realization shown in fig. c) constitutes an optical cavity as light is confined vertically between two Bragg mirrors and horizontally by total internal reflection. Alternatively, we can also replace the upper Bragg mirror by a metallic surface and etch a metallic disk on the Bragg mirror : this will induce **plasmonic Tamm modes** confined in the metallic disk.

The **coupling of the nanocrystal emitter to the cavity** will be evidenced by measuring the nanocrystal emission dynamics : the delay between excitation by a pulsed laser and emission of a single photon ("lifetime" of the emitting energy level) will be modified in the presence of the cavity (Purcell effect). Moreover, the efficiency of the coupling will be studied as a **function of the emission decoherence**, which is related to the presence of **phonons** and can be tuned via the temperature over almost 6 orders of magnitude. This effect, which is specific to cavity quantum electrodynamics experiments in solid state, has raised recent interest as decoherence can be used to **allow coupling between spectrally non-resonant emitter and cavity**.

a)


b)


c)