Organic molecules for integrated quantum photonics

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Organic molecules of polyaromatic hydrocarbons were the first system in the solid state to show single photon emission [1, 2]. However they are still considered unconventional sources of non-classical light. I will try to show how they could effectively contribute to integrated quantum photonic platforms, discussing two of our recent experiments.

Efficient quantum light sources are basic ingredients for photonic quantum technologies. On the other hand, on-chip integration is necessary to envision a scalable platform for quantum information and communication. In this contribution I will discuss a novel hybrid technology which combines single organic molecules as quantum emitters and dielectric chips, consisting of ridge waveguides and grating far-field couplers [3] (fig.1). Dibenzoterrylene molecules (DBT) in anthracene crystals (Ac) are particularly suitable quantum systems for this task, due to outstanding photophysical properties [4, 5] demonstrated both in bulk and in samples as thin as few tens of nanometers. Here the emitters are integrated by spin-coating onto the photonic chip. We demonstrate at room temperature the emission of single photons from DBT molecules into ridge waveguides with a branching ratio up to 40%, corresponding to an estimated on-guide brightness around 50 MHz for CW pumping at saturation. These results are competitive with state-of-the-art single photon emission into propagating guided modes from solid state systems [6, 7], while offering a novel platform with high versatility.

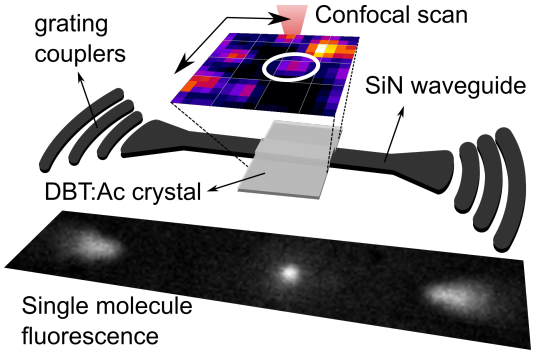

Figure 1: Concept for the demonstrated device, showing single molecule emission into an integrated photonic waveguide.

In order to surpass evanescent coupling and address the challenge of deterministic positioning, we have also developed a single-photon source based on Ac nanocrystals [8](average size of 200 nm) doped with DBT molecules. Nanocrystals (NCs) are naturally prone to the integration in hybrid devices, including heterostructures and complex photonic devices, and can be useful for quantum technologies in general [9]. However, spectral diffusion has so far hindered the deployment of traditional (inorganic) NCs for narrow-band applications and coherent light-matter interaction. In the second part of our contribution, we report on the unprecedented performances of single-photon emission from DBT:Ac NCs in terms of spectral and intensity stability and emission purity, both at room and at cryogenic temperature. Moreover, when cooled down to 3 K, the 00-zero phonon line shows linewidth values (50 MHz) close to the lifetime-limit [10]. The results on the optical and morphological characterization are here summarized in fig.2. Our recipes and techniques may be extended to different molecular host-guest systems, making active organic nanocrystals a new toolbox for the integration of quantum emitters in photonic and optoelectronic circuits, as well as in complex hybrid devices.

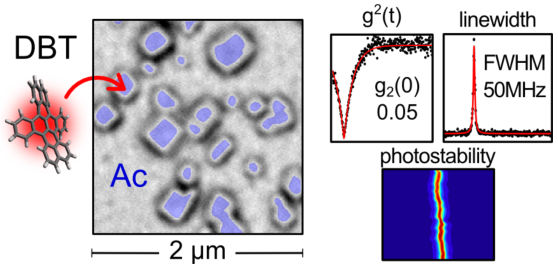

Figure 2: Optical characterization of DBT:Ac nanocrystals.

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