# Integrated Organic Molecules for Quantum Technologies

P. Lombardi,[1,2] S. Pazzagli,[1] A. P. Ovvyan,[3] D. Martella,[4] M. Colautti,[4] N. Gruhler,[3] O. Neitzke,[5] G. Kewes,[5] B. Tiribilli,[6] O. Benson,[5] F. S. Cataliotti,[4,2] W. H. P. Pernice,[3] and C. Toninelli[1]

[1] *National Institute of Optics (CNR-INO), Florence, Italy*
[2] *Dipartimento di Fisica ed Astronomia, Universitá degli Studi di Firenze, Sesto Fiorentino, Italy*
[3] *Physikalisches Institut, Westfalische Wilhelms-Universitat Münster, Heisenbergstrasse 11, 48149 Münster, Germany*
[4] *European Laboratory for Nonlinear Spectroscopy (LENS), Sesto F.no, Italy*
[5] *AG Nano-Optik, Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany*
[6] *CNR-ISC Istituto dei Sistemi Complessi, via Madonna del Piano 10, I-50019 Sesto F.no, Firenze, Italy*

**E-mail:** toninelli@lens.unifi.it, colautti@lens.unifi.it

The efficient interaction of light with quantum emitters is crucial to most applications in nano and quantum technologies. We have recently shown how single molecules can be effectively deposited on a photonic chip, launching single photons in single mode waveguides [1]. On-chip integration and miniaturization allows for minimized losses and tailored interaction. Similar results have been obtained with different platforms, facing common challenges such as the control over emitter position and the scattering it might introduce.
In the present contribution we discuss also a novel hybrid technology which combines self-assembled organic nanocrystals as quantum light emitters and polymeric photonic structures.
Anthracene (Ac) nanocrystals (NCs) doped with dibenzoterrylene (DBT) fluorescent molecules show [2] unprecedented performances of single-photon emission and are naturally suitable both to deterministic positioning and to the integration in hybrid devices. Despite the NC average size of hundreds of nanometers, the outstanding photo-physical properties of the bulk system [3] are well-preserved in the sub-micrometric environment. In particular, the source exhibits bright and photostable emission at room temperature and almost lifetime-limited linewidth at cryogenic temperatures.
Harnessing these features, we propose and report preliminary results on a three-dimensional suspended waveguide [4] directly embedding a DBT:Ac NC in its middle point and efficiently coupling out fluorescence in a quasi-gaussian mode (see fig. 1). The total integration is realized via a properly tailored fabrication method based on Direct Laser Writing of commercial polymers (IPs). This solution, thanks also to the high 3D resolution of the writing process, offers a big advantage in terms of coupling efficiency of the emitted fluorescence to the guiding structure, estimated to be around 80% (doubling the result of the analogous platform based on evanescent coupling [1]).
These results suggest a competitive platform for on-chip processing of single guided photons, promising for applications in quantum technologies.

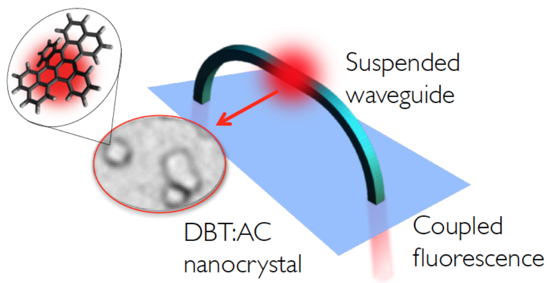


FIG. 1. Scheme of the integrated single-photon source: a polymeric suspended waveguide embedding the DBT:Ac NC in its middle point and efficiently guiding fluorescence throughout the outcouplers.

[1] P. Lombardi et al., *ACS Photonics* **17** (1), 126-132 (2018).
[2] S. Pazzagli et al., *ACS Nano*, DOI:10.1021/acsnano.7b08810, April 9 (2018).
[3] C. Toninelli et al., *Opt. Express* **18**, 6577 (2010).
[4] Q. Shi et al., *Sci. Rep.* **6**, 31135 (2016).