Cavity-Enhanced Single-Photon Emission from Organic Molecules in Polymeric Pillar Microcavities

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Single-photon emitters are essential for photonic quantum communication, where information is carried one photon at a time. Among the many possible systems, organic molecules particularly polycyclic aromatic hydrocarbons (PAHs) remain highly attractive because they can produce bright, narrow and nearly transform-limited emission when cooled to cryogenic temperatures. Dibenzoterrylene (DBT) embedded in anthracene crystals is a well-studied example [1]. However, a fundamental limitation of single molecules is that they radiate in all directions, making efficient photon collection and coupling into optical circuits challenging.

In this work, we address this limitation by integrating DBT-doped anthracene crystals with polymer microcavities that confine and redirect the emitted light. The cavities are fabricated via two-photon polymerization and subsequently transferred onto the crystal matrix surface [2], enabling deterministic placement above molecule-rich regions [3]. The design of each cavity is optimized through numerical simulations to resonate at the DBT zero-phonon line near 785 nm, increasing the emission rate and steering photons into well-defined optical modes through the Purcell effect.

This direct-laser-writing strategy avoids difficult bonding or etching steps and is compatible with integrating arrays of organic molecule - based quantum emitters. The long-term goal is to push organic molecules from lab demonstrators toward scalable, compact and integrated single-photon sources on chip-scale platforms for quantum photonic technologies.

This method provides a practical pathway to improving the brightness and directionality of organic single-photon emitters while enabling their integration into coherent quantum photonic circuits.

Funding acknowledgement

This work was supported by the ERC project QUINTESSEnCE (Grant Agreement No. 101088394) and the ToEQPL project funded by the EU Horizon Europe programme (Grant Agreement No. 101160101).

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