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Integrated Organic Molecules for Quantum Technologies

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The realization of a robust and scalable nanophotonic platform which efficiently integrates quantum emitters as on-demand sources of non-classical light is crucial to the successful development of photonic quantum technologies. However, conventional strategies to on-chip integration, based on lithographic processes in semiconductors, typically introduce dephasing effects which broaden the transition linewidth of the emitter and are detrimental for its coherence properties. Moreover, such fabrication techniques are intrinsically limited to planar geometries and in this sense are difficult to scale up to a big number of integrated emitters. In the present contribution we demonstrate an alternative platform based on molecules that preserve near-Fourier-limited fluorescence even when embedded in polymeric photonic structures [1]. Deterministic integration is achieved in three-dimensions via direct laser writing (DLW) around selected molecular emitters, with a fast, inexpensive and scalable fabrication process. In particular, organic molecules of dibenzoterrylene (DBT) are embedded in anthracene (Ac) nanocrystals (NCs), which have shown photostable single-photon emission, near to lifetime-limited linewidths at 3K [2], and are especially suitable for the integration in polymeric devices. We integrate DBT:Ac NCs via DLW on different substrates and at variable heights in different polymeric designs. Enhanced light extraction is achieved in a micro-dome solid-immersion-lens, reporting unprecedented detected count rates for a single cold molecule and efficient coupling to a single-mode fiber. The proposed technology may represent an important step in the integration of single emitters into robust quantum protocols based on molecules, including arrays of indistinguishable single-photon sources. In this latter merit, we will also discuss the possibility of using an all-optical approach to independently shift the transition frequency of individual emitters and bring them into resonance, with spacial resolution at the micron level and maintaining the coherent spectral properties [3].

[1] M. Colautti et al., Adv. Quantum Technol., (2020) doi:10.1002/qute.202000004
[2] S. Pazzagli et al., ACSNano 12, 4295–4303 (2018).
[3] M. Colautti et al., Under Review

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