Towards Integrated Quantum Interface with Rare-Earth Ion-Doped Thin Film

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Integrating quantum emitters into photonic circuits significantly enhances their functionalities, enabling the realization of on-demand single-photon and multiphoton entanglement sources, quantum memories, and photon-photon nonlinear quantum gates. Rare-earth (RE) ions, known for their unique optical and spin properties with long radiative and coherence times, are particularly interesting for these applications. Despite serious progress in integrating RE ions with nanophotonic structures [1], obtaining a high-quality interface between rare-earth ion-doped nanomaterials and other platforms remains challenging. At the same time, thin films of rare-earth ion-doped oxides provide significant advantages for their integration while keeping good coherence properties [2]. In this work, we explore a hybrid platform that combines high-quality GaInP photonic crystal cavities [3], with Yb-doped yttrium oxide thin films. We present the fabrication of both the photonic crystal structure in GaInP and the Y2O3 membrane, as the optimization of the cavity itself using deterministic and inverse design strategies. The optimized L3 cavity demonstrates a high simulated quality factor and efficient photon collection, paving the way for the development of nanophotonic interfaces with easy and efficient addressability of RE ions through free space fiber coupling.

References

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Figures

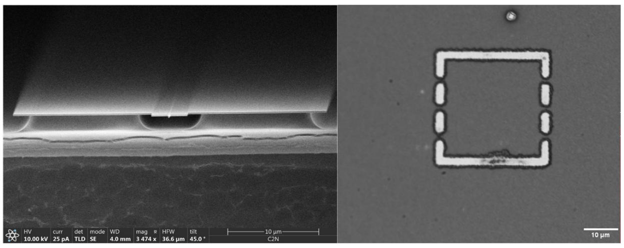

Figure 1: SEM image of the GaInP photonic device (left) and microscope image of the Y2O3 membrane after the lithography (right).

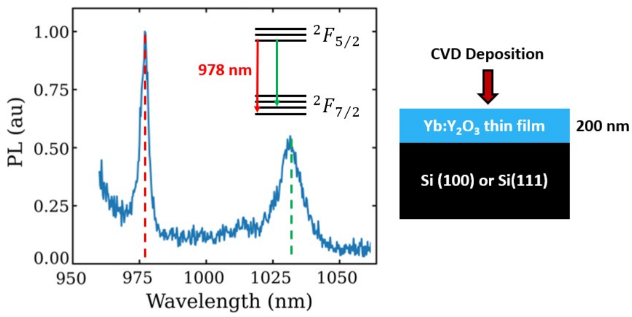

Figure 2: Ytterbium Yb3+ emission spectrum of the 200 nm Y2O3 thin film deposited by chemical vapor deposition (CVD) on silicon substrate.