Fabrication of Bull's Eye Cavities within the EQUAISE project

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The EQUAISE project (https://equaise.pwr.edu.pl/) is a QuantERA II Confund project aimed at *Enabling QUAntum Information by Scalability of Engineered quantum materials*, in particular via the realization of efficient single-photon sources based on strained, transition metal dichalcogenades (TMD) single-photon emitters (SPEs) coupled to Bull's Eye (BE) cavities. The project exployes two routes to obtain site-controlled SPEs in TMDs: the hydrogen-assisted formation of straiend TMD nanobubbles [1,2], and the mechanical nano-indentation of TMD monolayer on micropillars [3]. In both cases, the SPEs are positioned in a spatially-controlled manner at the center of purpusly designed BE cavites.
In this contribution, we will report on the fabrication of BE cavities on silicon nitride (Si_3N_4) membranes sputtered on different (Si, GaAs, or piezo) substrates, with a particular focus on the structural and optical properties of the realized cavities. Finite-difference time-domain method (FDTD) simulations are used to optimize the cavity's geometry and achieve cavity modes resonant with the emission energy of WSe_2 or WS_2 strained monolayers, at ~750 nm and ~650 nm, respectively. A lithographic tuning of the cavity's parameters (*i.e.*, cavity radius and trench width) are also employed to finely tune the cavity resonance wavelegth.

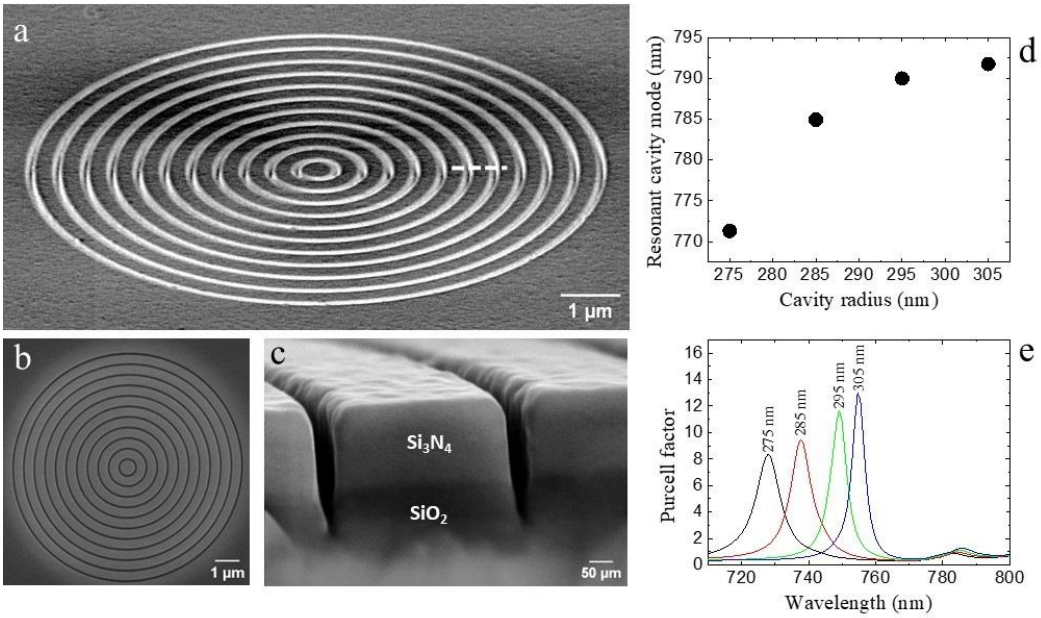

Figure. SEM images of BE cavity fabricated on a Si_3N_4/SiO_2 membrane on top of a GaAs substrate: a) 60°-tilted view, b) top view, and c) lateral view along a cut in the area indicated by the dashed line in panel a. Si_3N_4 and SiO_2 layers are well visible as well as the verticality of the trench's walls. d) Experimental values of resonant cavity modes as a function of the cavity radius. e) FDTD simulation of the Purcell enhancement induced by the BE cavity for different radius.

[1] S. Cianci *et al.*, Adv. Optical Mater. **11**, 2202953 (2023). [2] D. Tedeschi *et al.*, Adv. Mater. **31**, 1903795 (2019). [3] O. Iff *et al.*, Nano Lett. **21**, 4715 (2021).