**Fabrication and Characterization of Single-Crystal Diamond Membranes for Photonic Devices**

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The development of quantum technologies is one of the big challenges in modern research and one of the most promising materials is diamond with its color centers in the crystal lattice. A crucial component for many applications is an efficient, coherent spin-photon interface. In order to yield an efficient outcoupling from the zero-phonon line (ZPL) of the color centers and improve the photon collection efficiency, various light-confining architectures can be used like Fabry-Pérot microcavities, nanopillars or photonic crystal cavities. They should be fabricated on thin single-crystal diamond (SCD) membranes with a good quality regarding not only the bulk material, but also its surface. To structure such micrometer thin SCD membranes, it is important to minimize the defects originating from polishing or etching procedures and properly prepare the starting material. We fabricated SCD membranes with various diameters, exhibiting a low surface roughness down to 0.4 nm on a small area scale, by etching through a diamond bulk mask with angled holes. A significant reduction of pits induced by micro-masking and polishing damages was accomplished by the application of alternating Ar/Cl2 + O2 dry etching steps. By a variation of etching parameters regarding the Ar/Cl2 step an enhanced planarization of the surface was obtained in particular for surfaces with a higher initial surface roughness of several nanometers. We present the successful bonding of a SCD membrane via van der Waals forces on a cavity mirror and perform finesse measurements which yielded values between 500 and 5000, depending on the position and hence on the membrane thickness. Furthermore, photonic crystals were structured in the SCD membranes by electron beam lithography (EBL) and inductively coupled plasma reactive ion etching (ICP-RIE) with SiO2 hard mask.

**Keywords :** Single-crystal diamond, Membranes, Roughness reduction, Nanophotonics