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Hybrid integration of diamond membranes with GaN waveguides

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The nitrogen vacancy (NV) is a photostable emitter in diamond which is optically accessible at room temperature and a potential candidate for quantum information processing as a spin register. The challenge facing research today is the efficient collection and manipulation of the NV's emissions, such as by enhancing the zero phonon line transitions for a coherent spin-photon interface.

Integrating diamond with other photonic materials would allow for resonant coupling of the defect centre to optical devices on large area photonic integrated circuits (PICs). Emitted photons collected by bus waveguides could then be guided elsewhere on chip for entanglement or measurements.

This work focuses on integrating ultra-thin diamond membranes with GaN waveguide and resonator devices. Mode simulations (see Fig. 1(a)) show that light can be coupled significantly into and out of the membranes by this method. Membranes of < 200 nm have been fabricated using Ar-Cl_2 etch recipes that cumulatively smooth the diamond over time; an r.m.s roughness value of 0.19 nm has been achieved.[1] The smooth surface and ultra-low thickness allow a good conformation and strong bonding of the membrane to other materials. This should allow for the integration of diamond membranes with photonic integrated circuits as shown schematically in Fig. (b).

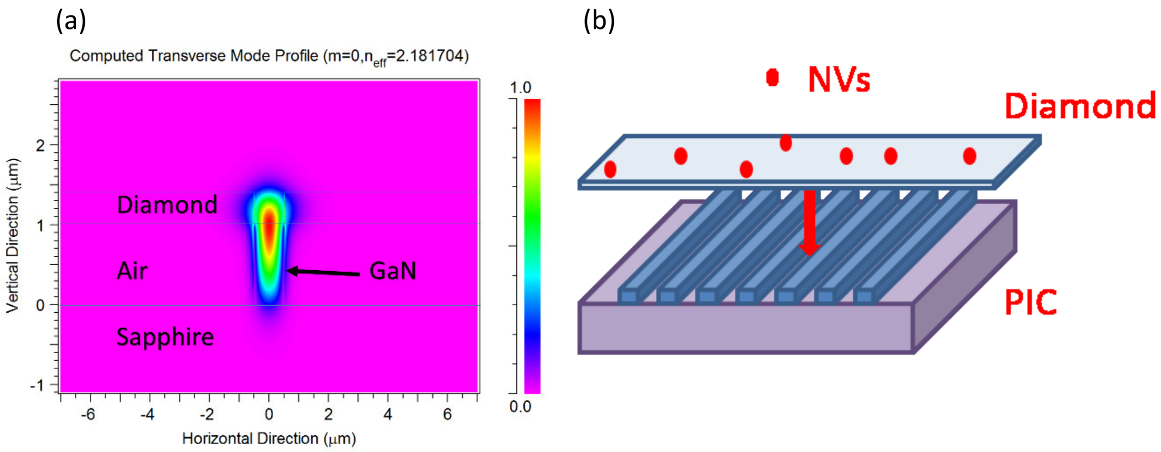

Figure 1: (a) Mode simulation showing single mode propagation through GaN waveguides in the presence of a bonded diamond membrane. (b) Cartoon plan to integrate ultra-thin diamond membranes with large area PICs of other established photonic materials.

Free standing ultra-thin diamond membranes can also be used in tuneable open access cavities – where a low mode volume and high Q factor are desired;[2] or as templates for fabricating diamond optical devices on non-native substrates.[3]

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3. Hausmann, B. J. M. et al, 2013 *Nano Letters*, 13(5), 1898–902. http://doi.org/10.1021/nl3037454