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High Q Gallium Nitride Microring Resonators

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Gallium nitride (GaN) is a promising material for nonlinear microresonators. It has large intrinsic $\chi^{(2)}$ and $\chi^{(3)}$, excellent thermal properties and a relatively large bandgap [1] and can be used for example for parametric conversion and frequency doubling [2]. Furthermore it is quite resilient and can withstand high temperatures and power. In this paper, we demonstrate GaN microring resonators with a quality factor (Q) larger than 10^5, which, to the best of our knowledge, is the highest demonstrated Q for microring resonators in a pure GaN platform [3].

GaN was grown on sapphire in Dragon-125 MOVPE system using low-temperature GaN nucleation layer annealed under H_2-free ambient for promoting planar growth of thin layer. A PECVD SiO_2 layer was then deposited on top of the wafer for protection before cleaving it into small pieces with a laser micromachining tool. E-beam lithography in HSQ resist and Cl_2 ICP RIE was used to create the device. A SEM image of the coupling region (before cladding) between bus waveguide and resonator is shown in Fig. 1(a). Finally the devices were cladded with PECVD SiO_2 and cleaved with a laser micromachining tool in a region where the waveguides are tapered out to match the mode profile of a lensed optical fiber used for characterization. A resonator with an FSR of 1 THz having a radius of 19.33 µm and a racetrack resonator with an FSR of 100 GHz with a bending radius of 19.33 µm and a circumference of 1239 µm were fabricated and characterized. The waveguide for resonators has a width of 1.25 µm and a height of 700 nm. The resonators were characterized in the 1550 nm band by measuring the transmission of the bus waveguide. All resonators were under-coupled, and the intrinsic Q was calculated from the loaded Q as $Q_{int}=2Q_{load}/\left(1+\sqrt{T_0}\right)$ [4] with T_0 being the relative transmission at the resonance. The 1 THz resonator exhibited a maximum intrinsic Q of 119,000 and the 100 GHz an intrinsic Q of 137,000 (an example of a Lorentzian fit for a1 THz resonator shown in Fig. 1(b)).

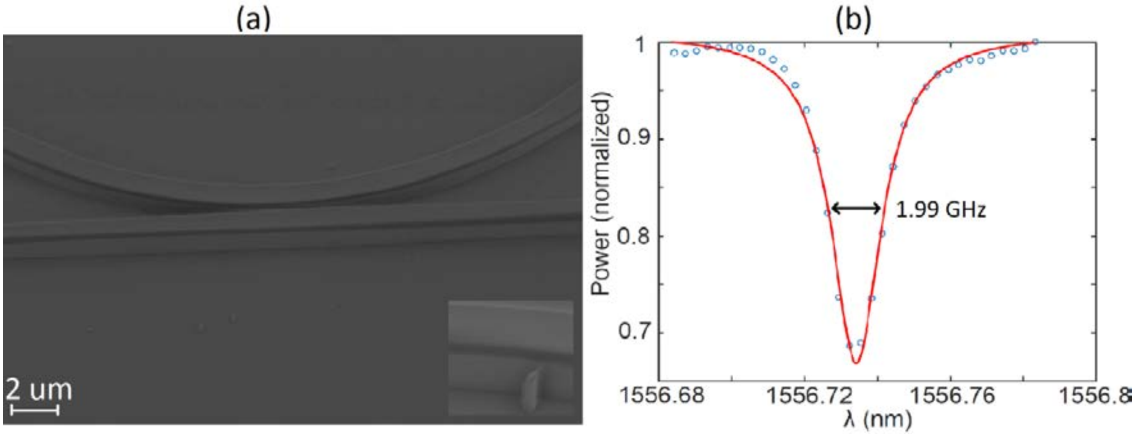

Fig. 1(a) SEM picture of the coupling region of a GaN microring resonator after etching process. The E-beam resist HSQ is kept on the device. Inset: zoom in on particle near sidewall. (b) Lorentzian fit to a resonance of a 1 THz resonator.

The characterization was carried out using a scanning laser system with a resolution of 3 pm. The performance of the resonators may be affected by randomly distributed particles (probably originating from incomplete removal of the SiO_2 protection layer) which are highlighted in the inset of Fig. 1(a). In conclusion, we demonstrate the highest Q for microring resonators fabricated in a pure GaN platform, which is promising in nonlinear applications.

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