Bound states in continuum confined in GaN based subwavelength gratings

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Subwavelength gratings are photonic structures made of stripes of subwavelength thickness spaced periodically in one direction. They are a canonical example of an open optical system that can confine optical bound in the continuum (BIC) states. BIC arises from the symmetry of the system due to destructive interferences, resulting in the confinement of the mode. The quality (Q) factor of BIC states approaches infinity and they coexist with a continuous spectrum of unbound states. In real systems, due to finite dimensions, one observes so-called quasi-BIC, with a finite Q-factor. Use of gallium nitride (GaN) in photonics is highly advantageous due to its negligible absorption in visible spectrum and durability. Despite well established growth technology, nano-structuration still requires development.

We present two sets of GaN subwavelength gratings produced by e-beam lithography followed by dry-etching. One set was fabricated from MOVPE-grown GaN on sapphire substrate. The second one was etched in MBE-deposited GaN on porous GaN substrate made by electrochemical etching. Figure 1a) shows an example of the angle resolved reflectivity map of the grating on sapphire. Presence of vanishing reflectivity features at photon momentum $k = 0$ confirms the existence of quasi-BIC state. In addition, we detect a rarely observed interference based quasi-BIC for k at the border of the Brillouin zone. The Q-factors of quasi-BICs in both sets are determined to be above 10^4 and their linewidth goes below measurement resolution of 0.1 nm. Polarization resolved measurements reveal the presence of vortexes in reflected light, which further supports existence of quasi-BIC [1].

In summary, thanks to developed structuration technology we demonstrate modes of very high Q-factor in different types of GaN-based subwavelength gratings, as well as the existence of quasi-BIC states with non-zero wavevector values.

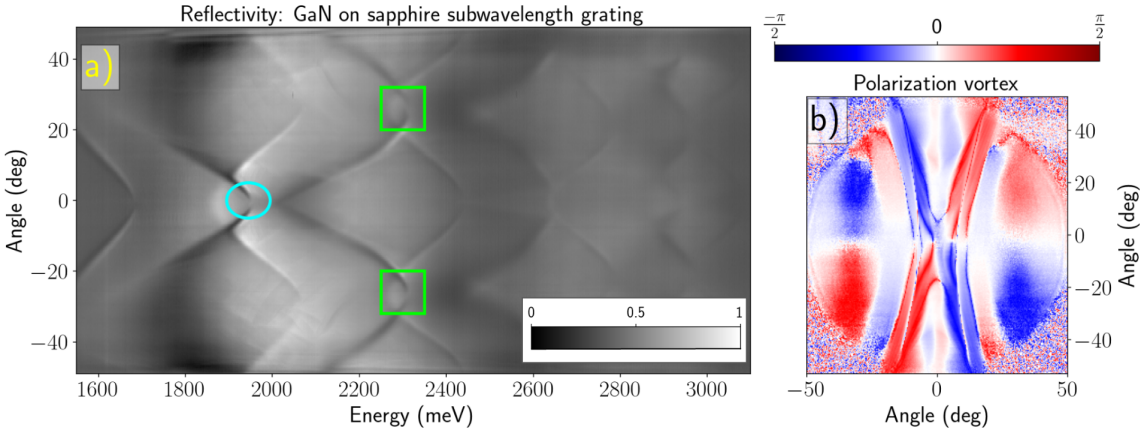

Figure 1: a) Angle resolved reflectivity measurements of GaN on sapphire subwavelength grating. BIC states are observed at $k = 0$ (blue circle) or $k \neq 0$ (green rectangle). b) Polarization vortex of a mode involving BIC at $k = 0$.

[1] H. M. Doeleman et al. *Nature Photonics*, 12(7):397–401, Jul 2018.

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