Room temperature lasing from a bound state in the continuum

T. Fąs [1,*], E. Pruszyńska-Karbownik [1], M. Sawicka[2], O. Gołyga[2], A. Feduniewicz-Żmuda[2], G. Muzioł[2], M. Słowikowski[2], Cz. Skierbiszewski[2], T. Czyszanowski[3], J. Suffczyński[1]

[1]Faculty of Physics, University of Warsaw, Warsaw, Poland
[2]Institute of High Pressure Physics, Polish Academy of Sciences, Warsaw, Poland
[3]Institute of Physics, Łódź University of Technology, Łódź, Poland
[4]CEZAMAT, Warsaw University of Technology, Warsaw, Poland

This study demonstrates room-temperature lasing around 440 nm using a nanoscale laser based on bound states in the continuum (BICs). The device consists of subwavelength gratings etched into gallium nitride (GaN), below which indium gallium nitride (InGaN) quantum wells and a low-refractive-index porous GaN layer are placed (see Fig. 1a). GaN has been selected for its high refractive index, low visible-light absorption, and robust thermal properties, making it ideal for visible photonic applications.

BICs, which arise in periodic structures via destructive interference of radiative channels, coexist with a continuum of radiating states and enable exceptionally high quality (Q) factors. Subwavelength gratings — diffractive structures with a period smaller than the wavelength of light — are employed here as a platform to confine BIC modes. The gratings were fabricated using electron beam lithography and dry etching, while the porous GaN substrate was fabricated via electrochemical etching.

Figure 1b) illustrates angle-resolved photoluminescence spectra from gratings with a 437 nm period and nominal 89 nm GaN stripe spacing, measured below and above the lasing threshold. Below threshold, a rich modal structure is observed, consistent with BIC-driven light confinement. Above threshold, a dominant emission peak emerges at 443 nm, which together with nonlinear increase in intensity confirms laser action. Tunability of the laser emission has been observed by studying hundreds of gratings which were manufactured with different periods and stripe widths. This compact, room-temperature nanolaser provides a robust platform for further research and applications.

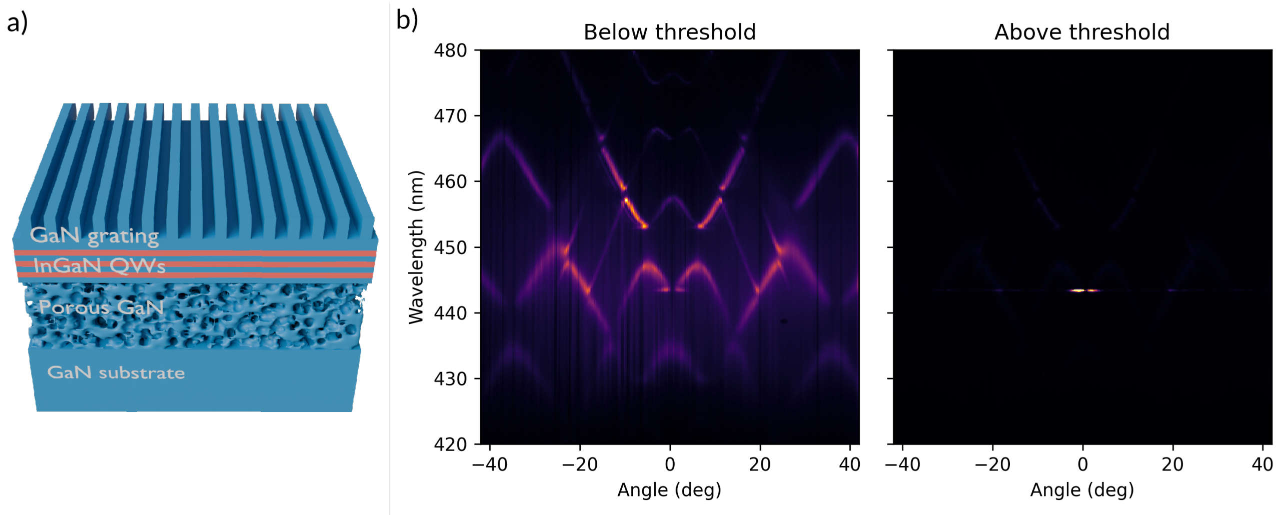

Figure 1: a) Schematics of the sample. b) Photoluminescence spectra of InGaN quantum wells coupled to a BIC mode in a GaN subwavelength grating, excited by a 375-nm femtosecond pulsed laser. Below the lasing threshold, multiple resonant modes are visible. Increasing the pump power results in a single dominant laser emission peak at 443 nm.

*E-mail: t.fas@uw.edu.pl