III-nitride-based photonic crystal surface-emitting lasers with UVC emission

Dogukan Apaydin[1], Hjalmar Andersson[1], Lukas Uhlig[2], Joachim Ciers[1], Sarina Graupeter[3], Giulia Cardinali[3], Michael Kneissl[3,4], Ulrich Schwarz[2], Philippe Tassin[1], Åsa Haglund[1]

[1] Chalmers University of Technology, [2] Chemnitz University of Technology, [3] Technische Universität Berlin, [4] Ferdinand-Braun-Institut

A photonic crystal surface-emitting laser (PCSEL) is an emerging type of semiconductor laser which utilizes a two-dimensional photonic crystal that provides light confinement and surface emission through diffraction. The large area of the photonic crystal in a PCSEL yields high single-mode output powers and low beam divergence, as demonstrated at infrared and blue wavelengths. This combination of performances has not been obtained by conventional laser diodes, and it is thus of interest to also implement PCSELs in AlGaN to provide the same benefits in the ultraviolet, where few laser sources are available.

Here we demonstrate UVC lasing from optically-pumped photonic-crystal surface-emitting lasers. The devices feature a 60 nm Al0.70Ga0.30N waveguide with 3x2 nm Al0.30Ga0.70N quantum wells sandwiched between AlN claddings. The photonic crystal with an area of 140x140 μm2 is patterned by e-beam lithography and etched into the top AlN cladding using a Cl2/Ar plasma. Under pulsed optical pumping at 266 nm with an 82 μm-wide (full-width half maximum) beam, the PCSELs exhibit single mode lasing around 279 nm with a lasing threshold ranging from 4 to 20 MW/cm2 depending on the photonic crystal parameters. The photonic crystal parameters affect the photonic band structure. This determines which mode that will be favored for lasing, which in turn greatly influences the far-field. By optimizing the hole-filling factor, unwanted emission bands in the far-field are reduced and a divergence angle below 1° can be obtained.