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Continuous and Dynamic Lasing Tuning of Single GaN Nanowires with sub-nanometer resolution using Hydrostatic Pressure

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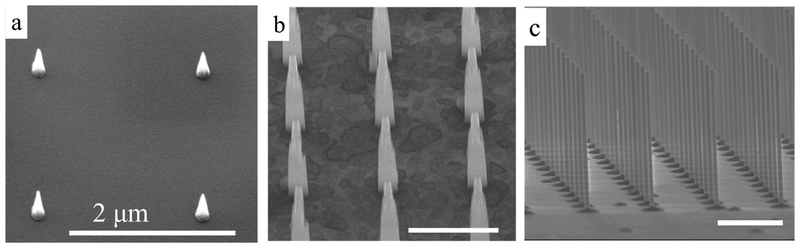
GaN Nanowire Lasers

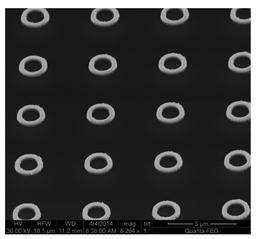
Nanowire lasers have been attracting intensive attention for both fundamental research and technological applications ranging from optical sensing, signal processing, and on-chip communications to quantum optics. Although III-Nitride materials with direct bandgaps are excellent gain materials with luminescent spectra extending from near-infrared (IR) to near-ultraviolet (UV), their uses for nanowire lasers are studied much less compared with II-VI materials.

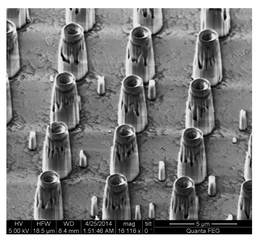


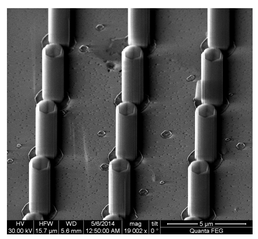
Fabrication of GaN nanowires in Sandia is achieved by two-step dry plus wet top-down fabrication technique which produces uniform and vertically aligned *c*-axis n-type GaN NW arrays starting from a *c*-plane (0001) n-type GaN epilayer grown on a sapphire substrate by metal-organic chemical vapor deposition. Electron-beam lithography is used to accurately pattern dry etching masks consisting of Ni dots.

Annular Emission from GaN Nanotube Lasers

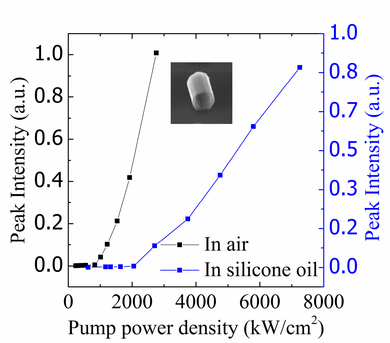
Fabricate GaN nanotube lasers using top-down two-step etch process.

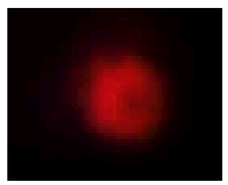

EBL patterning

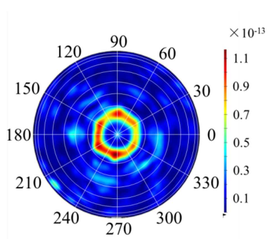

ICP Etch


AZ400K wet etch

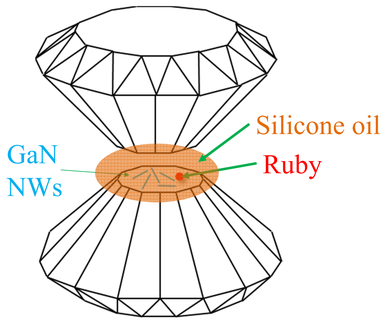
Annular emission is good for broad applications such as atom trapping and stimulated emission depletion (STED) microscopy.



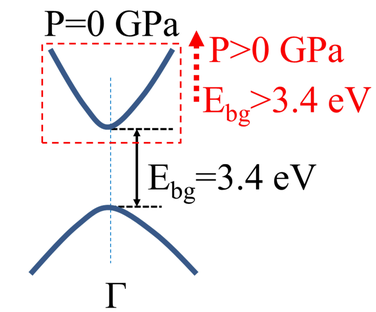




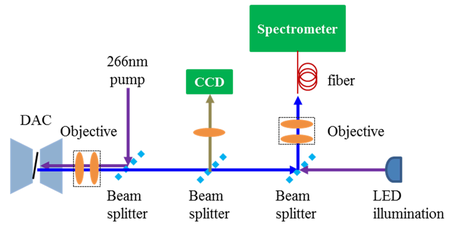
Spectral Tuning of GaN Nanowire Lasers using Hydrostatic Pressure

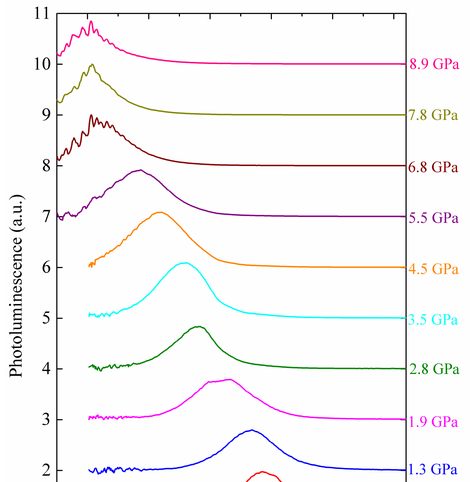


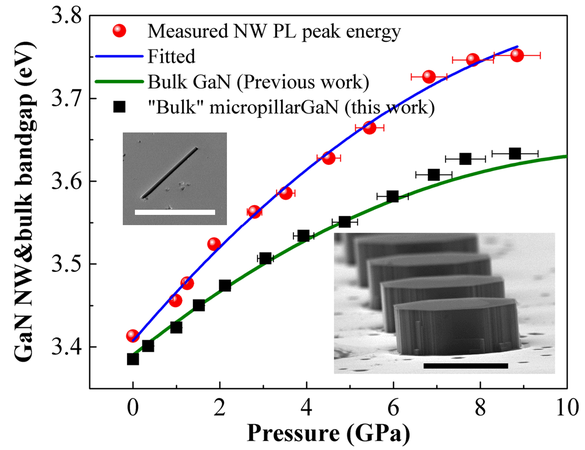
Diamond Anvil Cell

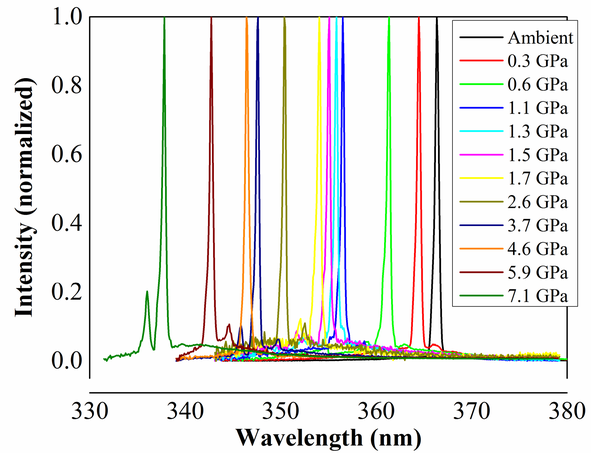


GaN bandgap diagram

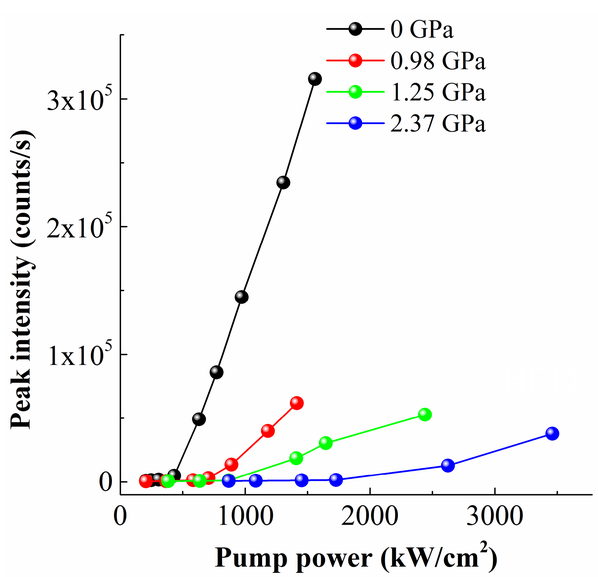


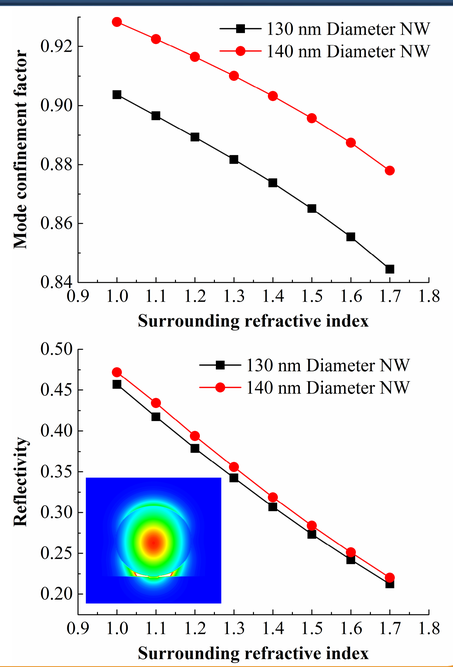






Lasing Threshold vs Pressure





Conclusions

- Dynamic, reversible and continuous lasing tuning up to ~30 nm with sub-nanometer tuning resolution.
- The lasing intensity decreases and the lasing threshold increases as the applied pressure increases.
- Larger pressure coefficients for the GaN NWs is a nanoscale effect (under investigation) not observed at larger bulk-like dimensions.
- Modal confinement factor and end facets' reflectivity decrease as the refractive index of the pressure transmitting medium (silicone oil) increases when pressure increases.

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