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Cross-sectional Controlled GaN Nanowire Lasers

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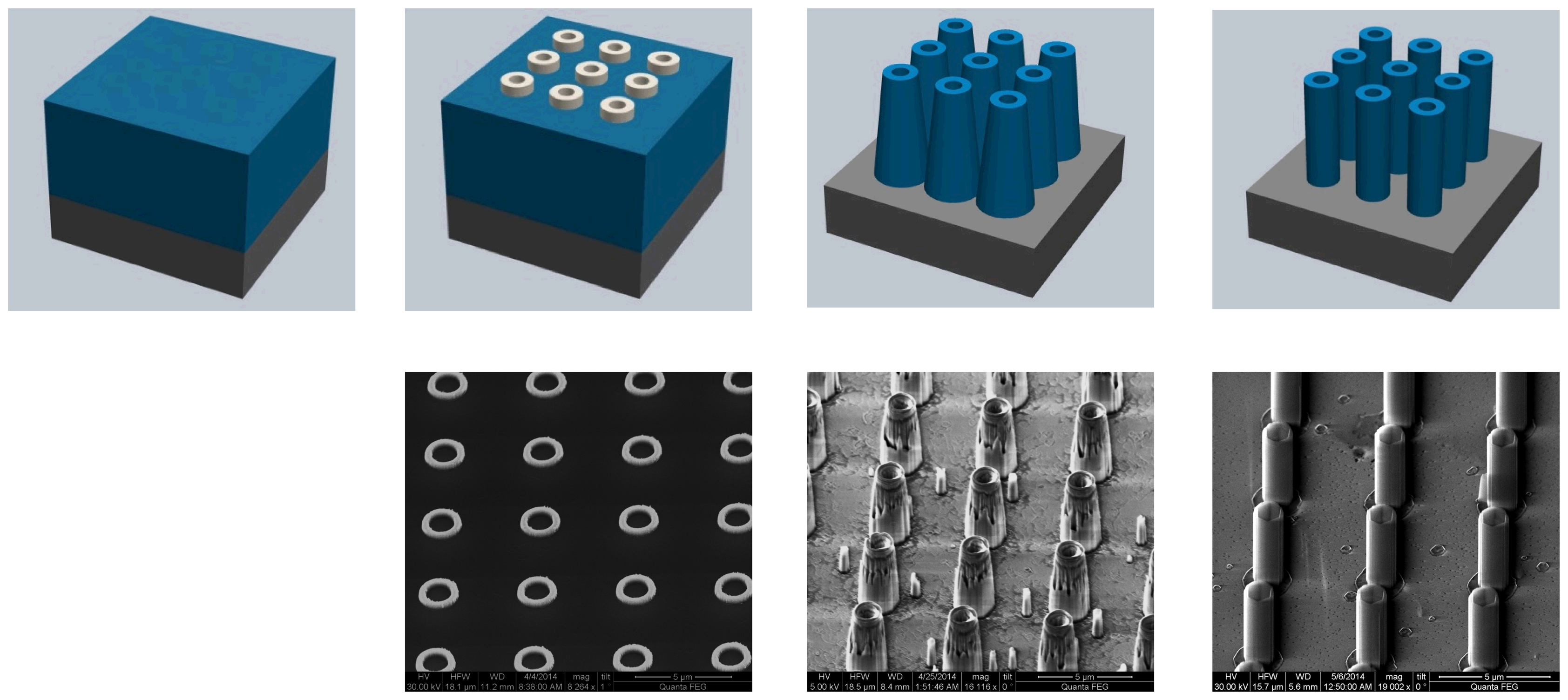
Why Cross-section Control?

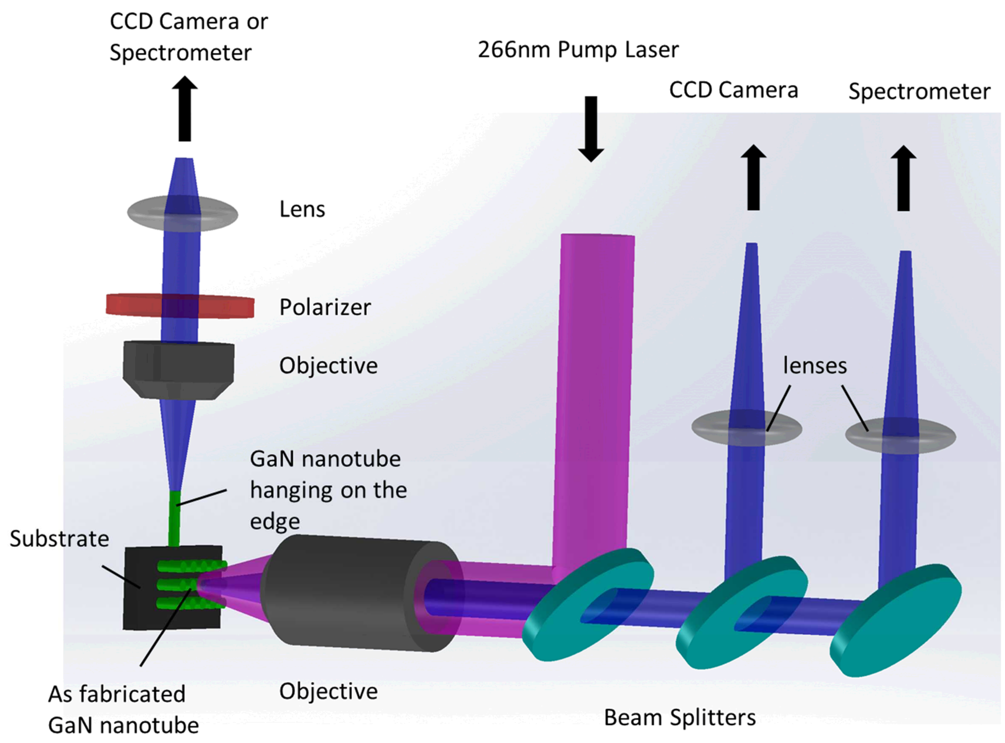
- Mode-selection
- Polarization control
- Beam-shaping

Top-Down Technique for Nanowire Fabrication

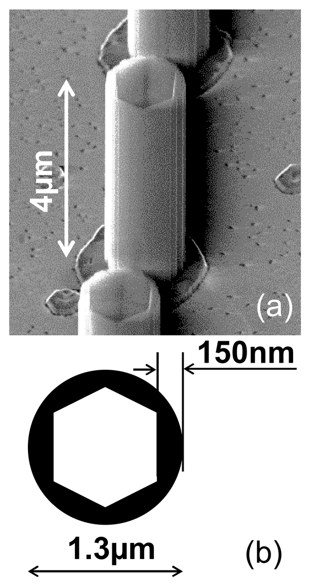


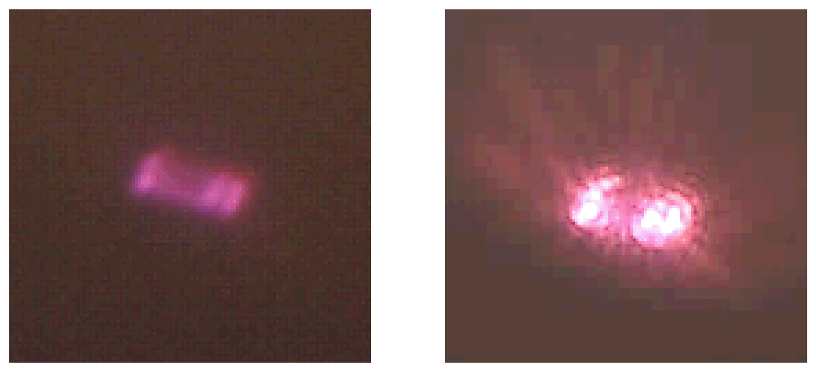
GaN epitaxial film | EBL patterning | ICP Etch | AZ400K wet etch

Experimental Setup

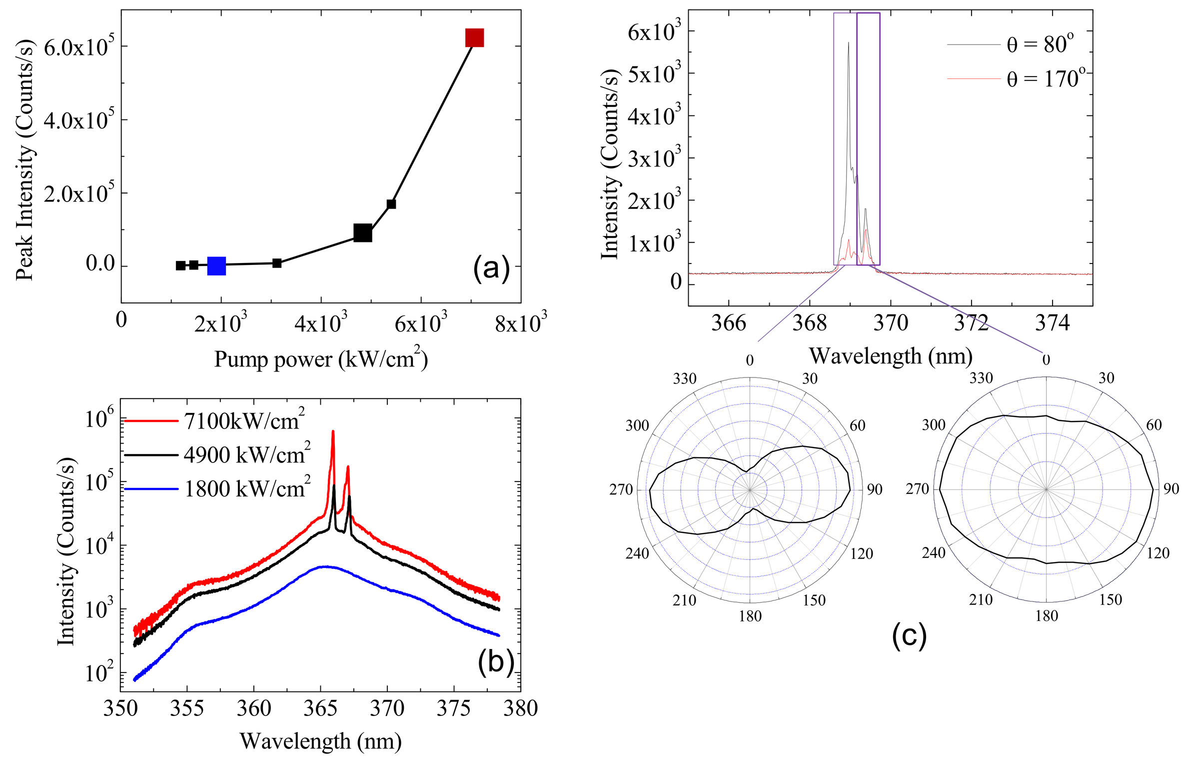


Structure 1: GaN Nanotube Lasers

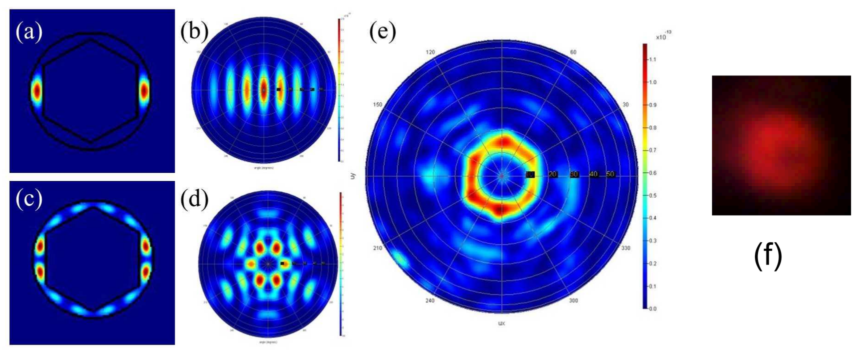




(a) The SEM image and (b) scheme of the cross-section of the as fabricated GaN nanotube laser. CCD images of the GaN nanotube laser excited (c) below and (b) above lasing threshold



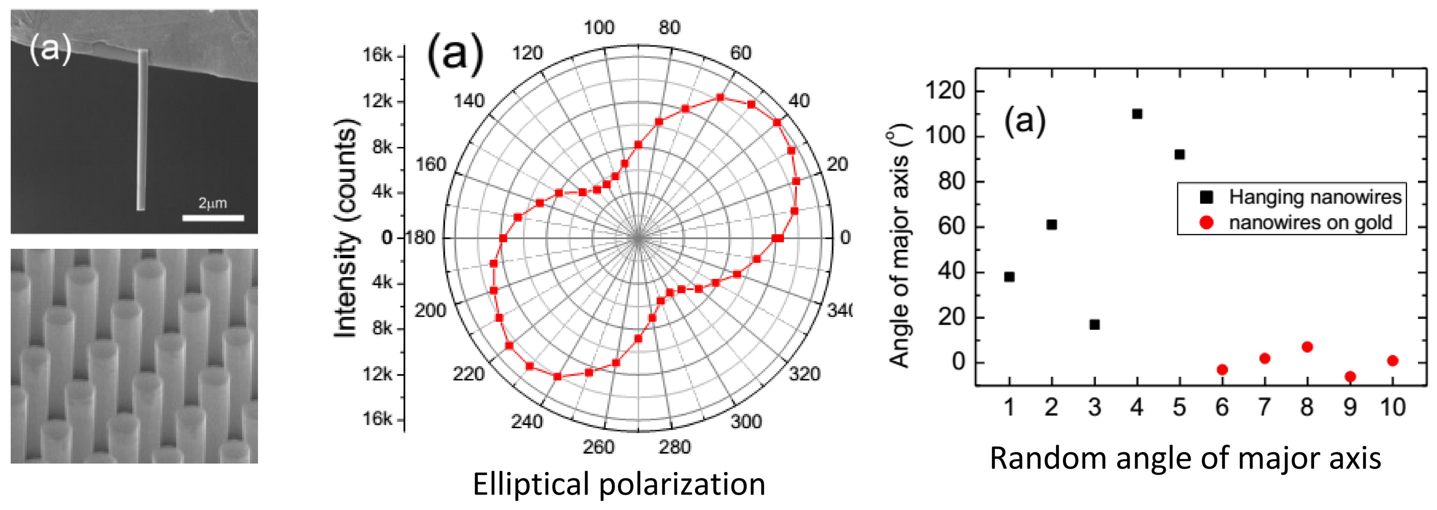
(a) Light-light curve and (b) spectra of the GaN nanotube laser. when the GaN nanotube is excited over a pump power density of approximately 4500 kW/cm², the peak intensity increases with a much larger slope as the pump power density increases, implying that stimulate emission dominates and the nanotube is excited above lasing threshold.
(c) Peak intensities of the lasing peak groups versus polarization angle. The two groups show different polarization property, indicating multi-mode lasing.



Simulation results of the GaN nanotube laser: Transverse mode profile of (a) "solid" mode and (b) "hollow" mode, Far-field pattern of (b) the "solid" mode and (b) the "hollow" mode, and (e) the far-field pattern of multi-transverse modes. (f) shows the CCD image of the far-field pattern of a GaN nanotube laser.

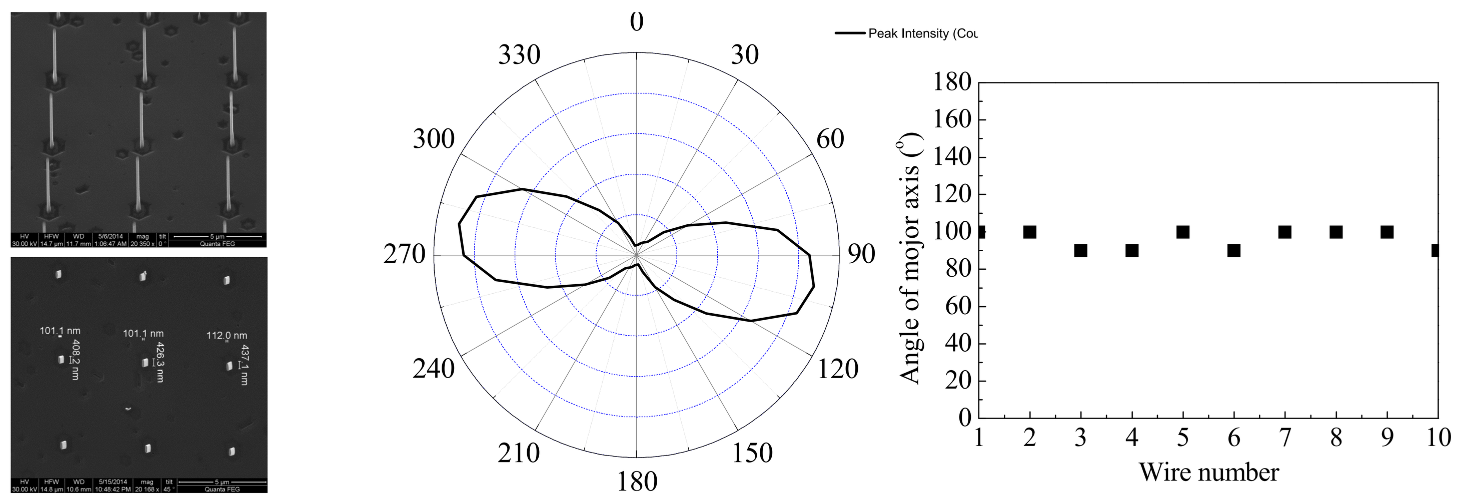
Structure 2: Rectangular GaN nanowire laser

Cylindrical nanowire laser



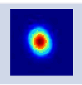
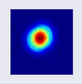
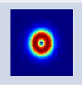
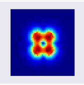
Elliptical polarization | Random angle of major axis

Rectangular nanowire laser

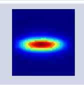
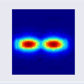
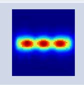
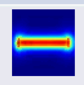


The asymmetric cross-section of the rectangular nanowire laser breaks the degeneracy. The "y polarized transverse modes" are cut-off. Only the "x polarized transverse modes" survive.

Cylindrical nanowire laser

Mode Profile	$\frac{\lvert E_x \rvert}{\lvert E \rvert}$
	0
	100
	50
	50

Rectangular nanowire laser

Mode Profile	$\frac{\lvert E_x \rvert}{\lvert E \rvert}$
	100
	100
	99
	97

Summary

- The ability to precisely control the cross-section of nanowire lasers offers interesting advantages, such as mode selection, polarization control, and beam shaping.
  - GaN nanotube lasers : Annular emission
  - Rectangular GaN nanwire lasers: Linear polarization with controlled polarization direction

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