SAND2014-0946C

Gallium Nitride Nanowire Distributed Feedback Lasers

Jeremy B. Wright[1,2], Salvatore Campione[1,3], Sheng Liu[1,3], Julio A. Martinez[3,4], Huiwen Xu[2], Ting S. Luk[1,3], Qiming Li[1], George T. Wang[1], Brian S. Swartzentruber[1,3], and Igal Brener[1,3]
[1]*Sandia National Laboratories, Albuquerque, New Mexico 87185, USA*
[2]*Center for High Technology Materials, The University of New Mexico, Albuquerque, New Mexico 87111, USA*
[3]*Center for Integrated Nanotechnology, Sandia National Laboratories, Albuquerque, New Mexico 87123, USA*
[4]*Department of Chemical Engineering, New Mexico State University, Las Cruces, New Mexico 88003, USA*
e-mail: jbwrigh@sandia.gov

Web Abstract: Achieving single-mode laser operation in nanowire lasers remains a challenge due to a lack of mode selection approaches. We have implemented single-mode lasing using distributed feedback by externally coupling gallium nitride nanowires to a dielectric grating to achieve mode-control. We placed GaN nanowires onto a silicon nitride grating structure using a dry transfer technique. Nanowires were randomly oriented on the grating structure and then optically pumped at room temperature. We observed a direct relationship between the number of transverse/longitudinal lasing modes and the relative misalignment of individual nanowires to the grating. The effective periodicity of the grating experienced by the nanowires was altered using nanomanipulation to change the angular alignment between the nanowires and the grating. The effective periodicity controls the spectral location of the stop-band associated with distributed feedback. Nanowires were rotated so that the designed periodicity of the grating was experienced by the nanowires. At this orientation the stop-band was spectrally located in the center of the GaN material gain bandwidth. When the nanowires were aligned this way, we achieved single-mode emission with a mode suppression ratio of 17dB.

This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. Work at Sandia National Laboratories was supported by Sandia's Solid-State-Lighting Science Energy Frontier Research Center, funded by the U.S. Department of Energy, Office of Basic Energy Sciences.

Gallium Nitride Nanowire Distributed Feedback Lasers

Jeremy B. Wright[1,2], Salvatore Campione[1,3], Sheng Liu[1,3], Julio A. Martinez[3,4], Huiwen Xu[2], Ting S. Luk[1,3], Qiming Li[1], George T. Wang[1], Brian S. Swartzentruber[1,3], and Igal Brener[1,3]
[1]Sandia National Laboratories, Albuquerque, New Mexico 87185, USA
[2]Center for High Technology Materials, The University of New Mexico, Albuquerque, New Mexico 87111, USA
[3]Center for Integrated Nanotechnology, Sandia National Laboratories, Albuquerque, New Mexico 87123, USA
[4]Department of Chemical Engineering, New Mexico State University, Las Cruces, New Mexico 88003, USA
e-mail: jbwrigh@sandia.gov

The achievement of mode selection techniques in free-standing nanowire lasers has been difficult because of the small scale, size dispersion, and lack of well-developed placement methods for single nanowires. By externally coupling free-standing nanowires to a dielectric grating we have demonstrated a proof-of-concept distributed feedback in nanowire lasers. GaN nanowires were placed onto a SiN grating via a dry transfer technique a SEM image of a nanowire in contact with the grating is shown in figure 1c). We optically pumped and analyzed the emission from GaN nanowire lasers in contact with the grating using a micro-photoluminescence (μPL) setup. The initial spectrum obtained from a representative nanowire, oriented so that there is no additional feedback from the grating, is shown in Figure 1a). The spectrum shows the typical multimode behavior associated with nanowire lasers that lack mode selection. We controlled the spectral location of a stop-band formed by the coupling of the nanowire and the grating by nanomanipulation of the nanowires. We achieved single-mode nanowire lasing with a mode suppression ratio of 17dB when the nanowire was oriented to align the spectral location of the stop-band to the optical gain bandwidth of GaN. The spectrum obtained from this orientation is shown if Figure 1b).

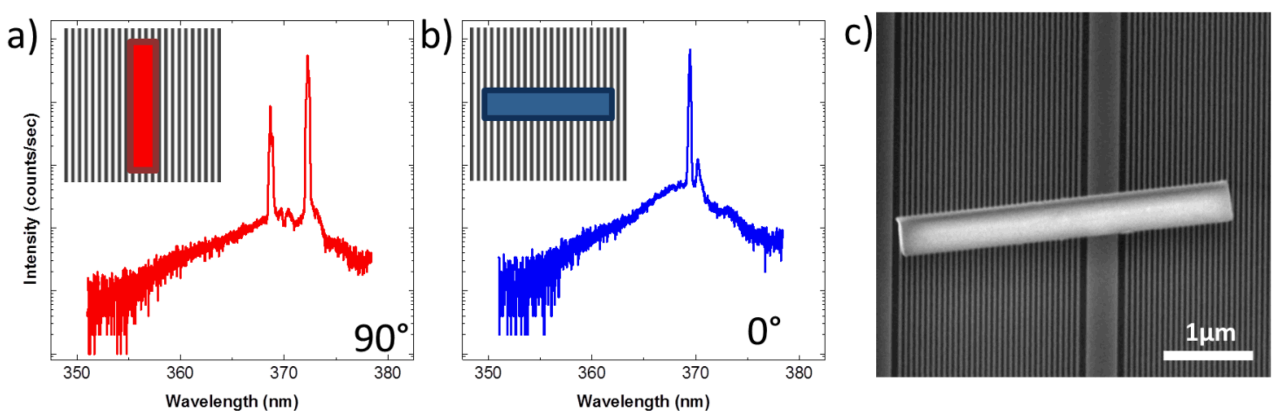

Figure 1 a) Lasing spectrum obtained at 90° nanowire substrate alignment angle for a single wire. **b)** As in **a)**, for 0° alignment angle. The nanowire was rotated with respect to the grating for optical characterization studies. **c)** SEM image of a single GaN nanowire lying in contact with the distributed feedback grating.

This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. Work at Sandia National Laboratories was supported by Sandia's Solid-State-Lighting Science Energy Frontier Research Center, funded by the U.S. Department of Energy, Office of Basic Energy Sciences.