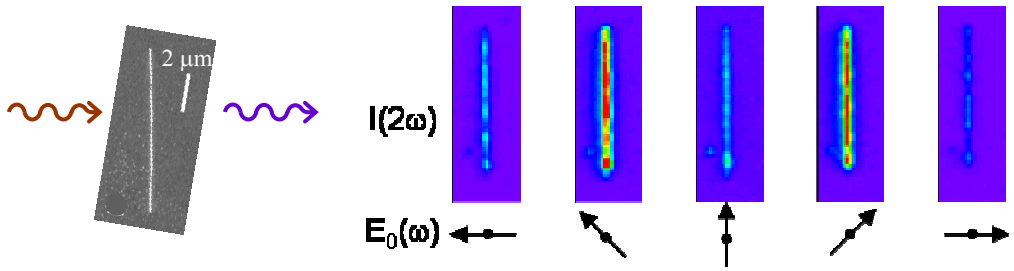
Nonlinear Optical Signatures of Semiconducting-Nanowire Orientation

Progress in nanotechnology benefits from new, convenient methods for screening individual nanostructures. Far-field optical microscopy can provide an especially efficient probe of nanostructures that emit or scatter light, even when the nanostructures are too small to be fully resolved. As such, the application of far-field methods to the nanorealm is an active area of investigation. This research developed a new far-field method for assessing the orientation of GaN nanowires lying on a surface. The technique exploited second harmonic generation (SHG), wherein an intense laser pulse at frequency ω induces a material to emit light at twice the frequency, 2ω. Because the second-harmonic emission is sensitive to the crystallographic axes of the material, the method offers a purely optical means of sensing the crystallographic orientation of the nanostructure. The approach is applicable to any crystalline nanostructure with non-centrosymmetric symmetry, including many III-V and II-VI semiconductors of technological interest. This research can be expected to improve the efficiency of nanoscale screening of crystallographic orientation, as might be important, for example, if sensing molecules bound with different properties on different crystallographic faces.



The figure shows a scanning electron micrograph of an 80-nm wide nanowire (NW) under test. Focused laser pulses of 100-fs duration and 860-nm wavelength (in the near infra-red) illuminated the nanowire. The NW responded nonlinearly by radiating purple light at 430 nm. When the incident optical electric field $E_0(\omega)$ was rotated as indicated by the arrows, the intensity of the NW emission varied as shown by the false-color optical micrographs. Remarkably, the emission exhibited a minimum when the polarization was aligned along the NW (central micrograph), contrary to the expectations for *linear* response, such as photoluminescence, for which the emission would have peaked. Detailed analysis, verified by electron diffraction, showed that the SHG polarization dependence was a consequence of the GaN crystallographic c-axis for this NW pointing ~114° away from an axis perpendicular to the substrate.

Reference: "Far-field imaging of second-harmonic generation in single GaN nanowires," J.P. Long, B.S. Simpkins, D.J. Rowenhorst, P.E. Pehrsson, *Nano Letters* **7**, 831, 2007.

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