SECOND-HARMONIC GENERATION MICROSCOPY OF VERTICALLY ALIGNED SEMICONDUCTOR NANOWIRES USING VECTOR BEAMS

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For a decade, there has been great progress in the development and characterization of semiconductor nanowires [1]. However, there is still a lack of tools that can address the optical properties of vertically aligned nanowires in their native environment. In order to conveniently couple light into the long axis of the nanowire, the longitudinal field that arises from focused radial polarization can be used [2]. Here, we demonstrate second-harmonic generation (SHG) microscopy with a radially polarized input beam [3] to characterize vertically aligned as-grown GaAs nanowires [4]. The studied nanowires were grown on a GaAs substrate by metal-organic vapor-phase epitaxy using vapor-liquid-solid technique with gold nanoparticles as catalysts (Fig. 1a) [5]. Using different input polarizations, we found that SHG from an individual vertically aligned nanowire is highest when tightly focused radial polarization is used (Fig. 1b-d). We found that our experiment results are in good agreement with SHG modeling of a GaAs nanowire described with zinc-blende structure and dipolar bulk nonlinearity. Our results provide direct evidence that SHG from oriented one-dimensional nanowires is mainly driven by the longitudinal field along the nanowire growth axis. Consequently, radial polarization provides a superior tool to characterize such nanowires in native growth environment compared to linear and azimuthal polarizations, showing that the longitudinal field and its strength significantly influence the efficiency of SHG.

Figure 1. (a) SEM image of vertically aligned zinc-blende GaAs nanowires (diameter 40 nm, length 10 μm) grown on a GaAs substrate. Measured far-field SHG images of GaAs nanowires using focused (b) radial, (c) linear along x, and (d) azimuthal polarization. The SHG images were taken at similar experiment settings.