High-Performance Core–Shell GaAsSb Nanowires on Functionalized Graphene via MBE for NIR Photodetection

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ABSTRACT

This work presents the growth of high-performance, self-assisted n-i-p core-shell (C-S) GaAsSb nanowires (NWs) on surface-functionalized monolayer graphene using molecular beam epitaxy (MBE). The vertical yield of core GaAsSb NWs was carefully examined in relation to essential growth factors, including substrate temperature, Ga droplet flux, opening duration, V/III ratio, and oxygen plasma treatment duration. With an intrinsic GaAsSb section at the top to improve optical absorption, a hybrid n-i core/i-p shell architecture was designed utilizing an axial n-core Sb composition gradient design that varied from 40 at. % to 20 at. %. 4K Photoluminescence (PL) peak revealed PL emission at ~1.5 μm on graphene. Raman spectroscopy exhibited the longitudinal optical (LO) phonon mode of GaAs at 282 cm^{-1}, the transverse optical (TO) phonon mode of GaAs at 261 cm^{-1}, and the TO phonon mode of GaAsSb at 237 cm^{-1} . Additional confirmation of Sb's inclusion in the core-shell structure came from X-ray diffraction investigation. At a wavelength of 860 nm, electrical tests utilizing conductive atomic force microscopy (C-AFM) on a single nanowire device showed a photocurrent of 2×10^{-9} A and a dark current of 10^{-11} A. This led to a detectivity of 3.6×10^{13} Jones at -1 V and a responsivity of 0.11 A/W. Higher responsivity (> 10^{3} A/W) and detectivity (> 10^{14} Jones) were attained for ensemble nanowire photodetectors on graphene, with spectral response extending beyond 1.5 μm at -1 V. Furthermore, low cut-off frequencies and temperature-independent features were found in the photodetector's low-frequency noise and temperature-dependent capacitance-voltage (C-V) investigations, respectively. The potential of combining photodetectors with 2D platforms to improve device performance is highlighted by this work.

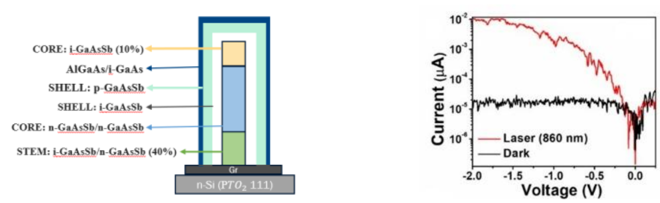

Figure 1. Schematic representation of (a) C-S GaAsSb NW photodetector architecture, and (b) I−V characteristics of single NW photodetector using C-AFM.

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