Internal Structures of Gallium Nitride Nanowires and Effects in Nanoelectronics

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Catalyst-free vapor-solid nanowire growth is under investigation by several research groups, as it can result in higher crystalline quality compared with traditional vapor-liquid-solid growth. Our group has demonstrated that new nanowire orientations and multiphase relationships are also enabled[1,2,3]. These are strongly influenced by growth temperature, which is known to affect constituent atom kinetics. In vapor-solid growth, our group has demonstrated that it also affect nucleation site formation and availability. The types of nanowires that form and the corresponding nucleation sites over the growth temperature range 850-1000°C will be discussed. Multiphase nanowires typically form at 850-950°C with $[11\bar{2}0]$ wurtzite and $[011]$ zinc blende domains that extend the full length of the nanowire. High-resolution transmission electron microscopy (HRTEM) of cross-sections created with focused ion beams (FIB) has demonstrated the presence of totally coherent interfaces between the wurtzite and zinc blende phases within these nanowires. New nanoscale ledges on growth matrix platelets have been indentified as potential nucleation sites. By 1000°C, nanowire growth orientation changes, and single-phase $[0001]$ wurtzite nanowires and rods result. HRTEM of FIB cross-sections have demonstrated the presence of hollow core screw dislocations or nanopipes in these nanowires and rods, which indicates that a dislocation-driven growth mechanism may be enabled at higher growth temperatures.

Nanowires with well-defined internal structures could provide unique flexibility for photon and carrier confinement, offering improvements over single-phase nanowires in device applications. The electronic performance of the new multiphase nanowires in a NanoFET configuration was investigated using 2-point and 4-point probe current-voltage characterizations[4]. The current-voltage characterizations were carried in a special nanoprobing system, in which oxide sharpened ~30 nm radius tungsten nanoprobes were coupled to directly a nanowire while the experiments were directly visualized using a scanning electron microscope. Evidence for single-phase current transport within the multiphase nanowire structure will be discussed. Further experiments examined the live performance of the multiphase nanowire NanoFET configuration during heavy ion irradiation at the National Superconducting Cyclotron Laboratory with promising results[5].

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Biography

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