ZnO nanorods and nanodevices

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Quasi-one-dimensional semiconductor materials including nanowires, nanorods, and nanobelts have been attracting great research interest as fundamental building blocks for fabrications of electronic, photonic, and biological nanodevices. Of the numerous semiconductor nanomaterials, ZnO nanorods and nanowires are particularly interesting owing to their unique electrical and optical properties: ZnO is an oxide semiconductor with a direct band-gap energy (E_g=3.4 eV) and a large exciton binding energy (60 meV). Meanwhile, for realization ofnano-scale devices based on ZnO nanorods, there still remain many scientific and technical issues to be overcome; (i) preparation of high purity ZnO nanorods and accurate *n*- and *p*-type doping controls of ZnO nanorods and (ii) reliable heterostructure and device fabrications. High purity material preparation and accurate doping controls will enable the materials to exhibita wide range of conductivity, essentially necessary for many device applications. In addition, well-designed heterostructure growth and reliable device fabrication enhance the device performance and also open up possibility of new functional device realization.

Recently we developed a "catalyst-free" metalorganic chemical vapor deposition (MOCVD) technique to grow vertically aligned ZnO nanorods. The catalyst-free MOCVD technique has several advantages over the "catalyst-assisted" vapor-solid-liquid methods. First of all, the catalyst-free method yields high purity and single crystalline ZnO nanorods. Second, an accurate thickness control in a monolayer level is readily achievable with the aid of computer-controlled reactant gas delivery system of MOCVD. This is a very important advantage to grow nanorod heterostructures including nanorod quantum structures with composition modulation along axial or radial direction, with sharply defined interfaces. Third, diverse substrates including Al_2O_3, Si, GaN, glasses, polymers and metals can be employed for the growth of vertically aligned ZnO nanorod arrays. Here after briefly introducing catalyst-free MOCVD growth of ZnO based nanorods and their heterostructures, I will talk about our activities on ZnO nanorod device fabrication and evaluation, including field-effect transistors, Schottky diode arrays, logic gates, and light emitting devices.