GaAs nanowires with oxidation-proof arsenic capping for the growth of epitaxial shell

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III-V compound semiconductors (SCs) provide the material basis for a number of well-established commercial technologies, as well as new cutting-edge classes of electronic and optoelectronic devices.[1] During the last decade, III-V-SCs-based nanowire materials have drawn a great attention in the researching community as the building blocks for future electronic and photonic devices. Due to their nanometric diameter and the efficient elastic relaxation at the lateral surface, nanowires (NWs) can accommodate more strain, and thus minimize lattice-matching constraints, inevitable in conventional thin film epitaxial growth. In order to improve the physical properties of such NWs, core / shell structures were intensively developed in the last years. The core / shell heterostructure takes advantages of both components and offer original properties through a reinforcement or modification of each other.[2] However preparing core / shell NWs with good quality is quite challenging for the necessity of the perfect control of the core / shell interface. Targeting a shell made of heterogeneous materials which are obligated to be grown in a different reactor, it is necessary to prevent the NW core from the oxidation in air, which is also less studied.

In this work, GaAs NWs, working as inner core, were successfully fabricated on (111) oriented silicon substrate by molecular beam epitaxy (MBE) using Vapor-Liquid-Solid (VLS) method with gallium as catalyst. The morphology of NWs is uniform, about 50 nm in diameter and 1 µm in length, while the NWs surface density is as high as 7 μm^{-2}. To obtain a better understanding of its growth mechanism, the effect of different experimental parameters were investigated, including the effect of substrate orientation, pre-deposition temperature of the catalyst, and the temperature and time of the growth. Aiming for synthesis an epitaxial layer around the as-prepared GaAs NWs, chemical surface information of NWs is gathered by performing TEM and XPS measurements. A typical GaAs NW possesses a quite smooth lateral surface with an extremely thin amorphous layer outside which is composed of oxides of gallium and arsenic, attributed to the oxidation in the air. Such oxidation will affect the subsequent fabrication of a core-shell structure with introducing defects and enlarging the lattice mismatch. We propose a reversible arsenic-capping method without introducing any other impurity into the system in order to exclude the interference of oxidation.

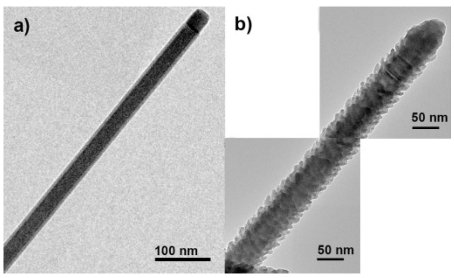

Figure 1 a) GaAs NWs; b) GaAs NWs with As capping.

1. Vurgaftman, I., Meyer, J. & Ram-Mohan, L. Band parameters for III-V compound semiconductors and their alloys. Journal of Applied Physics 89, 5815 (2001).
2. Xia, X. et al. High-Quality Metal Oxide Core/Shell Nanowire Arrays on Conductive Substrates for Electrochemical Energy Storage. ACS Nano 6, 5531 (2012).