Boron Distribution in Individual Ge / Si Core-Shell Nanowires Investigated by Atom Probe Tomography

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Introduction

Ge / Si core-shell nanowires (NWs) showing substantial potentials in the application of biological detectors, solar cells as well as one-dimension field-effect transistor have attracted considerable attention in recent years due to its unique electronic properties caused by the one-dimensional quantum confinement effect [1]. The dopant distributions in the Ge / Si core-shell NWs directly affect the performance of devices. Therefore, it is important to get clear of the dopant distribution in individual Ge / Si core-shell NWs.

Laser-assisted atom probe tomography (APT) has proved to be a powerful method to study semiconductor NWs in the atomic-scale resolution [2]. In the previous report, we have introduced the method of using APT to study Ge / Si core-shell NWs [3]. In this study, the Ge / Si core-shell NWs were investigated by APT to study the Boron distribution in this kind of NW. The core-shell structure was clearly observed in the atom map, and the dopant, B atoms, distributed in the Si shell.

Experiment

The structure of Ge / Si core-shell NWs is shown in Fig. 1 (a). Ge / Si core-shell NWs were grown on Si (111) substrate by chemical vapor deposition (CVD), with gold nano colloid particles as the catalyst for vapor-liquid-solid (VLS) growth. B atoms were doped during the growth of Si shell [4]. Individual Ge / Si core shell NW specimens for APT analysis were prepared by gallium focused ion beam, with FIB-SEM dual-beam system (Helios NanoLab600i, FEI). APT analysis was performed using a laser-assisted local electrode atom probe (LEAP4000X HR, AMETEK).

Results

Figure 1(b) shows a 3D atom map of Ge / Si core-shell NW. To study the elemental distributions in NW, the 20 nm-thick sliced atom maps were displayed in Fig. 1 (c). From the sliced atom maps, the core-shell structure can be clearly observed. Moreover, the B atoms were detected in the Si shell as expected. In this presentation, the details of sample preparation and more analysis data will be shown.

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References