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MS-8-P-2613 Size-dependent structural quality of InAs Nanowires Grown by Molecular Beam Epitaxy

Zhang Z.[1], Lu Z.[2], Chen P.[2], Xu H.[1], Guo Y.[1], Liao Z.[1], Shi S.[2], Lu W.[2], Zou J.[1,3]

[1]Materials Engineering, The University of Queensland, St. Lucia, Queensland 4072, Australia, [2]National Laboratory for Infrared Physics, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, 500 Yu-Tian Road, Shanghai 200083, People's Republic of China, [3]Centre for Microscopy and Microanalysis, The University of Queensland, St. Lucia, Queensland 4072, Australia

Email of the presenting author: z.zhang6@uq.edu.au

III-V nanowires have attracted great interest due to their potential applications in optoelectronics and nanoelectronics.1 For nanowires to be practically useful, controlling the structural quality is critical. Here we report the size-dependent structural quality of Au induced InAs nanowires grown on the GaAs {111}B substrate in a molecular beam epitaxy (MBE) reactor. The morphological, structural and chemical characteristics of the grown nanowires and their corresponding catalysts were investigated by scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

Fig.1 shows SEM and TEM investigations of InAs nanowires. Fig.1a is a typical tilted SEM image in which nanowires, in which nanowires have varied diameters. TEM investigations were performed on the nanowires with different diameters. Figs. 1b and 1d show the high-resolution TEM images of a typical thick nanowire (~45nm) and a typical thin nanowire (~30nm), both near the nanowire tops, respectively. As can be seen, the thick nanowire has many planar defects along its growth direction, while the thin nanowire contains no lattice-defects. To understand this phenomenon, energy dispersive spectroscopy (EDS) analysis was preformed to determine the composition of the catalysts and their underlying nanowires. Figs. 1b and 1d show EDS spectra of a thick nanowire and a thin nanowire, respectively. Our quantitative analysis of the EDS results indicates both nanowires are InAs, and the catalyst's composition of the thick nanowire contains ~16 at.% In and ~84 at.% Au, while the catalyst's composition of the thin nanowire contains ~39 at.% In and ~61 at.% Au.

Based on these experimental results, the following growth behaviour of nanowires can be proposed. When Au nanoparticles are formed from its thin film, different sizes of Au nanoparticles cab be formed. With introducing the In source, In atoms diffuse into the Au nanoparticles to form Au-In alloyed particles. Due to different In diffusibility in Au nanoparticles with difference sizes, smaller Au nanoparticles may quickly absorb more In to form Au-In catalysts with a high In concentration, while larger Au nanoparticles tend to absorb relatively less In. Since nanowire growth at high supersaturation favors wurtzite structure, InAs nanowires induced by small catalysts with a high In concentration and therefore high In supersaturation2 have defect-free wurtzite structure, while defected InAs nanowires are induced by larger catalyst with a low In supersaturation.

References

1 H. Xia, Z. Y. Lu, T. X. Li, P. Parkinson, Z. M. Liao, F. H. Liu, W. Lu, W. D. Hu, P. P. Chen, H. Y. Xu, J. Zou, and C. Jagadish, Acs Nano 6, 6005 (2012).

2 F. Glas, J-C. Harmand, and G. Patriarche, Phys. Rev. Lett. 99, 146101 (2007).

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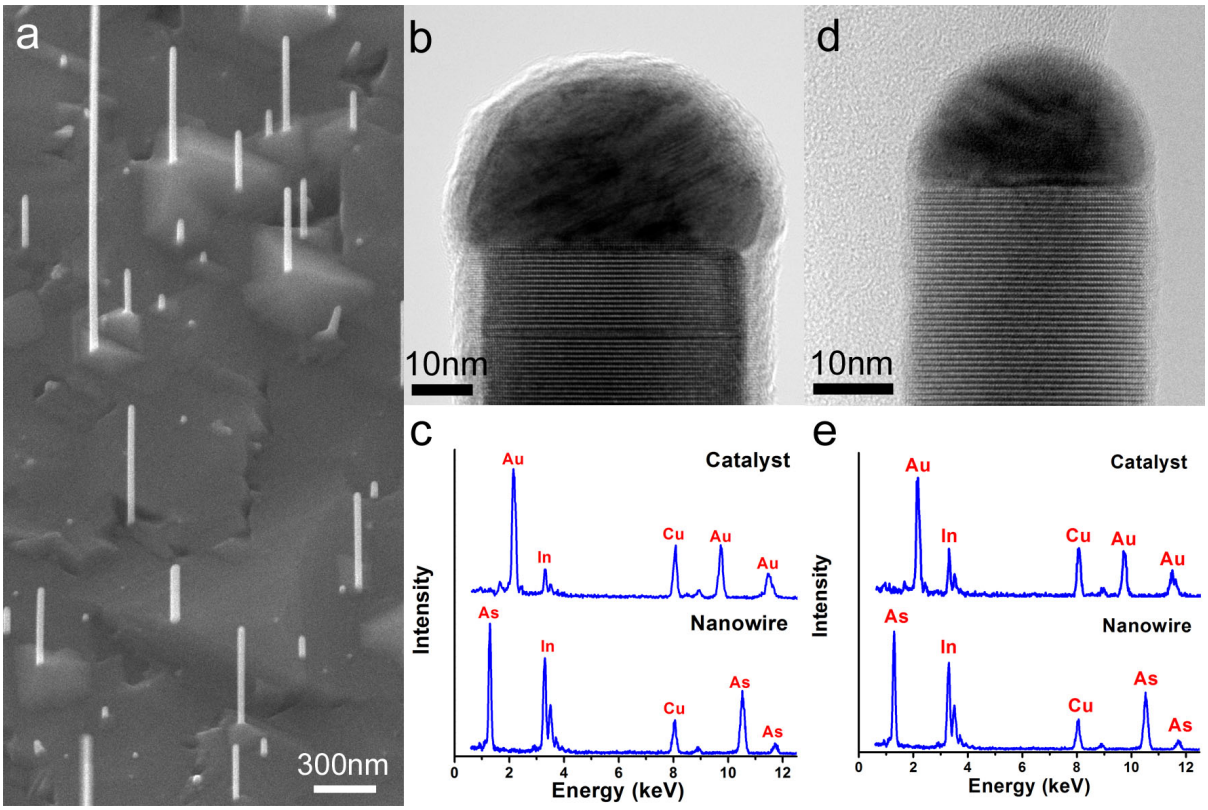

Fig. 1: (a) Tilted SEM image showing thick and thin nanowires. (b, d) High-resolution TEM images taken from the top of thick nanowire and thin nanowire, respectively. (c,e) EDS spectra of catalyst and its underlying nanowire from thick and thin nanowire, respectively.