DOI: 10.1017/S1431927605510791
Microsc Microanal 11(Suppl 2), 2005

Synthesis and Microstructural Study of Fe-doped $Zn_{1-x}Cu_xO$ Diluted Magnetic Semiconductor Nanowires

R. T. Huang*, M. C. Wang*, J. Y. Yan*, T. W. Wu*, Z. Y. Wu*, J. J. Kai*, and F. R. Chen*

*Department of Engineering and System Science, National Tsing Hua University, Hsinchu 300, Taiwan, R. O. C.

Diluted magnetic semiconductors (DMSs) have drawn much attention and interesting in recent years because of the possibility involving charge and spin degrees of freedom in a single substance [1]. However, as dimension closed to nanoscale, the quantum effect will also be even more apparent. One-dimensional (1-D) nanowire heterostructures are potentially functionalities feasible for nanoscale electronics and optoelectronics [2, 3]. Hence, synthesis of DMS nanowire heterostructure is of particular interest in nanoscale spintronics. Moreover, it is necessary to understand the correlation of magnetic properties and microstructure in DMSs with spatial resolution of near or even better than nanometer scale.

In this letter, we study a systematic work of synthesis, microstructure, and magnetic measurements on 1-D Fe-doped $Zn_{1-X}Cu_XO$ nanowires. These are synthesized and proceeded by using thermal evaporation and ion implantation, in which the dose of the Fe ions implanted into the $Zn_{1-X}Cu_XO$ nanowires are 3 x 10^{16} cm^{-2}, and 5 x 10^{16} cm^{-2}, respectively. Atomic scale structural characterization including high-resolution transition electron microscope (HRTEM), and nanobeam energy dispersive x-ray spectroscopy (EDX) map were done to study the behavior of Fe atoms. Figure 1(b) shows the HRTEM image of Fe-doped $Zn_{1-X}Cu_XO$ nanowires with the [0001] growth direction of single crystal, which is the same as that of as-grown $Zn_{1-X}Cu_XO$ nanowire (Fig. (a)), for the dose of 5×10^{16} ions/cm^2. It also suggests that any nano-sized clusters or second phase are absence in the Fe-doped $Zn_{1-X}Cu_XO$ nanowires. Figure 2 is the subsequently EDX elemental map analysis. It is apparent that Fe element is successfully doped into $Zn_{1-X}Cu_XO$ nanowires of well-controlled size and exhibits gradually enhanced magnetic behavior with increasing Fe element from a superconducting quantum inference device magnetometer measurement. Furthermore, the characteristic iron L_2 and L_3 absorption edge was analyzed by using electron energy loss spectrum. Further calculations on the ratio of the integrated intensity counts, done on the L_3 and L_2 absorption edge of iron, correspond to valence state of +3 [4]. This suggests that Fe ions supplies an extra electron carrier and contributes the inherent magnetic properties based on the double-exchange mechanism.

Reference

[1] H.ohno, Science, **281** (1998) 951
[2] L. J. lauhon, M. S. Gudiksen, D. Wang, C. M. Lieber, Nature **420** (2002) 57
[3] M. H. Huang, S. Mao, H. Feick, H. Yan, Y. Wu, H. Kind, E. Webber, R. Russo, P. Yang, Science **292** (2002) 1897
[4] T. I. Morrison, M. B. Brodsky, and N. J. Zaluzec, Phys. Rev. B **32** (1985) 3107

The authors profusely thank the National Science Council of R. O. C. (NSC 92-2216-E-007-039) for the financial support of this work.

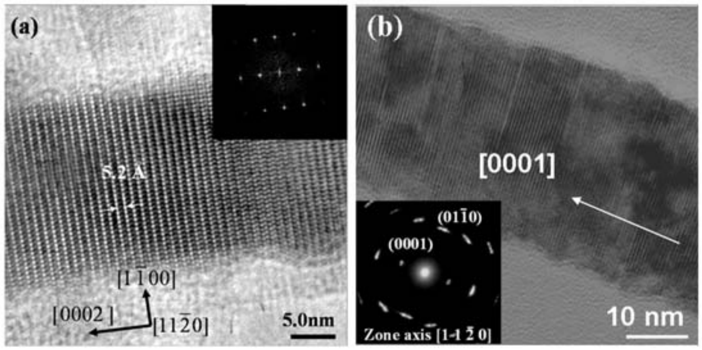

Fig. 1. The HRTEM image of (a) as-grown $Zn_{1-X}Cu_XO$ nanowire and (b) Fe-doped $Zn_{1-X}Cu_XO$ nanowires for the dose of 5×10^{16} ions/cm^2.

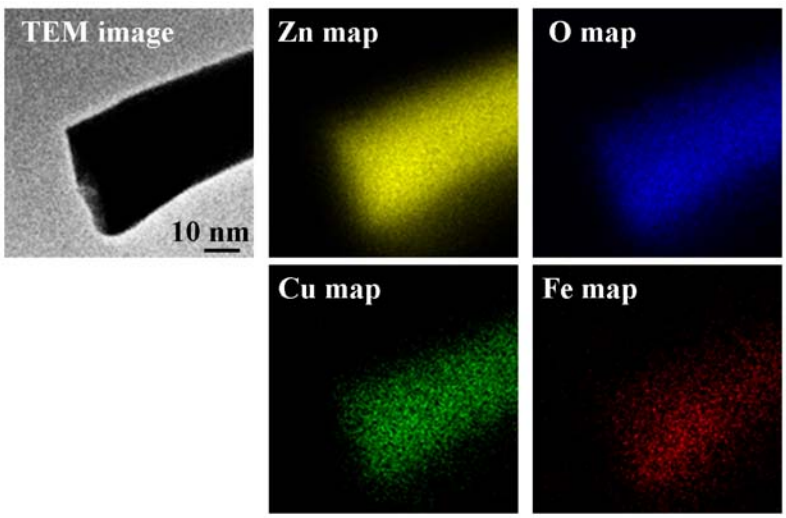

Fig. 2. The EDX elemental map of Zn, O, Cu, and Fe for the Fe-doped $Zn_{1-X}Cu_XO$ nanowires with the dose of 5×10^{16} ions/cm^2.

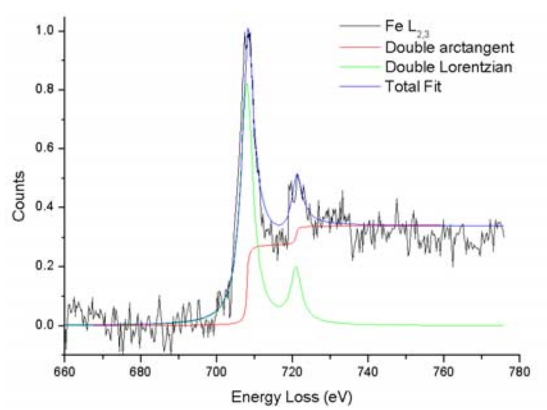

Fig. 3. Electron energy loss spectrum analysis of the characteristic iron L_2 and L_3 absorption edge based on the double arctangent background subtraction function.

https://doi.org/10.1017/S1431927605510791 Published online by Cambridge University Press