# ZnO/magnetic-metals hybrid core/shell nanowires grown by electrochemical deposition method

Japan Advanced Institute of Science and Technology, Huyen T. Pham and Masashi Akabori*

*E-mail: akabori@jaist.ac.jp

ZnO nanostructures in general and ZnO nanowires (NWs) in particular are well-known as promising functional materials for various applications such as solar cells [1], laser [2], and spin field-effect transistors [3]. To further improve the property of ZnO NWs, many combination and modification techniques have been developed, especially hybrid structures. In this study, we reported a simple and effective method for fabricating high-quality ZnO/magnetic metals (Co and Ni) hybrid core/shell NWs grown by electrochemical deposition method. The hybrid core/shell NW concept in our research is an important structural modification technique to enhance the electric and magnetic properties of the semiconductor materials [4].

The ZnO NWs, firstly, were prepared by electrochemical deposition method using a mixture of 0.025 M zinc nitrate hexahydrate ($Zn(NO_3)_2 \cdot 6H_2O$) and 0.025 M hexamethylenetetramine ($C_6H_{12}N_4$) solution. The growth temperature, time and applied potential were 90 °C, 2 hours and -0.8 V, respectively. After that, the coating step for such ZnO NWs was conducted to obtain the final ZnO/magnetic-metals (Co or Ni) hybrid core/shell NWs by dipping as-synthesized ZnO NWs into 0.025 M cobalt (II) acetate ($(CH_3COO)_2Co$) or 0.025 M nickel (II) acetate tetrahydrate ($(CH_3COO)_2Ni.4H_2O$) solutions at 70 °C under the applied voltage of -1 V. The electrochemical coating time was varied for 5, 10, 15 and 20 minutes, respectively, to control the thickness of the magnetic metal coating layer.

Figure 1 shows scanning electron microscope (SEM) images of ZnO NWs, ZnO/Co, and ZnO/Ni hybrid core/shell NWs on p-type Si (111) substrates. The Raman scattering spectra at room temperature indicated high crystalline quality of the ZnO nanowires and the presence of Co and Ni coating layers. The magnetic hysteresis curves were also obtained by superconducting quantum interference device magnetometer.

[1] M-L Zhang *et al.*, RSC Adv. 4 (2014) 10462. [2] J. M. Szarko *et al.*, Chem. Phys. Lett. 404 (2005) 171. [3] X. Hu *et al.*, J. Mater. Chem. C 4 (2016) 150. [4] H. Li *et al.*, Nanoscale 3(2011)654.

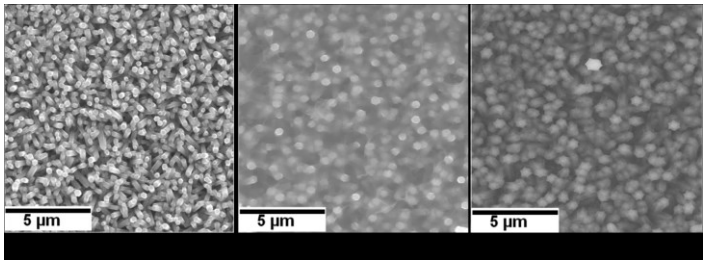


Fig. 1. SEM images of (a) ZnO NWs, (b) ZnO/Co and (c) ZnO/Ni hybrid core/shell NWs.