Biotemplated Co-Pt nanowire synthesis in TMV

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The semiconductor field using photochemical processes has been fast approaching its theoretical limit. Therefore, some breakthrough has been needed to make smaller devices. Recently, bottom-up processing such as building up atoms or molecules into functional structures has been studying actively. We are proposing "Bio Nano Process" of the bottom up technique to make inorganic nano-structure which uses protein's abilities, self-assembly, mineralization, and atomically same sizes. We have succeeded in fabricating the floating gate memory using cage shaped protein, ferritin[1]. We further has been trying to make nanowires to construct more functional nano-structures in future. We employed the inside cavity of Tobacco Mosaic Virus (TMV) to make nano-wires.

TMV is a tube-shaped protein, 300 nm in length with an outer diameter of 18 nm. It is composed of 2130 identical coat protein molecules, which are self-assembled in helical manner together with the TMV RNA and it has hollow central channel with a 4 nm diameter. Until now, monometallic nanowire have been synthesized inside TMV[2], no bimetallic alloy nanowire have been reported yet. We devised a simple and novel technique to synthesize bimetallic Co-Pt and Fe-Pt alloy nanowires in the central channel of the TMV.

The Sample was prepared an aqueous solution of 0.3 mg/ml TMV in 150 mM NaCl in a microtube. $(NH_4)_2Co(SO_4)_2$ and K_2PtCl_4 were added twice, first to a final concentration of 0.5 mM and 5 minutes later, to 1.0 mM. After 5 minutes, $NaBH_4$ was added twice at 5 minute intervals to a final concentration of 1.0 mM. This procedure was repeated three times, i.e., the final concentration of $(NH_4)_2Co(SO_4)_2$, K_2PtCl_4 and $NaBH_4$ was 3 mM each. Throughout the procedure, the reaction solution was exposed to ultrasonication with the bottom half of the microtube immersed in an ice-water bath. The sample was sonicated for 1 second at intervals of 5 seconds by direct immersion of the tapered microtip into the microtube. (20 kHz, ~20 W, Digital Sonifier Model 450, BRANSON, USA) To make Fe-Pt nanowires, $(NH_4)_2Fe(SO_4)_2$ was used instead of $(NH_4)_2Co(SO_4)_2$. The sample solution was observed by TEM after staining with aurothioglucose (Figure 1), we confirmed the formation of a wire in about 30 % TMV. Furthermore, we investigated existence ratio of Pt and Co by EDS which indicated that the obtained nanowires were CoPt(111) or $CoPt_3$(111). The high resolution TEM (HR-TEM)

image showed clear lattice fringe of nanowire, its distance were from 0.21 to 0.22 nm, which is consistent with CoPt(111),$CoPt_3$(111).(Figure 2) We measured magnetometry using a superconducting quantum interference device (SQUID), the M-H curve showed a hysteresis loop.(Figure 3) It indicates that the fabricated nanowire is ferromagnetic.

References:

[1] A. Miura, T. Hikono, T. Matsumura, H. Yano, T. Hatayama, Y. Uraoka, T. Fuyuki, S. Yoshii, I. Yamashita, *Jpn. J. Appl .Phys*. **2006**, 45**,** (1), L1-L3.

[2] Knez, M.; Bittner, A. M.; Boes, F.; Wege, C.; Jeske, H.; Mai, E.; Kern, K. *Nano Lett.* **2003**, 3, 1079.

Figures:

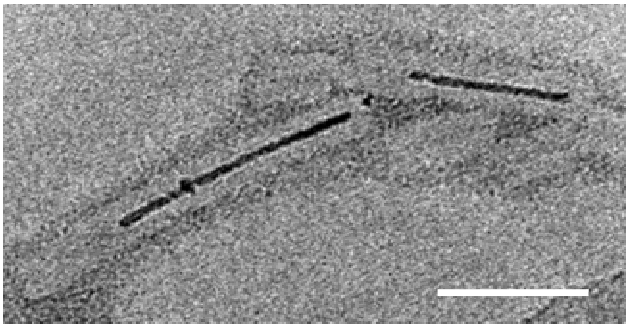

Figure 1: TEM micrograph of TMV-nanowire composites after biomineralization of Co-Pt alloy in the hollow central channel of TMV (stained by aurothioglucose). Scale bar is 50 nm.

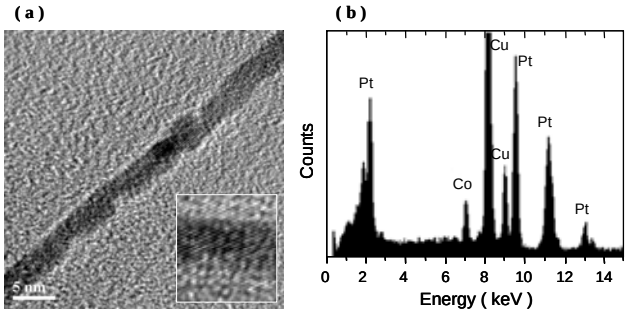

Figure 2: (a) HR-TEM micrograph of CoPt nanowire produced in the TMV central channel(no staining).Scale bar is 5 nm. The inset shows a lattice image of the nanowire.
(b) EDX spectrum of the nanowire showing the presence of Co and Pt.

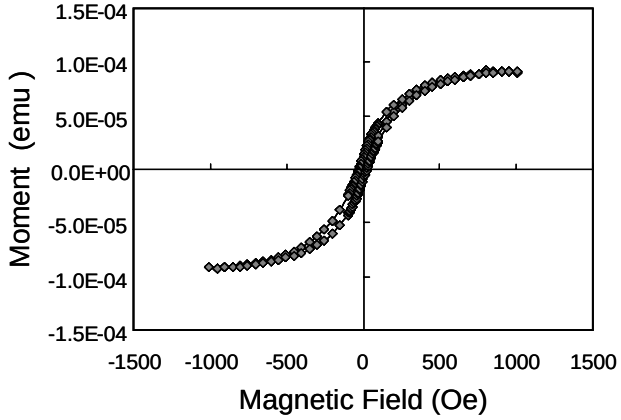

Figure 3: Magnetometry measurement of the nanowires produced in TMV central channel.