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. (NH₄)₂Co(SO₄)₂ and K₂PtCl₄ were added twice, first to a final concentration of 0.5 mM and 5 minutes later, to 1.0 mM. After 5 minutes, NaBH₄ 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 (NH₄)₂Co(SO₄)₂, K₂PtCl₄ and NaBH₄ 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, (NH₄)₂Fe(SO₄)₂ was used instead of (NH₄)₂Co(SO₄)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 CoPt₃(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),CoPt3(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:


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.