Fabrication of Co/Cu Multilayered Nanowires Using a Pulsed Current Deposition Technique

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Abstract

Co/Cu multilayered nanowires were electrochemically fabricated using a pulsed current deposition technique into a nanochannel template. Time-dependence of deposition current was monitored to determine the growth rate of Co and Cu nanowires. Co layer and Cu layer thicknesses were adjusted to several tens nanometers, by controlling the deposition times. With decreasing the each layer thickness, the coercive force of Co/Cu multilayered nanowires was decreased and the soft magnetic property was improved.

Keywords: *pulsed current, electrodeposition, nanowire, nanochannel, Co/Cu*

Introduction

One dimensional metallic nanowire with large aspect ratio has much attention due to their shape anisotropy and extremely large surface area. This unique structure can be applied to develop the novel functional nano-materials such as electronic, magnetic and optical nano-scale devices. Metallic nanowires can be fabricated by manipulating metallic atoms one by one using a scanning tunneling microscope (STM) probe, while they can be also prepared by electrochemically depositing metallic atoms into a nanoporous template with numerous cylindrical nanopores [1-4]. In this study, Co/Cu multilayered nanowires were electrodeposited into ion-track etched polycarbonate membrane filters with numerical cylindrical nanochannels using a pulsed current deposition technique.

Experimental

Ion track-etched polycarbonate membrane filters with pore-diameter of 40 nm, pore-length of 6000 nm and pore-density of 10^8 pore•cm^{-2} were used as a template for growing metallic nanowires. On a surface of the membrane filter, a gold layer was sputter-deposited to cover the pores and make a cathode. Aqueous solution containing $CoSO_4$, $CuSO_4$ and H_3BO_3 was used as electrolyte. Co/Cu multilayered nanowires were electrodeposited by alternatingly changing the cathode potential from -0.6 V to -1.0 V.

After the growing nanowires, polycarbonate membrane filters were dissolved in organic solvent and the remains consisted of nanowires and a gold layer was served as a sample for SEM and TEM observation. Magnetic hysteresis loops of electrodeposited nanowires were obtained using VSM with increasing the magnetic field up to 10 kOe.

Results and Discussions

For growing Cu and Co nanowires, cathode potentials were fixed to the range from -0.1 V to -1.1 V. To determine the growth rate of nanowires, the filling time of nanochannel with 6000 nm in length was estimated by monitoring the time-dependence of deposition current at each cathode potential. When the nanochannels are filled and the nanowires reach the membrane surface, the current will increase drastically due to the formation of hemispherical caps. The growth rates were estimated by dividing channel length by channel-filling time. Figure 1 shows the effect of cathode potential on the growth rate of Cu and Co nanowires. At –0.6 V, the filling time is around 300 s and the deposition rate is estimated to be about 20 nm s^{-1}, while the filling time is close to 30 s at –1.0 V and the deposition rate is estimated to be around 200 nm s^{-1}. On the basis of the results shown in Fig.1, Co/Cu multilayered nanowires were electrodeposited by alternatingly changing the cathode potential from -0.6 V (for Cu layer) to -1.0 V (for Co-rich layer).

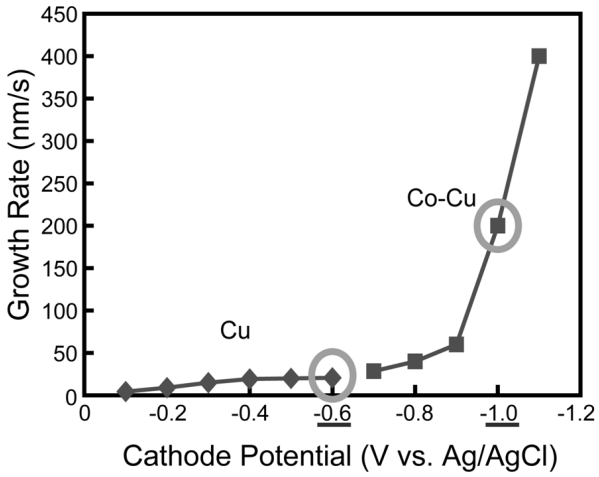

Fig.1 Effect of cathode potential on the growth rate of Cu and Co nanowires electrodeposited into polycarbonate templates with channel-diameter of 40 nm.

Conclusions

Optimum deposition potentials of Cu and Co are determined to be about –0.6 and –1.0 V. Typical deposition rates of Cu and Co were roughly 20 nm s^{-1} (at –0.6 V) and 200 nm s^{-1} (at –1.0 V). Co/Cu multilayered nanowires were electrodeposited by alternatingly changing the cathode potential from -0.3 V to -1.0 V. The composition of Co-rich alloy electrodeposited at –1.0V was around Co-20at.%Cu.

References

1. T. M. Whitney, J. S. Jiang, P. C. Searson, and C. L. Chien, *Science* **261**, 1316-1319 (1993).
2. K. Nielsch, F. Müller, A. P. Li, and U. Gösele, *Adv. Mater*. **12**, 582-586 (2000).
3. T. Ohgai, X. Hoffer, L. Gravier, J. E. Wegrowe, J.-Ph. Ansermet, *Nanotechnology* **14**, 978-982 (2003).
4. T. Ohgai, X. Hoffer, A. Fabian, L. Gravier, J.-Ph. Ansermet, *J. Mater. Chem*. **13**, 2530-2534 (2003).