Electrochemical Processing of Ni Nanowire Arrays in a High Magnetic Field

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Introduction

The nanoscaled magnetic wire array has been of great interest as patterned magnetic recording media, sensor devices, and energy conversion devices. Current nanofabrication techniques for nanostructured devices structures include electron-beam, interferometric lithography and microprobe-assisted manipulation [1]. These methods are relatively time consuming and expensive. Another method is electro-deposition of metal into templates. Electrodeposition has the attractive features of cost-effectiveness, simplicity in operation, and the ability of deposition onto substrates with complex geometries. In this study, Ni nanowire arrays have been electrodeposited into polycarbonate(PC) membrane filter with nanosized pores at different potentials in a high magnetic field.

Experimental

One side of a PC filter surface with 200, 100, 15 nm sized pored was sputtered with Pt alloy. The thickness of sputtered layer was roughly 100 nm. It works as a cathode substrate, when a pore is filled with organic-free Watt's bath containing 280 g/l $NiSO_4 \cdot 7H_2O$, 45 g/l $NiSO_4 \cdot 6H_2O$ and 38 g/l H_3BO_3; pH 3.4 at room temperature. Electrodeposition were performed potentiostatically at potentials –0.9 ~ –1.2 V with respect to Ni / Ni^{2+} reference electrode. It was faced to the cathode surface with 3 mm distance. The electrolysis was carried out in the presence or absence of externally applied magnetic field 0.5 and 5 T. The magnetic field used was generated by the permanent magnet of Fe-Nd-B and the cryocooled superconducting magnet at the High Field Laboratory for Superconducting Materials, Institute for Materials Research, Tohoku University, Japan. The direction of the applied magnetic field is perpendicular and parallel to the electric field. In the present, the conventional electrolytic configuration was employed with vertically installed electrode.

Results and Discussions

Figure 1 shows the transient variations of cathodic current at various potentials. The transient behavior of current was classified into four stages of I to IV as seen in the electrodeposition of Cu nanowires [2]. The sudden increase of the current in Stage III indicates the first emergence of nanowires from the surface of the membrane into the bulk electrolyte. At lower overpotentials, the transient current behavior obviously shows the difference between with a magnetic field and without a magnetic field. From calculated amount of electricity from t = 0 to the time when the sudden increase of current is recorded in Stage III, the larger amount of electricity is consumed in the magnetic field. The difference may be caused by the enhanced H^+ mass transfer by MHD flow. Figure 2 and Figure 3 show SEM images of Ni nanowires with a diameter of 100 nm deposited in condition of (d) and (f) in Figure 1 respectively. No difference in their morphologies has not been clearly observed.

Reference

[1] M. Zheng, et al., *J. Phys.: Condens. Matter* **12** (2000) L497
[2] Y. Konishi et al. 201th Meeting of The Electrochemical Society, Philadelphia, PA, USA, May 12-17,2002.

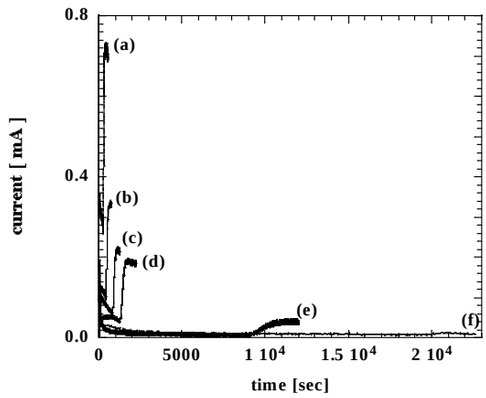

Figure 1. Transient Behavior of Cathodic Current Accompanied Electrodeposition of Ni Nanowires with a Diameter of 100 nm at (a) –1.0 V, (b) –0.9 V, (c) –0.8 V, (d) –0.7 V without a Magnetic Field, (e) –0.7 V with Lorentz Force Working Upward, (f) –0.7 V with Lorentz Force Working Downward under B = 0.5 T.

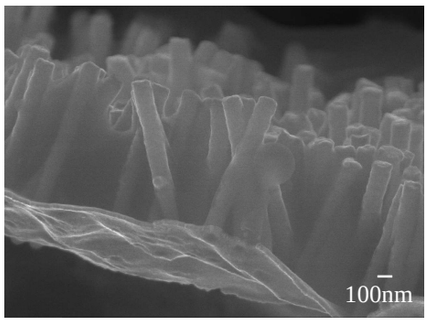

Figure 2. SEM Image of Ni Nanowires Deposited at –0.7 V without a Magnetic Field.

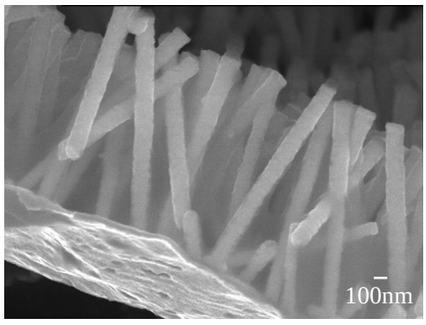

Figure 3. SEM Image of Ni Nanowires Deposited at –0.7 V under B = 0.5 T.