Asian Journal of Chemistry; Vol. 28, No. 11 (2016), 2529-2531
ASIAN JOURNAL OF CHEMISTRY
http://dx.doi.org/10.14233/ajchem.2016.20078

Fabrication and Characterization of Ni–Mo Nanowires by Electrodeposition

RANA AFIF ANAEE[1,*], ALAA H. ALI[1] and AHMED RAJIH HASSAN[2]

[1]Department of Materials Engineering, University of Technology, Baghdad, Iraq
[2]Engineering Collage, Al-Muthanna University, Samawah, Al Muthanna Province, Iraq

*Corresponding author: E-mail: dr.rana_afif@yahoo.com

Received: 16 May 2016; *Accepted*: 5 July 2016; *Published online*: 10 August 2016; AJC-18033

Ni–Mo nanowires have been fabricated by electrochemical deposition. Anodic aluminum oxide (AAO) was used as template to deposit nanowires. SEM and TEM were used to characterized the pores in prepared anodic aluminum oxide with 70 nm diameter of pores which calculated by J program. Nickel sulfate and sodium molybdate in boric acid were used as electrolyte to deposit 83.8Ni–16.2Mo nanowires. The nanowires were characterized by SEM and TEM after partially and completely dissolving of template to obtain nanowires with 70-72 nm in diameter and 420-500 nm in length. TEM of single Ni–Mo nanowire gave probability to form tetragonal structure of Ni_4Mo phase.

Keywords: Nanowire, Ni–Mo, Electrochemical method, Anodic aluminum oxide template.

INTRODUCTION

Metallic nanowires can be prepared by electrochemically depositing metallic atoms into a nanoporous template with numerous cylindrical nanopores. In electrodeposition of nanowires, nanoporous templates such as anodized aluminum oxide films with high density of nanopores have been used so far.

Many authors interested in fabricating nanowires as pure metal, alloy or composite by electrodeposition in anodic aluminum oxide template. Michael *et al*. [1] fabricated molybdenum nanowires by electrodeposition, Yoon and Suh [2] fabricated CdS/Co nanowire. Cheng and Cheng [3] fabricated Ag nanowires, Bisrat *et al*. [4] fabricated single-crystal Bi nanowires, Edward [5] studied template-directed synthesis of Au–TiO_2–Au nanowires. Kazeminezhad and Nabiyouni [6] fabricated Ni-rich/Cu multilayered nanowires, Shamaila *et al*. [7] fabricated CoCrPt nanowires and nanotubes.

Virk [8] studied the syntheses of Cu-Se hetero-junctions, Saidin *et al*. [9] fabricated Au/Ni multilayered nanowires by electrochemical deposition. Gheorghies *et al*. [10] fabricated Ni-Co and Ni-Co/BaFe nanowires in anodic aluminum oxide template. The present work aims to fabricate Ni–Mo nanowires using anodic aluminum oxide template and characterize them by SEM and TEM.

EXPERIMENTAL

Preparation of anodic aluminum oxide template: Aluminum sheet with thickness (0.5 mm) was cut to circle shapes with (20 mm) diameter to prepare anodic aluminum oxide template for depositing the nanowires. Cleaning with acetone has been done for Al specimens and to get more active Al surface. The Al specimens were treated with 3 M NaOH and then electrochemically polished also done.

Oxalic acid (0.3 M) was prepared in distilled water used as electrolyte for anodization. The anodization was achieved in two steps, in the first; the Al specimen was connected to the positive terminal of power supply to act as anode and stainless steel 316 L as rod was used as cathode in electrochemical cell with applying 30 V. The period time of first anodization was 8 h at room temperature and then the specimen was treated with (H_3PO_4 + $H_2Cr_2O_4$) mixture to open the pores for 1 h at 60 °C.

The second anodization was achieved in the same electrolyte for 6 h and then the specimens were wished with deionized water and finally with ethanol. The immersion in acetone at 60 °C for 1 h was performed to remove the remained alumina.

Deposition of Ni–Mo nanowire: Nickel sulfate 0.35 M, sodium molybdate 0.01 M and boric acid 30 g/L were used as electrolyte to deposit the Ni–Mo nanowires. The anodic aluminum oxide template was acted cathode in electrochemical

cell with Ni rod (purity 99.99 %) acts as anode. The voltage of deposition was 1.8 V for 40 min.

Characterization of nanowires: Scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS) and transition electron microscopy (TEM) were used for characterization of fabricated nanowires. These inspections were achieved for partial and complete removal of template. The partial dissolving of anodic aluminum oxide was performed by 10 % HCl and ethanol, while complete dissolving was by 6 M KOH solution.

RESULTS AND DISCUSSION

Fig. 1 shows the SEM and TEM images of prepared anodic aluminum oxide with ≈ 70 nm as diameter and this diameter was measured using J. Image program. By two-step anodization process, the hexagonally ordered porous alumina template has been obtained. The aluminum substrate was pre-structured by anodizing in a solution of 0.3 M $H_2C_2O_4$ at room temperature. Fig. 1 indicates a highly ordered aluminum oxide pore structure.

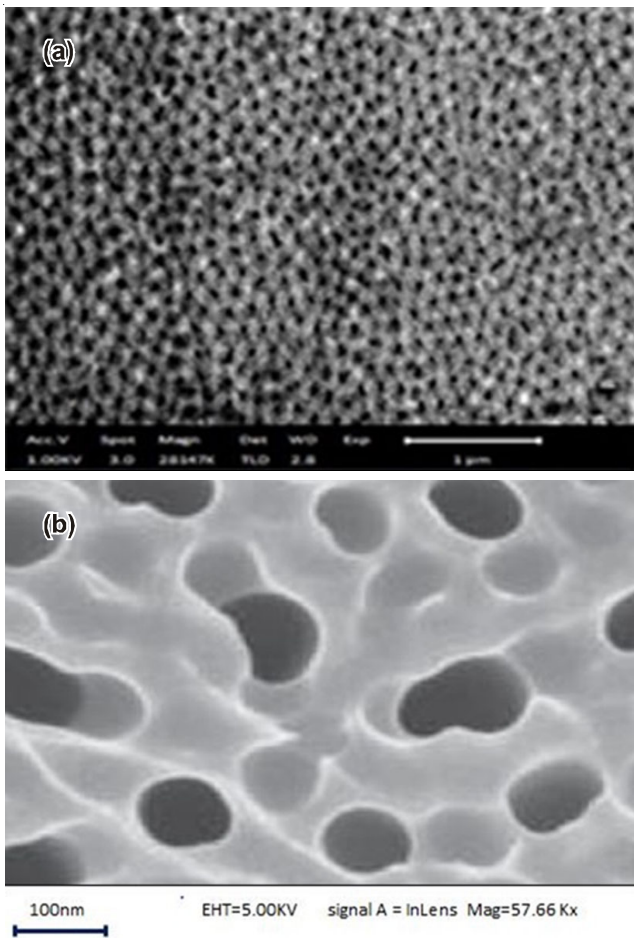

Fig. 1. SEM (a) and TEM (b) of anodic aluminum oxide template

Fig. 2 shows the SEM images, these images indicate the nanowires were deposit in anodic aluminum oxide pores. In plane view of partial removal for anodic aluminum oxide, can be seen the arrays of nanowires and can't distinguish the phases between Ni and Mo. Also these images demonstrate the growth of multilayer. The black and white bands seen are not from the individual layers, but are due to the strain contrast between the layers. The average diameter of the wires was measured to be (70-72 nm), which was considered in the J. program. In Fig. 2b showed the nanowires after dissolving the anodic aluminum oxide template. Generally, the fabricated wires are ordered with fixed length ranged between 420 and 500 nm, this phenomena confirms the homogenous growth of nanowires under experimental conditions. The EDS analysis of Ni–Mo nanowires is shown in Fig. 3, which indicates obtaining 83.8 wt % Ni and 16.2 wt % Mo.

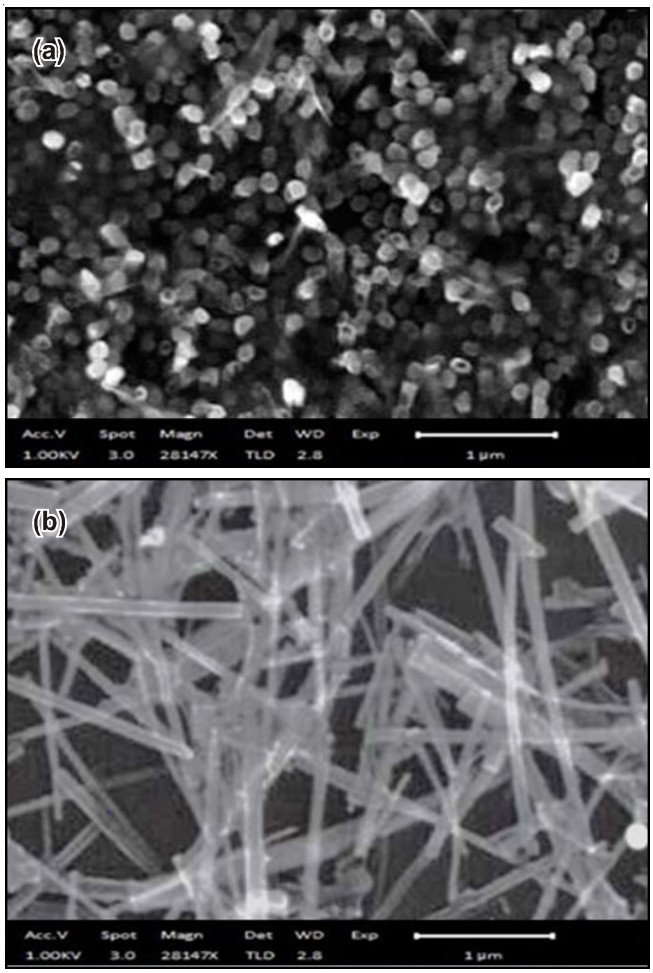

Fig. 2. SEM images for Ni–Mo nanowires; (a) Plane view and (b) Complete dissolving of template

Fig. 4 shows TEM images of Ni–Mo nanowires obtained by partial dissolving (a) and complete dissolving of template (b). These images show the uniformly wires arrays with the same dimensions without distinguish the phases in nanowires. The image of single Ni–Mo nanowire can be seen in Fig. 5. This figure shows some white regions in Ni matrix (black colour). These regions (white colour) may be due to symmetric tetragonal structure of Ni_4Mo phase.

Conclusion

Ni–Mo nanowires have been fabricated by electrodeposition using anodic aluminum oxide template. The obtained nanowires were characterized by SEM, EDS and TEM with 70-72 nm diameter and 420-500 nm length. The EDS analysis showed the obtaining 83.8Ni–16.2Mo nanowires with uniformly arrays of wires.

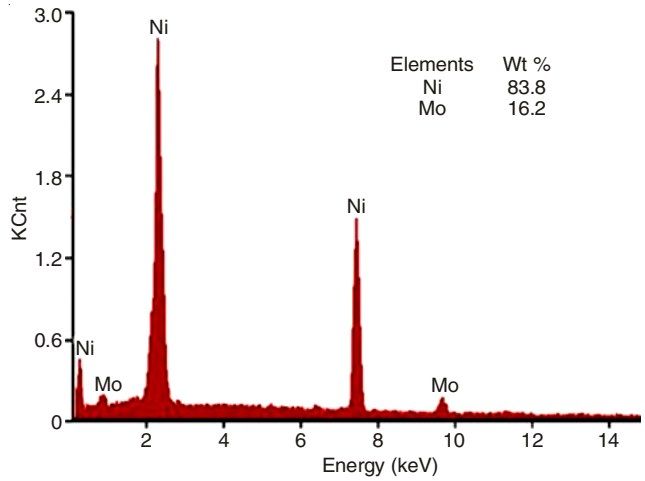

Fig. 3. EDS of fabricated Ni–Mo nanowires

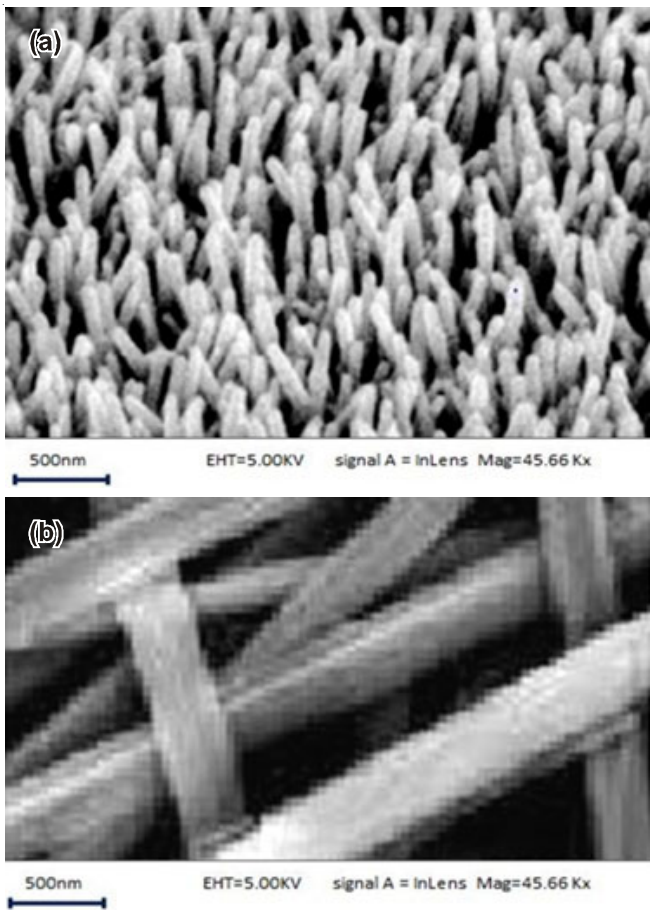

Fig. 4. TEM images for Ni–Mo nanowires; (a) Partial dissolving and (b) Complete dissolving of template

Fig. 5. Single Ni–Mo nanowire

REFERENCES

1. M.P. Zach, K.H. Ng and R.M. Penner, *Science*, **290**, 2120 (2000).
2. C. Yoon and J.S. Suh, *Bull. Korean Chem. Soc.*, **23**, 1519 (2002).
3. Y.-H. Cheng and S.-Y. Cheng, *Nanotechnology*, **15**, 171 (2004).
4. Y. Bisrat, Z.P. Luo, D. Davis and D. Lagoudas, *Nanotechnology*, **18**, 395601 (2007).
5. E.D. Herderick, J.S. Tresback, A.L. Vasiliev and N.P. Padture, *Nanotechnology*, **18**, 155204 (2007).
6. I. Kazeminezhad and G. Nabiyouni, *Afr. Phys. Rev.*, **2**, 145 (2008).
7. S. Shamaila, D.P. Liu, R. Sharif, J.Y. Chen, H.R. Liu and X.F. Han, *Appl. Phys. Lett.*, **94**, 203101 (2009).
8. H.S. Virk, *Digest J. Nanomater. Biostruct.*, **5**, 593 (2010).
9. N.U. Saidin, K.Y. Kok, I.K. Ng and S.H. Ilias, *J. Phys. Conf. Ser.*, **431**, 012006 (2013).
10. C. Gheorghies, D.E. Rusu, A.M. Cantaragiu, L. Gherghies and M. Buciumeanu, *Romanian Reports in Physics*, **67**, 933 (2015).