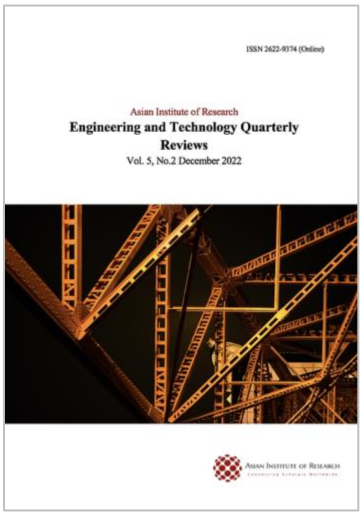

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Fabrication of Multilayer Nanowires (Ag/Co/Zn) by Electro-Chemical Deposition in the Anodic Aluminum Oxide Template

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Abstract
In this article, multilayer nanowires (Ag/Co/Zn) were produced by electrochemical deposition in the form of anodic aluminum oxide. The electrochemical deposition method to produce nanowires are performed by three different methods. We have examined the pulsed periodic method, and we have managed to fabricate the nanowires of Ag/Co/Zn. Then, the produce nanowires are confirmed by the SEM and XRD analyses. Anodic nanoporous alumina with a thickness of 205 nm and a distance between pores of about 250 nm is produced by combining hard and soft anodization. Two-step anodization method including soft anodization and hard anodization was performed. These two anodizations were performed using 0.3 M oxalic acid as electrolyte at 0 degrees Celsius and applying voltages of 40 and 130 volts, respectively. Then the potential was reduced from 130V to 12V to thin the barrier layer. Multilayer nanowire arrays had been electrodeposited into the pores of anodic aluminum oxide (AAO) template. The electrochemical impedance spectroscopy has been carried out to study the in situ growth process of multilayer nanowires at different electrodeposition times.

Keywords: Multilayer, Anodize and Nanowires

1. Introduction

The synthesis and study of nanoscale materials have attracted much attention in recent years. One-dimensional nanostructures, including nanowires, nanorods, and nanotubes, have many amazing properties such as high density, high aspect ratio, and low threshold voltage in field emission (Baibich, et al., 1988). To obtain multi-layered nanowires, it was necessary to place metal pieces in AAO channels in order (Peng, Wu, & Hwang, 2013).One of the possibly least complicated wires fabrication method is electrodeposition (Torabinejad, Aliofkhazraei, Assareh, Allahyarzadeh, & Rouhaghdam, 2017). Thermal decomposition of elements in the porous membranes (e.g. anodic aluminum oxide (AAO)) is also very powerful (Gong, Riemer, Kautzky, & Tabakovic, 2016); (Winkler, et al., 2008); (Szozstko, Orzechowska, & Wykowska, 2013); (Garcia, et al., 2014). Wires can also be obtained by deposition of elements in particular conditions on flat surfaces which were pre-structured by lithography, self-lithography, pre-deposition, oxidation, etc. This, however, often employs very sophisticated experimental setups Generally, a hard template containing nanometer-sized cylindrical pores is used as a membrane to synthesize multilayer nanowires, and the pores are filled with nanowire fragments of different elements (Schwarzacher & Lashmore, 1996) Anodic alumina films are known to have perpendicular holes normal to the film surface with a nanochannel density in the range 10^{11}–10^{13} cm−2 (Chaure, Stamenov, Rhen, & Coey, 2005).The electrodeposition is a simple and cheap method for the production of multi-layer nanowires by which we can control the aspect ratio of the nanowires (Mohanty, 2011). However, it is important to consider whether the deposition conditions can affect the quality and length of the obtained nanowires. One of the exciting achievements of the development of electrochemical deposition method is the production of multi-layer nanowires in the molds that are proposed by Piraux and Blondel almost simultaneously (Blondel, Meier, Doudin, & Ansermet, 1994)

2. Experimental

High-purity (99.999%) aluminum foil was cut to the desired sizes. Each sample was degreased in acetone and ethanol for 5 min in ultrasound cleanser and then washed with deionized water. To have a sample with a smooth and polished surface, it was electropolished at a potential of 20 V and current of 60 mA for 6 min in the electrolyte solution of 1:4 (v/v) perchloric acid in 99% ethanol. In order to fabricate a high ordered anodic aluminum oxide (AAO), two steps anodization method consisting mild anodize (MA) and hard anodize (HA) was done. MA and HA were performed by utilizing oxalic acid 0.3 M as an electrolyte at zero degree of centigrade and by applying 40 V and 130 V, respectively. Then for thinning of the barrier layer, the potential was decreased from 130 V to 12 V. The next part of research, the procession well is dawn in three step, at first we used solution 2.5g $AgNO_3$ and 4g H_3BO_3 in 100ml distilled water for Ag electrodeposition, second for cobalt electrodeposition $CoSO_2$, 0.3M solution were used and for third step the solution is 10.5g $ZnSO_27H_2O$ and 3.6g H_3BO_3 in 90ml distilled water 0.4M. Anodization and electrodeposition conditions are shown in Table.1.

Table 1: Anodization and electrodeposition conditions for (Ag/Co/Zn)

No	**Type of material**	**Charge (C)**	**Reduction-Voltage (V)**	**Reduction-Time (ms)**	**Oxidation Voltage (V)**	**Oxidation-Time (ms)**	**Off-Time (ms)**
1	Silver	0.2	14	5	14	5	**10**
2	Cobalt	0.2	14	5	14	5	**10**
3	Zinc	0.11	14	5	14	5	**10**

XRD characterization of Ag/Co/Zn nanowires is presented in Fig.1

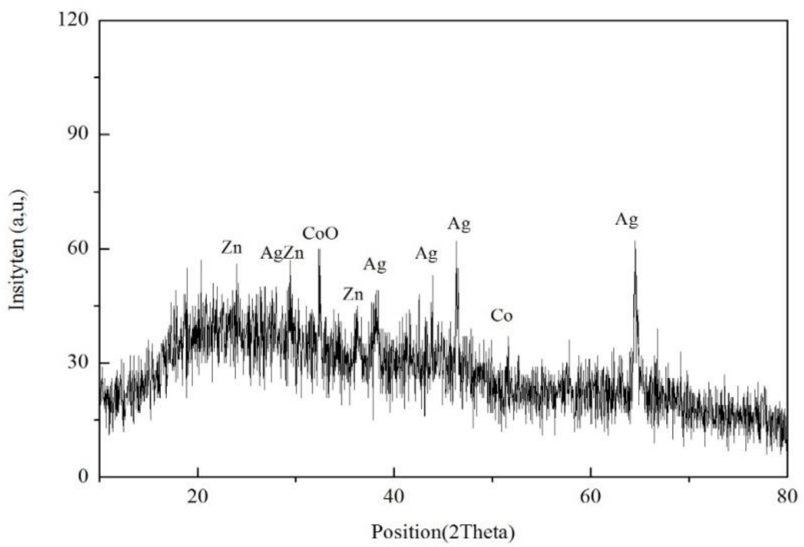

Figure 1: XRD of Ag/Co/Zn deposition on porous AAO template by applying alternative pulse electrodeposition.

Also, SEM image of the profile of fabricated Ag/Co/Zn nanowire is indicated in Fig. 2. It is possible to recognize from the profile of the structure that the nanowires are broken in the holes. It is clear that some parts of them are remained in the porous AAO.

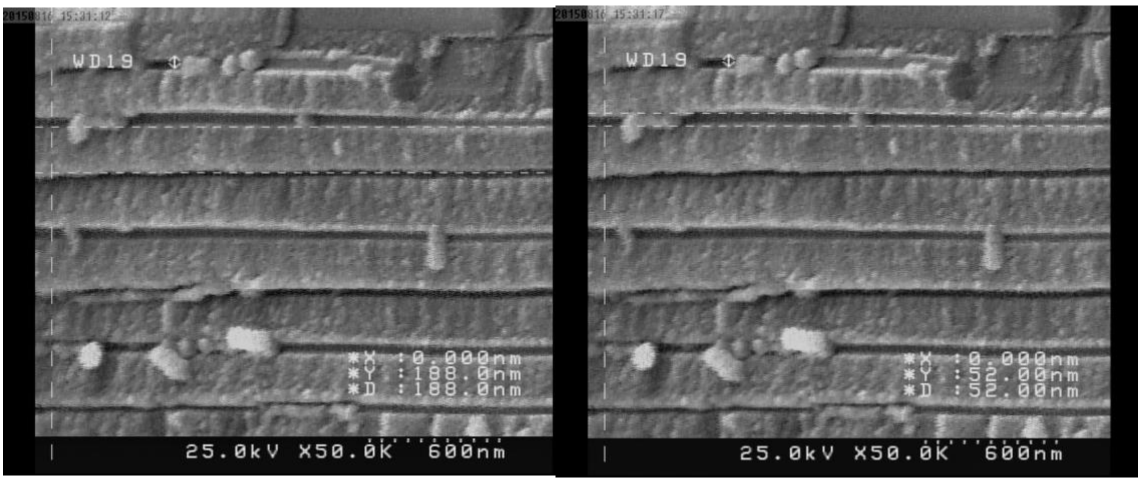

Figure 2: The profile of SEM image of Ag/Co/Zn.

3. Conclusions

In this research, using the anodization of aluminum with the High-purity (99.999%) aluminum foil by two steps anodize, mild anodonization and hard anodonization by 40 V and 130 V to produce alumina (Al_2O_3) nanopours templet then by thinning method, we produce roots in the barrier layer, the next step by electrodeposition method and Ag, Co and Zn salts, the multilayer nanowires fabricated in the nanopours.

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