SYNTHESIS OF Au NANOWIRES FOR BIOSENSING APPLICATIONS

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I. INTRODUCTION

Metal nanowires are the most attractive materials because of their unique properties, these nanowires are used for various applications such as perpendicular recording media, chemical and biological sensors etc [1-2]. The various nanoporous templates such as AAO [3], track etched polycarbonate membranes [4], self-assembled diblock co polymers [5] are used for growing different kinds of nanowire materials with different aspect ratios. The suspended Au nanowires are important due to its high ductility and wear resistance which is necessary for electrode contacts for miniaturized nanodevices [6].

Also, the aligned Au nanowires are used as sensing elements for biosensor application for targeted species detection, since they offer higher capture efficiency, faster response time due to their large adsorption surface, high electrical conductivity and smaller diffusion time [7].

In comparsion with the polycarbonate, AAO membrane pores are very uniform but the probability for the deposition is equal in both the cases. In the present study, three electrode potentiostatic electrodeposition method was employed to grow the Au nanowires in the commercially available polycarbonate and AAO membranes. Since, these two membranes are cost-effective, available at various thicknesses and different pore diameters, the arrays of desired Au nanowires were grown by filling a porous template that contains a large number of straight cylindrical holes with narrow size distribution at constant potential and deposition time [8]. The nanowires embedded in template cannot be integrated directly into conventional devices [9]. Hence, the templates must be dissolved after electrodeposition.

II. EXPERIMENTAL PROCEDURE

In the three electrode potentiostatic cell configuration the platinum thin sheet of 8-cm^2 was used as a counter electrode and Ag/AgCl was used as a reference electrode. The half cell potential, which determines the reduction of metallic ions from the electrolyte, was monitored with respect to a standard calomel reference electrode. The sputtered 200 nm gold layer on one side of the porous membranes serves as working electrode. Prior to the deposition the membrane is placed in the deposition cell containing DI water for several hours to wet the porous template and to make the pores hydrophilic. The room temperature electrolyte bath consists of 0.5 g/l of Gold (II) Cyanide, 3.1 g/l of potassium hydroxide, and 4.3 g/l of citric acid. During the deposition time the half cell potential, was kept at -1.0V, for the reduction of the metallic ions from the electrolyte, with respect to a standard calomel reference electrode. In order to understand the growth rate of Au nanowires during deposition, the current-time profiles were recorded and are shown in fig.2. The deposition processes were accomplished under mild stirring of the electrolyte while monitoring the current-time profiles to derive information related to the deposition rate. The electrodeposition was done for 30 min in order to achieve the full length of the wire. The deposited membranes were then fractured in liquid nitrogen to view the cross-sectional view of the membrane through the SEM.

III. RESULTS AND DISCUSSION

The polycarbonate membrane pores are randomly arranged in the long range and the spacing between the pores varies up to few tens of micrometers. The average length of the membrane thickness is approximately 6 μm and the pore diameter is about 50 nm in the polycarbonate membrane.

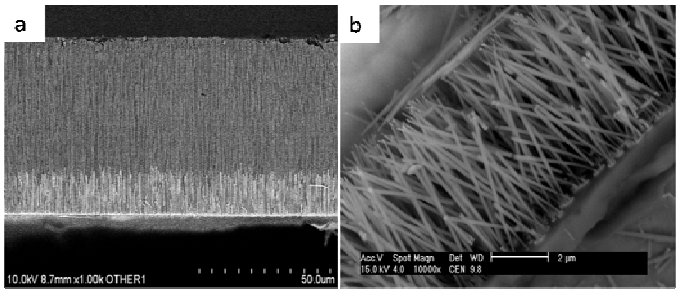

Fig.1 (a) SEM images of the Au nanowires showing partial deposition of Au nanowires in AAO membrane and (b) full length of the membrane in polycarbonate membrane for 30 min deposition time

On the other hand, AAO membrane with uniform distribution of pores with 20 nm diameter and thickness

of the membrane was 60 µm. There are several advantages of both these membranes. Figure 2 shows the current time profiles during the deposition time, metallic Au ions fills the pores from the bottom of the template, after an initial point, the current-time profile exhibits two distinct regions. The region 1 corresponds to the deposition of Au metal ions into the pores of polycarbonate membrane, the growth proceeds in the pores until they are filled up to the top of the membrane. In the region 2 the current will get saturated and thus by stopping the deposition at this certain point between region 1 and 2, an array of fully grown Au nanowires can be achieved.

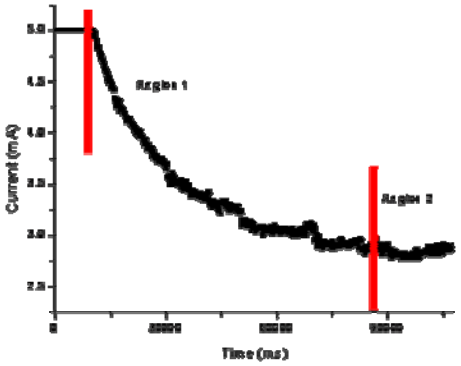

Fig.2 Current time profiles recorded during the nanowire

As explained, individual Au nanowires can be obtained by dissolving the membrane. The obtained nanowires are either stand still or lie down on the bottom surface. If the upper surface of the gold film is completely removed from the membrane, the obtained nanowires are usually lying down. However, if the top surface of the gold film is not completely removed a standing array of gold nanowires is observed. This control can be critical to obtain certain desired gold nanowires [10].

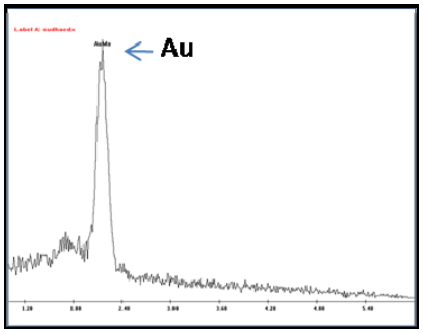

Fig.3 The elemental composition of Au nanowires were measured by EDAX

Figure 3 shows the compositional element of the Au measured by Energy dispersive X-ray analysis (EDAX). From the figure it is clearly evident that the intensity of the Au peak is higher and no other peaks existed.

IV. CONCLUSION

Au was deposited into the pores of the polycarbonate membrane with 50 nm pore diameter and length of 6 µm by keeping the applied potential and deposition time constant. Current-time profiles were taken into consideration to confirm the deposition parameters for Au. This study has provided the information of Au nanowire fabrication conditions. The electrochemical method for metal deposition procedure is a general and also versatile technique that can be extended for the deposition of various kinds of metals.

ACKNOWLEDGMENTS

This work was partially supported through fundamental R&D program for core technology of materials funded by the Ministry of Knowledge Economy, Republic of Korea and also by the grant from KOSEF under project number M10803001427-08M0300-42710.

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