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ELECTRODEPOSITION METHOD USED FOR THE SYNTHESIS OF IRON NANOWIRES VIA POROUS ANODIC ALUMINIUM OXIDE

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ABSTRACT

Nanowires of metals exhibit distinct electrical, magnetic, optical, thermoelectric, physical and chemical properties because of their unique morphology and high aspect ratio. Nanowires have drawn lot of research consideration for their diverse applications in electronic appliances like Junction diodes, Field Effect Transistors and logic gates. These can be fabricated by using semiconductor and superlattice nanowires. Nanowires also have a potential for sensors, bio-medical and environmental remedial applications. Present work includes highlights of the synthesis of nanowires via porous Anodic Aluminium Oxide (AAO) template using electrodeposition of pure metal/alloy inside the channels of AAO. This technique of forming nanowires using AAO is very simple, more cost-effective and requires a low temperature processing.

Keywords: *ELECTRODEPOSITION, IRON NANOWIRES, POROUS ANODIC ALUMINIUM OXIDE etc.*

1. INTRODUCTION

The swift growth in research and development involving materials of nanoscale size has propelled nanotechnology to the forefront of science and technology development. Nanotechnology has an extremely broad range of potential applications from nanoscale electronics and optics, to nanobiological systems and nanomedicine, to new materials, and therefore it requires formation of and contribution from multidisciplinary teams of physicists, chemists, materials scientists, engineers, molecular biologists, pharmacologists and others to work together on (i) synthesis and processing of nanomaterials and nanostructures, (ii) understanding the physical properties related to the nanometer scale, (iii) design and fabrication of nano-devices or devices with nanomaterials as building blocks, and (iv) design and construction of novel tools for characterization of nanostructures and nanomaterials. Synthesis and processing of nano wires is the another essential aspect of nanotechnology[1-5]. Studies on new physical properties and applications of nanomaterials and nanostructures are possible only when nanostructured materials are made available with desired size, morphology, crystal and microstructure and chemical composition. Metallic and metal oxide nanowires have also been widely studied due to their unique material properties which help in environmental remediation. Now a days numerous methods have been proposed for efficient removal of contaminants from water systems especially toxic metals which are believed to be a risk for human beings even at trace level [6-8]. Various methods for the removal of heavy metals from water include chemical precipitation, ion exchange, membrane filtration, adsorption technologies etc.

Among all these, adsorption offers flexibility in design and operation and moreover high quality treated effluent. Recent studies suggested that many metallic and metal oxide nanowires exhibits very favorable sorption to contaminants like heavy metals in terms of fast kinetics, high capacity and selectivity, which would result in deep removal of contaminants from ground water, specially nanowires of zinc oxide, magnesium oxide, titanium oxide, iron oxide, iron and its alloys etc. In view of the interest and immense importance that has been attached to different properties and applications of nanowires, the present study, therefore aims at the synthesis of metallic nanowires by using porous anodic aluminum oxide template by electrodeposition technique.

2. EXPERIMENTAL

2.1 Sample preparation

` Aluminum specimens were punched from 99.99% pure sheet, 0.4 mm thick, into square shape 1cm x 1cm. After cutting; samples were first degreased in ethanol for 200 s, then washed in deionized water and air-dried. These samples were then annealed at 673 K for 2 hrs in temperature controlled silicon carbide tube furnace and then cooled for 22 hrs. Annealing is necessary to improve the homogeneity of the aluminum substrate for well ordered pore growth, by increasing grain size, thus minimizing grain boundary area which is considered as a defect and eliminating residual stresses obtained as a result of rolling.

2.2 Pretreatment

Electropolishing tests were conducted in a typical rectangular container having the dimensions of 5 cm x 10 cm. During electropolishing the samples were used as the working electrodes with an exposed area 1 cm x 1 cm the electrical circuit consisted of 15V D.C. potentiostat/Galvanostat. The electropolishing solutions were composed of mixture of 5:1 ratio of phosphoric acid (H_3PO_4) and ethanol (C_2H_5OH). The temperature was maintained at 25^0C by thermo stated water circulation through the electrochemical cell and the electropolishing time was varied from 1 minute to 6minutes.

2.3 Anodisation

The electropolished Al sample then be anodized in an electrochemical bath using the sample as anode plate and Al as the cathode. During anodization, a thick porous alumina layer gradually grows over a very thin dense barrier oxide layer, which acts as an interface between the pure Al surface and porous alumina oxide layer. Anodization was carried out by using 0.3 M phosphoric acid at 150V having temperature range 30 ± 5^0c for 1 hr.

2.4 Fabrication of iron nanowires by pore filling through electro-deposition technique

Electrodeposition was performed at a.c. by using mixture of Ferrous Sulphate, Boric acid and Ascorbic acid. Characterization of Nanowires was done by Fe-SEM (ZEISS ULTRA PLUS). Confirmation of iron nanowires was done by EDS.

2.4 Result and discussion

To characterize the surface roughness of electropolished samples portable surface roughness tester was used.

S.NO.	Time (in minutes)	Roughness (in µm) in case of electro polishing
1)	3minutes	0.63
2)	4minutes 30 seconds	1.59
3)	6 minutes	1.67
4)	7minutes 30 seconds	1.44
5)	9 minutes	1.44

Table 1. Effect of time on surface roughness with electropolishing

As it is clear from above table 3 minutes are sufficient for obtaining smooth structure, which leads to ordered porous structure as shown in Figure 1.

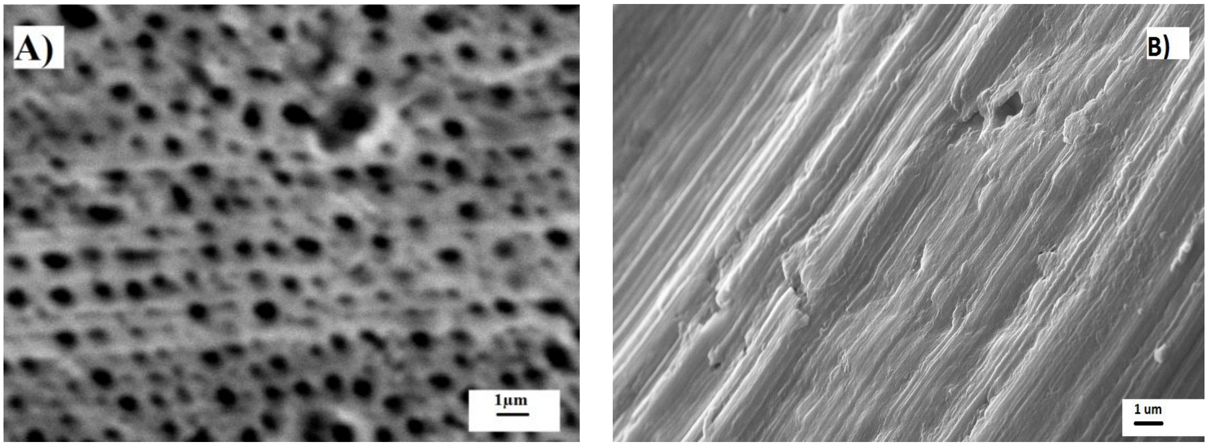

Figure 1. FE-SEM view of nanoporous anodized aluminium oxide in 1(a) and iron Nanowires shown in 1 (b)

Nanopores of about 158 nm diameter were obtained using anodisation with 0.3 M phosphoric acid solution at 150V at temperature 30 ± 5^{0}c for 1 hr as shown in fig. 1 (a).

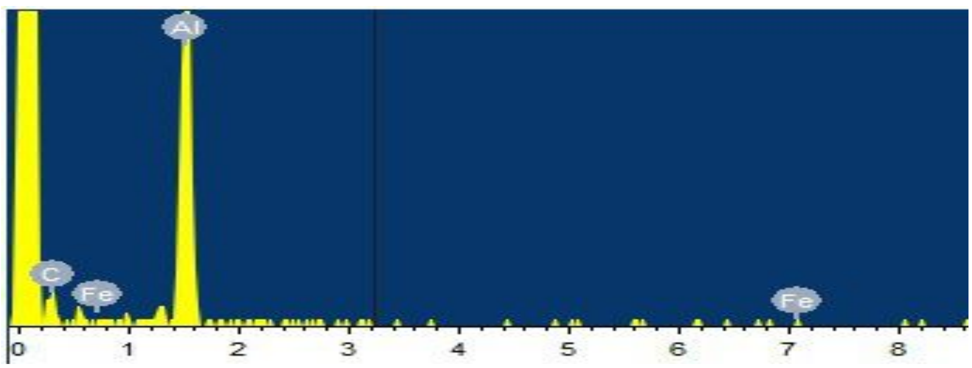

Figure 2. EDS confirmed the presence of iron wire by electrodeposition in nanopores of Anodised aluminum oxide

3. CONCLUSION

Among all the techniques used for fabrication of nanowires electrodeposition or electrochemical deposition is regarded as one of the most popular methods of pore filling with conducting metals to obtain continuous arrays of nanowires with large aspect ratios. Electrochemical deposition route is easy, low-cost as well as less skill dependent compared to other techniques mentioned above. Structural analysis shows that the electrodeposited nanowires tend to be densely packed, continuous and highly crystalline. Moreover, by simply monitoring the total amount of passing charge one can precisely control the aspect ratios of the metal nanowires.

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