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Template Based Synthesis of Low Dimensional Structures of Copper and Their Characterization

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Abstract—This paper describes the synthesis of low dimensional structures of copper by electrodeposition method using polycarbonate track etch membrane (PCTEM) as template. Copper microwires of different diameters were fabricated by using the membranes of pore diameters 0.2 & 0.4 um as template. The morphology of fabricated microwires was characterized by scanning electron microscope and material confirmation is carried out by X-Ray diffraction. I-V characterization was carried out for the confirmation of high conductive nature of copper microwires.

Keywords— Microwires, Template, Polycarbonate, Track Etch Membrane, Electrodeposition

I. INTRODUCTION

Recently, low dimensional structures have attracted considerable attention owing to their novel physical and chemical properties and the potential applications in new generation of nanodevices [1]-[3]. Nano/micro wires have to play vital role for nanoscience studies as well as for nanotechnology applications. Nano/micro wires, compared to other low dimensional systems, have two quantum confined directions, while still leaving one unconfined direction for electrical conduction. This allows nano/micro wires to be used in applications where electrical conduction, rather than tunnelling transport, is required. Copper is one of the most important metals in modern electronic technology. Copper nano/micro wires can be used in flexible displays, solar cells and lightning. Copper nanowires also have applications as interconnects for nanoelectronics, magnetic devices, chemical and biological sensors [4].

Many methods have been developed for the fabrication of copper nano/micro wires but template synthesis is considered to be the most suitable and useful for growth of low dimensional structures with in pores of host template [5]-[8]. Polycarbonate Track Etch Membranes (PCTEMs) provides an excellent alternative to be used as template because these are rouged, inert, durable and easy to handle. Their physical parameters of pores like - shape, diameter and porosity can precisely be determined by controlling the etching conditions during the manufacturing of PCTEMs [2], [3], [8]. In the present work PCTEMs are used as template to grow microwires by electrodeposition method and the synthesised wires were characterised for morphology, material confirmation and conductivity.

II. MATERIALS AND METHODS

A. Materials

Hydrophilic PCTEMs of high grade polycarbonate film (from Sartorius Stedium Biotech) were used as template to synthesize Cu microwires. PCTEMs having uniform cylindrical pore structures with precise narrow pore size distribution of different pore diameters 0.2 and 0.4 um were used. The thickness of the membranes was about 10 um and the porosity is 15%. The copper tape with conductive adhesive on one side was used as substrate for deposition. All the chemicals and reagents used were of AR grade, from Molychem, Mumbai, India. Double distilled water was used to prepare the solution of copper sulphate. Dichloromethane was used to dissolve the polycarbonate membrane after synthesis of Cu microwires and ethanol is used to wash the microwires

B. Experimental Details

Copper microwires were synthesized by template based technique using electrodeposition method [7], [9], [10] and PCTEMs were used as template. By electrodeposition method, copper ions were deposited within confined space of the pores in template placed on copper tape without air gap acting as working cathode and Copper rod dipped in the solution of $CuSO_4$ acted as reference anode. Utilizing the process of electrodeposition, free standing Cu microwires of 0.2 & 0.4 um diameter were synthesized on Cu substrate. The experimental set-up is shown in the figure 1. The concentration of $CuSO_4$ electrolyte solution used for synthesis of microwires was 1M. The electrodeposition has been carried out at very low potential of 0.2V at room temperature (30 ± 2^0C).

C. Characterization

To study the structural properties of synthesized microwires, XRD spectra of prepared sample was recorded on a RigaKuC/max-2500 diffractometer using graphite filtered CuKα radiation (λ = 1.54 Aº) at 30 kV and 15 mA with a scanning rate of $3^\circ min^{-1}$ from $2\theta = 30^\circ$ to 140°. Figure 2 shows the observed XRD patterns of the synthesized Copper microwires of different diameters 0.2 & 0.4 um.

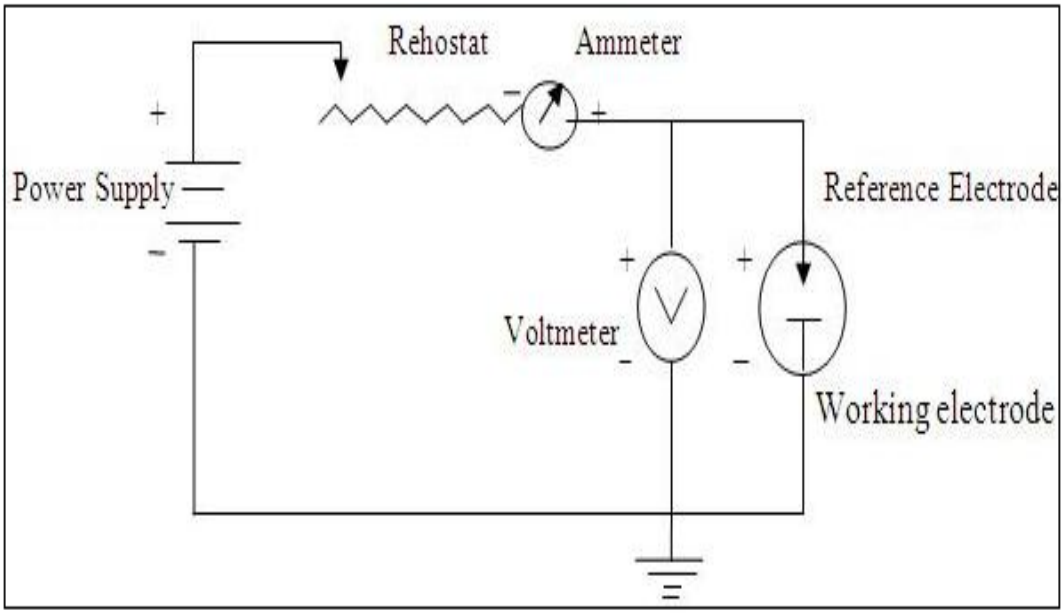

Fig. 1 **Experimental set-up**

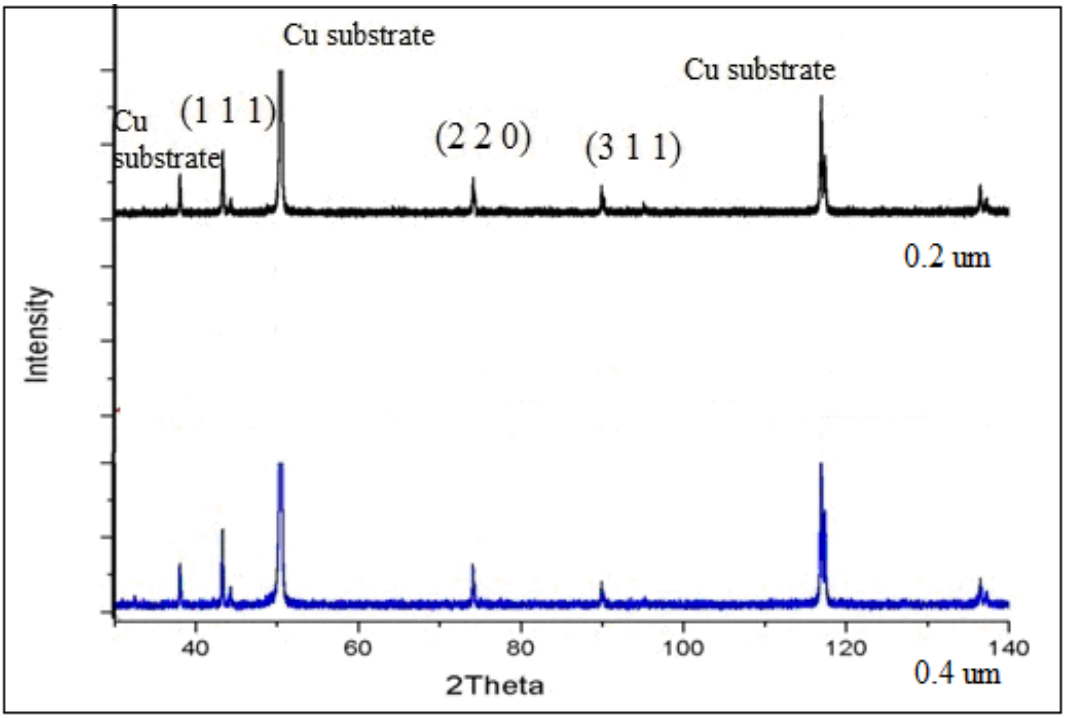

Fig. 2 **XRD patterns of Cu microwires with diameters 0.2 um & 0.4 um**

Morphological characterization of the synthesized copper microwires was carried out by scanning electron microscope JEOL, JSM 6100. The cleaned and dried samples were mounted on the specially designed aluminium stubs with the help of double side adhesive tape. The polycarbonate material of the sample was dissolved by dropping the dichloromethane in very small amount with very slow flow rate. After dissolving polycarbonate material, the sample was washed with the ethanol. Sample on stub is again dried and coated with a layer of gold using JEOL, fine sputter JFC- 1100 sputter coater. Images were recorded at different magnifications. Figure 3 & 4 shows the SEM images of Cu microwires synthesized using PCTEM templates of different pore size 0.2 & 0.4 um.

The current-voltage (I-V) characteristics of Copper microwires were measured to check the conductivity. The I-V curves were drawn using a 2-probe system via Keithley 2400 Series Source Measurement Unit by stepping the voltage from -0.5 volts to +0.5 volts. Silver paste was used to make contacts on the samples. Figure 5 shows the observed I-V characteristics. The observed current was in the range of mille-amperes. All the readings were taken at room temperature.

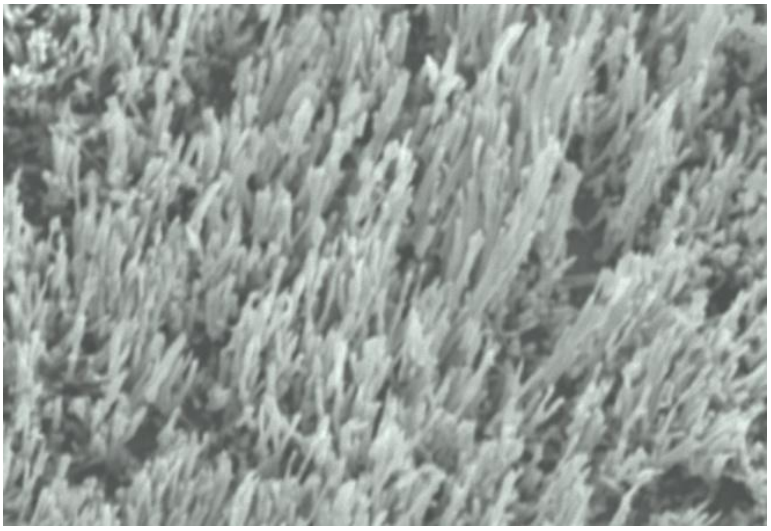

Fig. 3 **SEM image of Cu microwires of 0.2 um diameter**

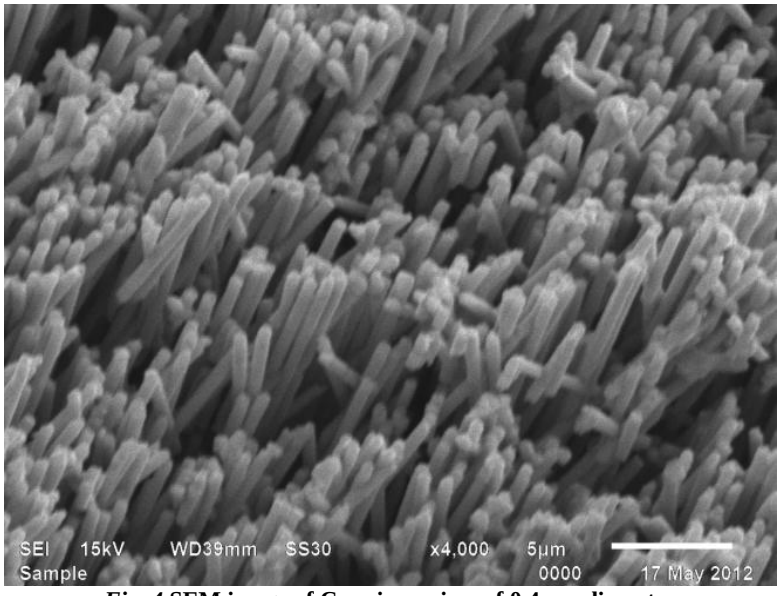

Fig. 4 **SEM image of Cu micro wires of 0.4 um diameter**

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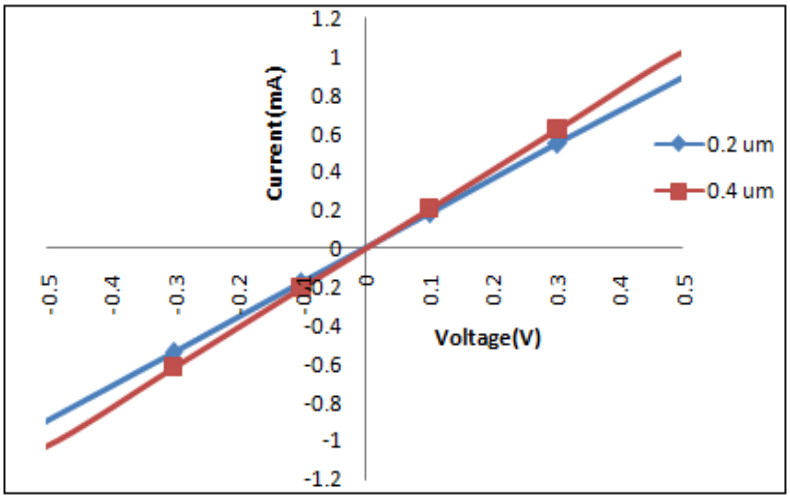

Fig. 5 **I-V Characteristics of Cu microwires**

III. RESULTS AND DISCUSSION

XRD patterns shown in figure 2 for the wires of different diameter indicate that there is no change in the position of peaks with respect to change in diameter of wires. The position of peaks confirms that material deposited was Copper in samples. SEM images in figure 3 & 4 shows the uniform directional growth of microwires which matches the morphology of pores in the template and length of wires is about 10 μm as of thickness of the template. The diameters of the synthesized wires are about 0.2 & 0.4 um as of the pore size of PCTEM templates. The I-V characteristics in figure 6 show high conductive nature of microwires and follow the ohm's law. The conductivity increases with increase in diameter of wires.

IV. CONCLUSIONS

Microwires of different diameters of copper were fabricated by electrodeposition method using PCTEMs as template. The XRD confirms the material deposited was copper and there is no change in position of peaks with diameter of wires. SEM confirms the morphology of synthesized micro structures which matches with morphology of pores in template. By changing the morphology of pores the nano/micro structures of different shapes and sizes can be fabricated. The I-V characterization indicates the high conductive nature of microwires.

REFERENCES

[1]. Iijima S., "Helical microtubules of graphitic carbon", *Nature*, vol. 354, pp 56-58, 1991.

[2]. Singh Ranjeet, Kumar Rajesh, Sharma S. K. & Chakarvarti S. K., "Non-galvanic synthesis of Ag_2Se nanowires using anodic alumina membrane as template and their characterization", *Digest Journal of Nanomaterials and Biostructures*, vol.1 (4), pp. 149 – 154, 2006.

[3]. Kumar Vijay, Kumar Sunil, Kumar Sanjeev & Chakarvarti S. K., "Optical studies of electrochemically synthesized CdS nanowires", *Journal of Materials Science: Materials in Electronics*, vol. 22 (4), pp. 335-338, 2011.

[4]. Virk H. S., "Fabrication and Characterization of Copper Nanowires", Hasim A. Abbass (Ed.), *Nanowires - Implementations and Applications*, pp. 455-47, INTECH Open Access Publisher, 2011.

[5]. Ferain E. & Legras R., "Track-etch templates designed for micro- and nanofabrication", *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, vol. 208, pp. 115-122, 2003.

[6]. Pra L. D., Ferain E., Legras R., Champagne S. D., "Fabrication of a new generation of track- etched templates and their use for the synthesis of metallic and organic nanostructures", *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, vol.196 (1-2), pp. 81-88, 2002.

[7]. Huczko A., "Template-based synthesis of nanomaterials", *Applied Physics A: Materials Science & Processing*, vol.70 (4), pp. 365-376, 2000.

[8]. Ferain E. & Legras R., "Efficient production of nanoporous particle track etched membranes with controlled properties", *Radiation Measurements*, vol. 34, pp. 585–588, 2001.

[9]. Cao G. & Liu D., "Template-based synthesis of nanorod, nanowire, and nanotube arrays", *Advances in Colloid and Interface Science*, vol. 136, pp. 45–64, 2008.

[10]. Kumar S. & Chakarvarti S. K., "Electrodeposition of copper nanowires in ion-crafted membranes as templates", *Digest Journal of Nanomaterials and Biostructures*, vol. 1(4), pp.139 – 143, 2006.