Synthesis of Cu/Metal nanowires for transparent electrodes applications

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Copper nanowires (NWs) are used in a variety of applications in the industry due to their high electric conductivity and very low price. Moreover, they can be used to form transparent conductive electrodes for optoelectronic applications such as flexible displays, touch screens and solar cells. Although it is in fact an advantageous material in many ways, the oxidation problems prohibits copper from being a bare metal used in nanowires' applications and for this reason it is desirable to improve its resistance against oxidation.

The aim of this study is the synthesis of Cu nanowires with higher resistance against oxidation. For this purpose, in the fabrication process two different approaches were adopted. The first one involves the coating of the copper nanowires with a protective metal. The second involves the formation of an alloy of Cu/metal nanowire. In both cases samples are prepared by DC electrodeposition process. Finally, Cu/metal nanowires are dispersed in a polymer matrix in order to form a transparent conductive electrode.

An easy and effective way to synthesize a large number of NWs with high aspect ratio (length to diameter ratio) is the so called "template synthesis" [1]. In this process, a metal is electrochemically deposited inside a porous material, which is acting as a template. A widely used material for this purpose is porous alumina membrane (PAM) due to its high mechanical and chemical strength and durability at high temperatures. The geometrical characteristics of PAM can be easily controlled during their synthesis process. PAMs with pore diameter between 10 and 250 nm and interpore distance between 25 and 500 nm can be easily synthesized, while the thickness of PAMs can be several hundreds of micrometers. The electrodeposition takes place in an electrochemical cell using a high purity copper wire as anode and a cathode of a nanoporous alumina membrane (Whatman) as a template with nominal pore diameter of 200nm and 60μm thickness. Electric contact is made through a 350nm Ag film deposited on the membrane's back side by physical vapour deposition (PVD). Nanowires of Cu/Sn, Ni, Au were synthesized, using the suitable electrolyte solution for every case [2-4]. In order to obtain coated metal nanowires, two electrodeposition processes have to take place [5]. In the first one we apply a high current density for the deposition of the protective metal. The intensity of the electric field is higher in the region closer to the membrane's wall. Thus, reduction of the metal ions occurs faster at the inner surface of the pore, forming a meniscus-like shape. The second electrodeposition is carried out under low current density and reduction takes place inside the metal shell deposited in the first stage

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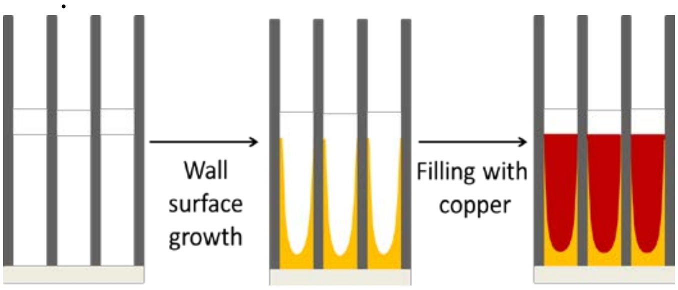

Fig. 1: *Schematic view of the experimental procedure for the synthesis of Cu nanowires coated with protective metal.*

For Cu/metal alloys NWs, electrodeposition is carried out with an electrolyte solution consisting of both metal salts. The final step involves the fabrication of the transparent electrode. The porous alumina template is chemically dissolved in NaOH. Then the NWs are collected by centrifugation. During the centrifuge process, the NWs are purified by rinsing with pure water. Then, the NWs are dispersed in a polymer solution consisting of 3%w/v PS and toluene. Spreading of the polymer-NWs solution on a glass substrate is accomplished by spin coating. The samples were characterized by XRD and SEM in order to assess the morphology and the size of nanowires, as well as their crystalline structure. Transparency and conductivity of the transparent electrode was also obtained for all fabricated electrodes and fabrication parameters were adjusted for optimum results.

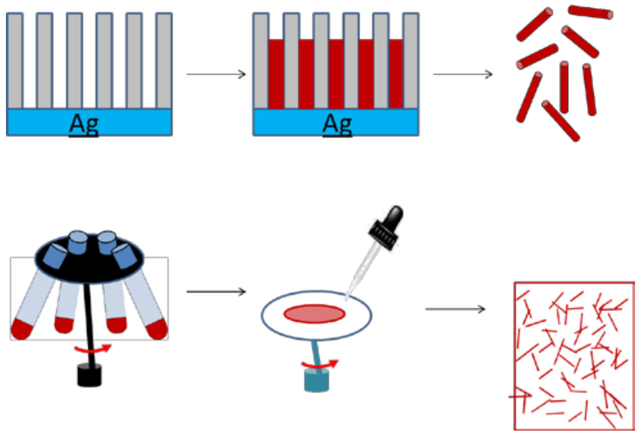

Fig. 2: *Schematic view of the experimental procedure for the synthesis of the conductive transparent electrode.*

References

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