Synthesis and Characterization of NiFeCu Alloy Nanowire and their Optical Properties

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Abstract: The template assisted electrochemical deposition technique has been used for the fabrication of well aligned metallic (NiFeCu) nanowires. Anodic Alumina membrane (AAM) is used as a template. The crystallographic study and imaging analysis tools used for the nanowires are x-ray diffractometer (XRD) and field-emission scanning electron microscope (FE-SEM) respectively. The absorption spectra have been studied using UV-Vis spectroscopy by varying the wavelength in the range of 200-800 nm. It has been observed that the alloy nanowires show an increase in the absorption value and peak occurred in UV region.

Keywords: *Template, Electrodeposition, Nanowires, Absorption.*

I. INTRODUCTION

In recent years, the synthesis of nanowires using different methods like laser ablation[1], Chemical vapor deposition (CVD)[2], vapor liquid solid (VLS)[3]-[4], ball milling and annealing[5], thermal evaporation[6] or electrochemical deposition[7]-[9] has attracted much interest to produce highly ordered, well aligned nanowires of large aspect ratio. Due to changes in properties from bulk to nano-scale, these have been fabricated for different potential applications such as sensors[9]-[10], optical devices[10], ultrahigh density magnetic storage[11], logic and memory functions and so on. High aspect ratio of nanowires plays a significant role in determining its optical properties. Like semiconductor nanowires, metallic nanowires also exhibit optical properties. In case of metallic or multilayer nanowires, only magnetic and electrical properties has been studied so far[12]-[15], however nothing substantial has been done regarding optical properties . In this work, metallic nanowires in the alloy form are fabricated and its absorbance value is determined using UV-Vis spectroscopy in the wavelength range of 200-800 nm.

II. EXPERIMENTAL

Anodic Alumina membrane was used as a template for the electrochemical synthesis of NiFeCu nanowires. The template had a pore diameter of 0.1µm and 60µm thickness. AAM membrane is sputter coated with silver paste from one side. Three-electrode electrochemical cell (Gamry Reference 600, Potentiostat) was used to carry out the deposition with silver/silver chloride (Ag/AgCl) as reference electrode, Platinum wire (1.5mm diameter) as counter/auxiliary electrode and AAM as working electrode. The electrochemical bath contains 1M of $NiSO_4.6H_2O$, 0.5M of H_3BO_3, 5mM of $CuSO_4.5H_2O$ and 0.001M of $FeSO_4.7H_2O$. All the solutions were prepared using distilled water. pH of the bath was maintained below 3. Cyclic Voltametry is performed to predict the reduction potential for the deposition of NiFeCu and it comes out to be -1.2V. Before starting the process, the membrane was dipped in the solution. By applying -1.2V potential for 2500 seconds nanowires were deposited in the membrane. The structural and imaging analysis was done through x-ray diffraction(XRD) (XPERT-PRO) and field-emission scanning electron microscope(FE-SEM) respectively. To study optical properties, sample was dipped in acetone to remove the silver paste and then in NaOH to liberate nanowires from AAM. The absorption spectra of NiFeCu nanowires suspended in NaOH was put in cuvette and then placed in the spectrophotometer. The measurement was carried out in UV-Vis region.

III. RESULTS AND DISCUSSION

FE-SEM images in figure1 show the cross- sectional view of nanowires embedded in AAM.

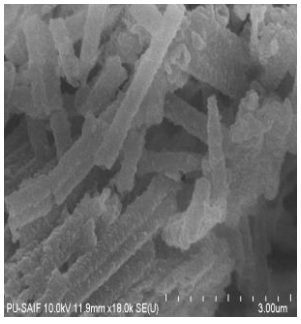

Fig.1: FE-SEM image of NiFeCu nanowire

XRD analysis of NiCuFe nanowires embedded in anodic alumina template(AAM) is shown in figure 2.

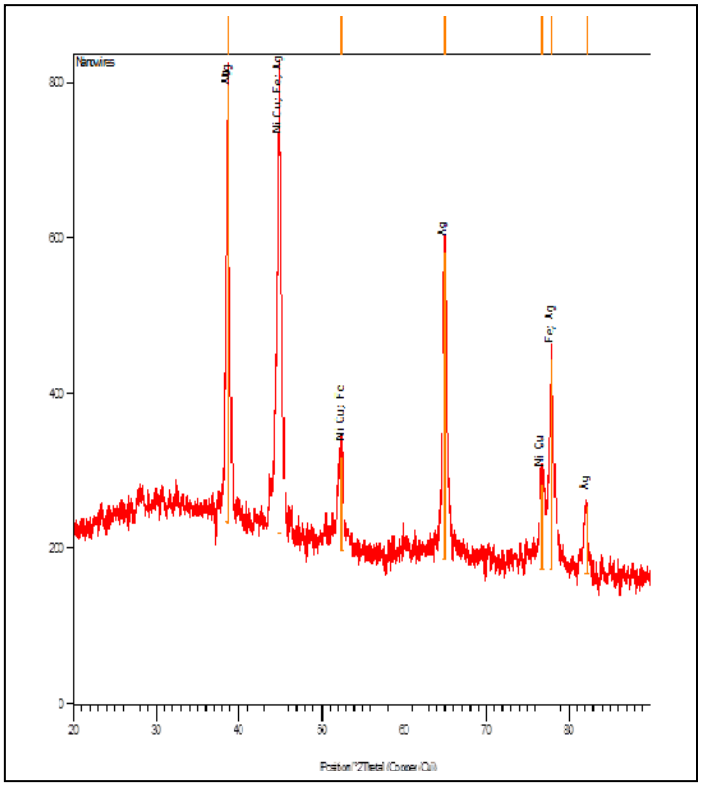

Fig.2: XRD pattern of synthesized NiFeCu nanowires

The observation results in different peaks, which corresponds to NiFeCu, Fe. Silver peak is also reported due to the silver paste on the membrane. The refection peak shows all the material collectively participated in the formation of nanowires and the result is compared with NiFe/Cu nanowires[16].

Absorption spectra is observed in the range of 200-800nm and shown in figure 3. The maximum value of absorbance comes out at λ_{max} =214 nm i.e.3.75 a.u.

As the concentration decreases, there is decrease in $\lambda_{max.}$ The results are compared with Cu-Ni[17] and hyperchromic effect is observed, i.e. increase in absorbance. Sample lies in UV region. This may be due to the interband transitions in electronic levels. Results are also compared with single layer nanowire[18] which leads to shift of the wavelength from visible to UV region.

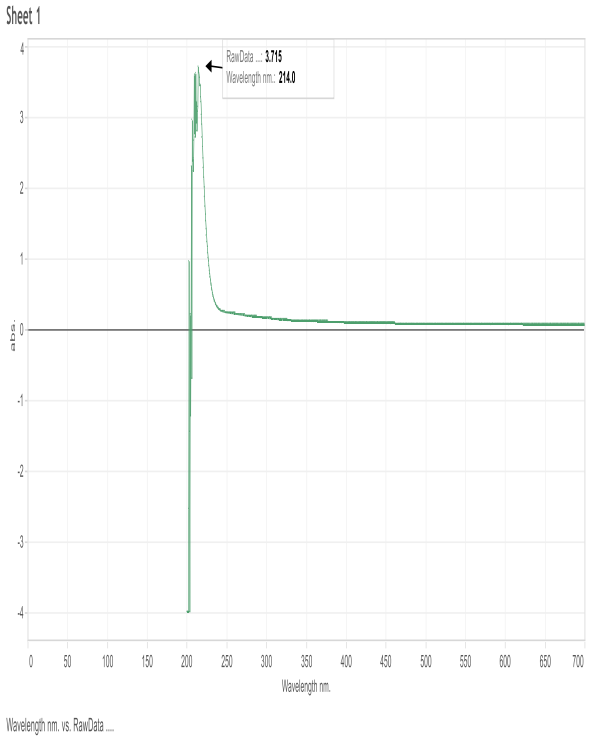

Fig.3: Absorption spectra of NiFeCu nanowire

IV. CONCLUSION

NiFeCu nanowires have been synthesized using the electrochemical deposition technique. SEM analysis resulted in uniform growth of nanowires. XRD revealed the crystal structure of nanowire. UV spectrophotometer is used to obtain the optical spectra of nanowires. It is concluded that the absorption spectrum of single layer metallic nanowire lies in the visible region while the absorption spectra of alloy (NiFeCu) nanowires lies in UV region.

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