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ELECTRODEPOSITION OF Cu/Co FILMS ON n-Si FOR GIANT MAGNETORESISTANCE

T. Sripadmini[b] , Debabrata Pradhan[b], Amit Nath[c], Rajiv Shekhar[a] and Monica Katiyar[a]

[a] *Department of Materials and Metallurgical Engineering, Faculty, IIT Kanpur, India*
[b] *hydrometallurgy lab IIT Kanpur, India., [c]Electronic Materials lab IIT Kanpur, India*

ABSTRACT

Cu/Co Multilayers have been electrodeposited directly on to n- type (100) Si substrate from a single bath under potentiostatic conditions. Co and Cu are weakly miscible elements and for this reason they are most likely to yield chemically sharp interfaces. The structure and the composition of the multilayers were characterized by Atomic Force Microscopy (AFM) and EDAX. Individual layer composition was determined to study the influence of the electrodeposition conditions on co-deposition. MR measurements were carried out on samples with stacking up to 15 magnetic multilayers at room temperature.

1. INTRODUCTION

Magnetic multilayers are composed of an alternating sequence of nonmagnetic and magnetic thin layers of only some nanometer thickness. In last decade, theses multilayer systems became more important in magnetic sensor technology and magnetoelectronics due to their giant magnetoresistance (GMR). The most common two methods of multilayers preparation are (i) Physical deposition techniques (Sputter deposition, Thermal evaporation or Molecular beam epitaxy) and (ii) Electrodeposition techniques.

Electroplating offers the advantage of low cost production with respect to the deposition processes in gas phase, since electrodeposition requires only relatively simple and inexpensive processing equipment. Moreover, electrodeposition is more suitable than vapour-phase deposition techniques for producing multilayers with a large area and arbitrary shape [1]. Two methods for producing electrodeposited alternate layers of two different metals are available: The dual bath method and the single bath method [2].

Electro-deposition has one feature, however, that can be a major disadvantage, namely need to use a conducting substrate. A much more promising approach is to electrodeposit the multilayer directly onto a semiconducting substrate, because semiconductors can conduct sufficiently well to allow film as a metal substrate would, due to Schottky barrier for conductor is *n* type, this Schottky barrier will be forward biased during deposition [3]

Giant magnetoresistance effect is strongly dependent on growing conditions, temperature, interfacial quality, etc. [4]. Co and Cu are weakly miscible elements and for the reason they are most likely to yield chemically sharp interfaces [5].
In this work, Cu/Co multilayers are produced using a sulphate- citrate, at 4.9 pH. Electrodeposition conditions were optimized to prepare good alternate layers, by minimizing the co-deposition and roughness of the layers. Morphology and the composition of the multilayers were characterized by Atomic Force Microscopy (AFM) and EDAX.

2. EXPERIMENTAL DETAILS

Deposition was carried out in a sulphate- citrate solution containing, $CoSO_4.7\ H_2O$, $CuSO_4.5\ H_2O$ and sodium citrate (Na3C6H5O7.2H2O) [6]. All solutions were freshly prepared with doubly distilled water. The bath contained 0.7 mol/dm $CoSO_4.7\ H_2O$ and 0.006 mol/dm $CuSO_4.5\ H_2O$. Citrate 0.25 mol/dm was added maintaining the pH close to 4.9

Experiments were carried out in a conventional two-electrode cell using an EG&G Potentiostat/Galvanostat model 263A, interfaced with host a computer (Pentium III micro-processor). Where the user program (Head start programming), suitable for rectangular or square pulses. The one side polished n-type (100) Si wafers with 2-6 Ω /cm ^{2} were used as the substrates. Electolesscopper deposited film is used for back contact. Prior to the electrodeposition, the Si substrate was cleaned by 10% HF water solution to remove the oxide layer by dipping the substrate in the solution for few minutes. Polycrystalline copper sheet (99.9% purity) was used as the anode. The copper anode was carefully mechanically polished on rotating wet abrasive alumina of different grades (3.75 and 1.85μm) followed by 0.1 μm diamond powder, rinsed with double distilled water. Prior to use, the substrate was polished electrochemically to a mirror finish by using Phosphoric solution as an electrolyte, washed with bidistilled water. The two electrodes are kept parallel to each other and the deposition area was 2cm ^{2}.

The multilayer surfaces were observed in air by means of AFM about 5 images of different areas were analyzed in order to average the roughness value. Surface roughness was quantified by its RMS value.

3. RESULTS AND DISCUSSION

3.1 MORPHOLOGICAL CHARACTERISATION AND ANALYSIS OF THE DEPOSITS

Multilayer preparation was performed using potentiostatic pulses ranging from potential at which only copper deposited (E_{cu}) to a potential at which mainly cobalt deposited (E_{co}). Pulse parameters are optimized using visual examination whether the film is bright and adherent to the substrate or not. The bright and adherent films are analyzed using EDAX to examine the co-deposition From the EDAX analysis of the above all samples, the best voltage value is used for further studies. AFM micrographs showed that Roughness of the film is low when electrode is electroplished [RMS 20nm] compared to that of as mechanically polished [RMS 45.9nm]

All quoted layer thicknesses are nominal thicknesses calculated from the current passed during deposition assuming bulk densities and 100% current efficiency. The exact total thickness of the layers is measured using the surface profilometer making a step on the substrate which value is necessary for GMR measurements. There is no big difference between the nominal thickness and the measured Value.

3.2 MAGNETO RESISTANCE MEASUREMENTS

The magnetoresistance (MR) experimental set-up consists of a four-point probe assembly and a Lakeshore Model 662 electro-magnet. The Four-point probe assembly consists of spring-mounted probes and a current source (21mA max.). The potential is measured using a Keithley 2182 Nano voltmeter.

A system of 10 and 15 double layers starting and ending with cu were deposited. Cu/Co Multilayers along with the substrate are cut into 8mm × 8mm pieces and MR was measured. 0.6

% MR value was observed in [Co $_{2.5\ nm}$ / Cu $_{2nm}$] $_{10}$ and 1.1% in [Co $_{2.5\ nm}$ / Cu $_{1nm}$] $_{15.}$ The MR ratio here is defined as (R_{max}-$R_{H=\infty}$)/$R_{H=\infty}$ X 100 %.

4. CONCLUSIONS

Cu/Co Multilayers deposited with low roughness value using electro polished anode on n-Si. Surface profilometer analysis showed that the thickness of the film is very close to the nominal thickness with the experimental conditions. Without using any physical deposition technique for back contact able to produce the films for Magnetoresistance.

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FIGURES

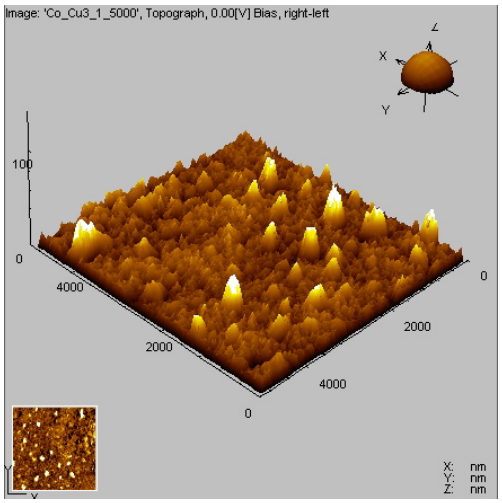

Fig 1. AFM image of electrodeposited multilayer of $[Co_{2.5\ nm} / Cu_{1nm}]_{15}$ on Si, Mechanically polished copper anode.

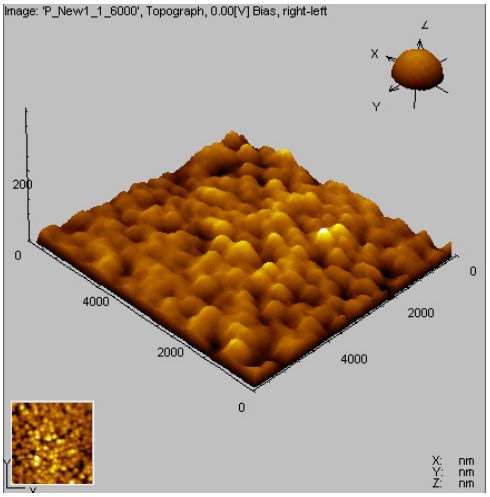

Fig 2. AFM image of electrodeposited multilayer of $[Co_{2.5\ nm} / Cu_{1nm}]_{15}$ on Si, electro polished copper anode.