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GROWTH ANALYSIS OF ELECTRODEPOSITED COPPER THIN FILM ON TUNGSTEN COATED SILICON SAMPLE

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ABSTRACT

Highly uniform, smooth and conformal coating of copper thin film have been investigated via electro deposition on tungsten coated silicon sample. The films are shiny, brown colored and electrically conducting. Tungsten rapidly reacts with air to form WO_3 which opposes the proper coating so we have given basic and acidic treatment to substrate to improve the selectivity of coating. The film shows adherent deposition at current density 5.13 mA/ dm^2 and voltage potential 0.6V. Cyclic Voltammetry technique have been used to study the electrochemical properties of copper deposited on tungsten coated silicon sample.
Keywords: Cyclic Voltammetry, Electro deposition, tungsten, thin films

I. INTRODUCTION

The use of copper as an interconnection material is increasingly needed in the fabrication of microelectronic devices because of its higher electrical conductivity and better electro migration resistance than aluminum [1,2]. Electro deposition of alloys is particularly important for applications to micro fabrication technologies. Tungsten metal and its alloys are used in ultrahigh temperature applications. The employment of tungsten as a current-carrying
material for metallization of ICs is of growing interest owing to its unique properties; as electronic devices become smaller, this material continues to withstand progressively greater current densities. Despite the fact that a tungsten layer has higher electrical resistance than an aluminum layer, in the production of semiconductor ICs, the former offers a number of advantages to the process of metallization [3-6]. Tungsten films are to a smaller degree prone to electro migration, and they differ but little in their thermal-expansion coefficient from silicon and silica, which are most often used in technology [7].

This work reports on the electro deposition of Copper thin films on tungsten coated silicon sample to provide ohmic contacts to optoelectronics devices. We used Cyclic Voltammetry to

study the electrochemical properties of copper deposited on tungsten coated silicon sample. The potential is measured between the reference electrode and the working electrode and the current is measured between the working electrode and counter electrode. The characteristics of the film properties such as adhesion, selectivity, grain size, surface morphology have been investigated by scanning electron microscopy.

II. EXPERIMENTAL PROCEDURE

Initially the surface preparation was done by cleaning the substrates with acetone and then emulsified it with KOH solution to remove particles on the substrate. Substrate then just dipped in HF + HNO_3 (3-3ml) for a second and rinsed with deionized water. A copper sulfate ($CuSO_4$) solution is used in electrochemical cell with Platinum as a counter electrode and calomel as reference electrode. The potential is measured between the reference electrode and the working electrode and the current is measured between the working electrode and counter electrode.
Electro deposition of copper on tungsten films were plated from a bath containing copper sulphate solution ($CuSO_4$: 35 ml), sulfuric acid (H_2SO_4: 20ml). The bath was maintained at pH 0.5, room temperature and current density (c.d.) ranging from 3.8 to 5.2 A/dm^2, and the plating time was 1-3 min under no agitation. In cyclic Voltammetry configuration the working electrode potential is ramped linearly versus time like linear sweep Voltammetry. Cyclic Voltammetry takes the experimental step farther than linear sweep Voltammetry which ends when it reaches a set potential. When cyclic Voltammetry reaches a set potential the working electrode's potential ramp is inverted. This current at the working electrode is plotted versus the applied voltage to give the cyclic voltammogram trace [8]. The thickness of film has been measured by stylus profilometer.

Table 1 Experimental details when electrochemical cell is connected to DC supply

Samples	**Potential Voltage**	**Current density**	**Time**	**Deposition**
Sample 1	**0.4V**	**3.82mA/dm^2**	**60sec**	**Uniform**
Sample 2	**0.5V**	**4.76mA/dm^2**	**60sec**	**Uniform & adherent**
Sample 3	**0.6V**	**5.13mA/dm^2**	**60sec**	**Uniform & adherent**

III. Results and Discussion

We have analyzed the electrical and structural properties of thin film deposited onto tungsten coated substrate. Fig.1 shows the cyclic Voltammetry curves of electrodeposited samples for various process parameters. Fig.2 shows the surface microstructures of the copper film on tungsten coated *n*-Si. In the case of current density 5.13 mA/dm^2, relatively larger grains were found compared to those at 3.82 mA/dm^2. Also smooth and adherent film surface has been achieved at higher current density. The surface roughness of films was measured by Bruker's AXS stylus profilometer (RMS roughness = 16 nm).

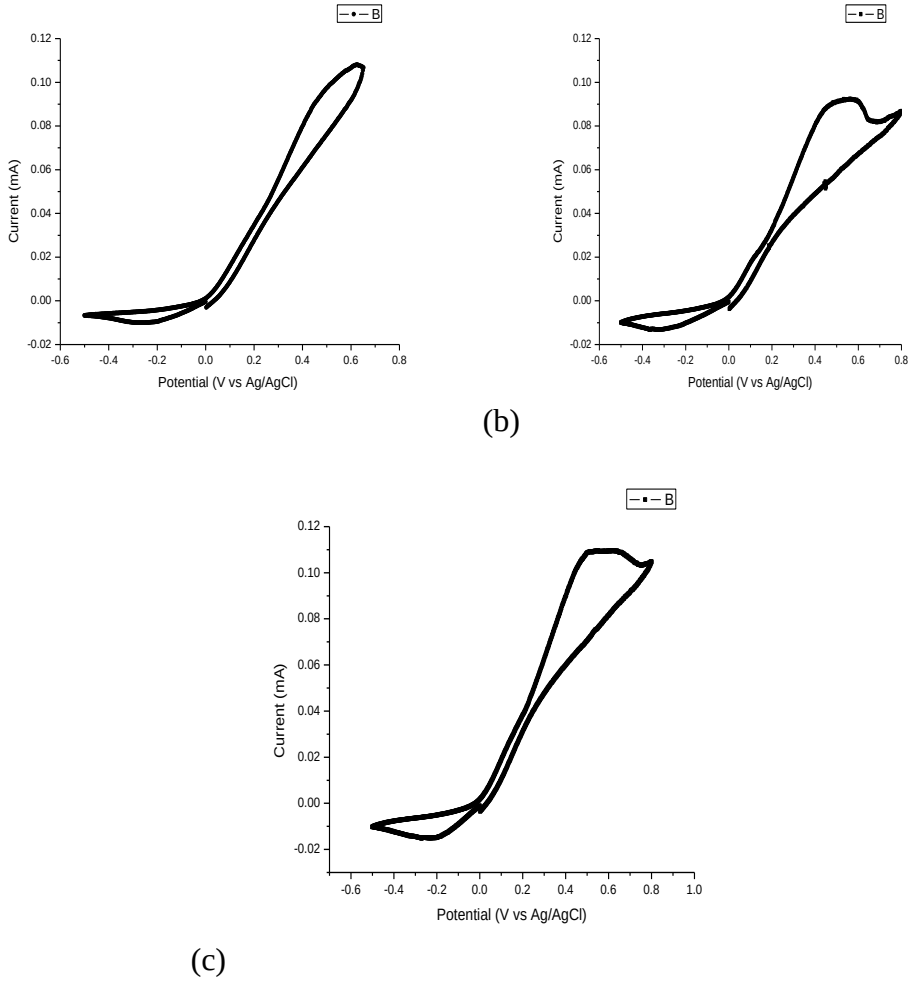
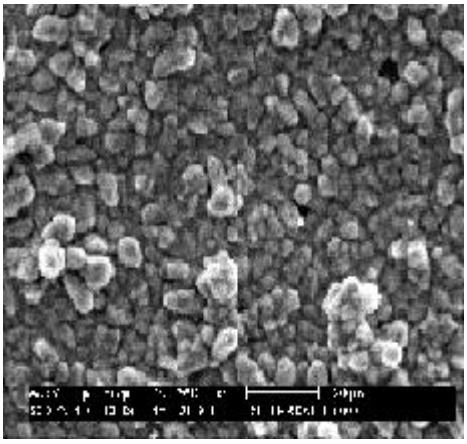


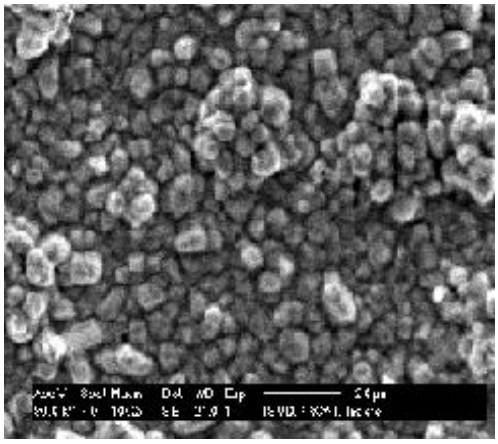
Figure 1: The curve showing Cyclic Volta metric analysis of Electrodeposited samples for various parameters at constant time a) current density 3.82 mA/ dm^2, voltage potential 0.4V b) current density 4.2 mA/ dm^2, voltage potential 0.5V c) current density 5.13 mA/ dm^2, voltage potential 0.6V.

The forward scan produces a current peak for any analyte that can be reduced through the range of potential scanned. The current will increase as the potential reaches the reduction potential of

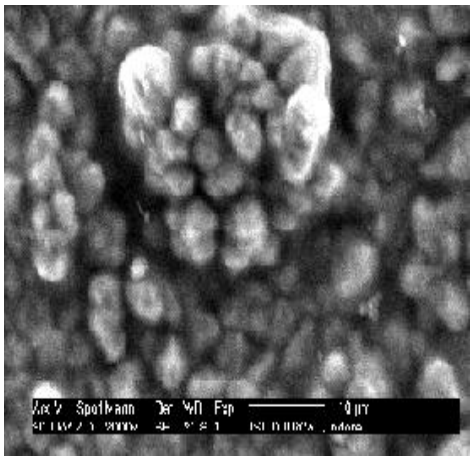
analyte, and it then falls off as the concentration of analyte is depleted close to the electrode surface.



(a) Sample 1



(b) Sample 2



(c) Sample 3

Figure 2: SEM image of Electrodeposited Sample: (a) Sample 1, (b) Sample 2, (c) Sample 3.

Based on the good results, the copper electro deposition is performed on the whole surface. We found the sample has better nucleation and growth of copper over Tungsten coated Si-wafer. Though Tungsten like metals are difficult to plate because it is a readily oxidizable metal and hence requires special procedures to ensure proper adhesion of coating of base metal.

IV. CONCLUSION

Copper films were deposited on tungsten coated silicon via electro deposition technique and a Cu-W interface has been investigated. We used Cyclic Voltammetry to study the electrochemical

properties of copper deposited on tungsten coated silicon sample. Smooth, uniform and adherent films were obtained by electro deposition from bath containing $CuSO_4$ solution. The tungsten film shows a resistivity of $3x10^{-7}$ Ωcm, which is close to the resistivity of metals.

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