Fabrication and Characterization of Thin Film Structure as Resonant Tunnelling Diode

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Abstract: **Al-Se-Cu thin film was prepared on a glass substrate by thermal evaporation at a pressure of 10^{-5} torr using vacuum coating unit. Three layers of different material were deposited on Glass substrate. I layer is Aluminum,II Layer is Selenium and III layer is Cu. Thickness of film is about ~200 nm. We propose to study the V- I Characteristics of this film, the effect described without any external voltage being applied to the actual PN junction resulting in the junction being in a state of equilibrium. However, if we have to make electrical connections at the ends of both the N-type and the P-type materials and then connect them to a battery source, an additional energy source now exists to overcome the potential barrier. Al-Se-Cu film resulting diode's forward current is found to be controlled by majority carrier tunnelling and negative differential resistance starts appearing which results maximum transition of electrons and results in decrease in current up to valley point (4-5 V)of I-V curve and negative differential resistance observed is - $0.64*10^7$ ohms. This represents RTD (Resonant tunnelling diode) Structure.**

Key Words: **Thermal evaporation, Negative differential resistance, Resonant tunnelling diode.**

1. INTRODUCTION

Copper selenide belongs to I–VI compound semiconductor materials. used Copper selenide can also be used as an ideal solar control coating. Different ***Al-Se-Cu*** atomic ratios have been evaporated in a vacuum chamber to be subsequently heated, the results on the dependence of the crystallite size, preferential orientation, roughness, optical transmittance and aluminum incorporation as a function of the stoichiometry have been studied, concluding that Al-Se-Cu atomic proportion [1-11].The effect of adding this additional energy source results in the free electrons being able to cross the depletion region from one side to the other. The behavior of the PN junction with regards to the potential barrier's width produces an asymmetrical conducting two terminal device, nano electronics to become a reality one must be able to fabricate the devices and circuits at nanometer dimensions, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage (I-V) relationship, Al-Se-Cu film resulting diode's forward current is found to be controlled by majority carrier tunneling, and negative differential resistance starts appearing and represents. RTD (Resonant tunneling diode) Structure. The energy levels appear in se semiconductor shows Negative differential resistance region starts appearing. [13]

2. EXPERIMENTAL

2.1 Sample Preparation

The samples of Al-Se-Cu were prepared by thermal evaporation method using Vacuum coating unit at a pressure of 10–5 torr. High purity aluminum (99×999%) selenium powder were used. The glass substrates were placed in the substrate holders above the boats carrying materials. Selenium having thicknesses 1000 Å was first evaporated and later aluminum of constant thickness (3000 Å) deposited over these films to get Al–Se bilayer structure. The thickness was measured using a quartz crystal thickness monitor [12]. Copper powder (99×5%) having thicknesses 500 Å were placed in the boat alternatively ,evaporated at high pressure and deposited on bilayer structure of Al-Se to form a Trilayer thin film structure of Al-Se-Cu.The total thickness of the Al-Se-Cu thin film is about 200 nm and the thickness of a single layer is 50 nm/100 nm/50 nm[3].

2.2 Thin Film structure

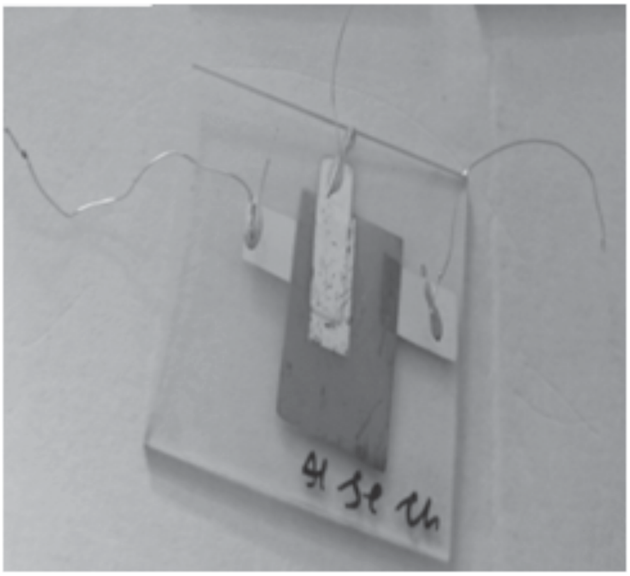
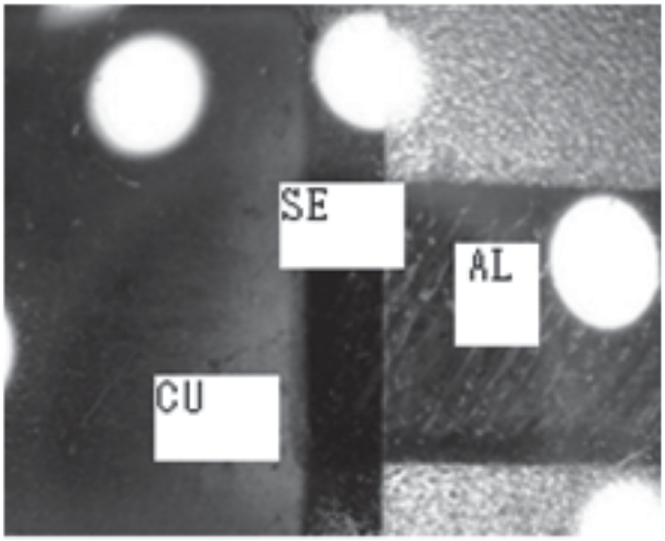


Fig1: Shows Photograph of three layer thin film sample with its electrical connections

2.3 Optical Surface structure



(a)

Fig2: Shows optical Photograph of three layer sample of Al-Se-Cu Thin film

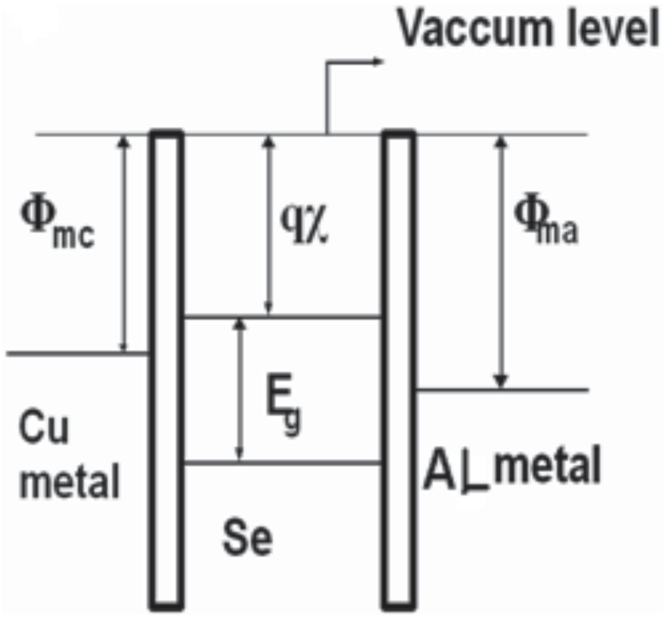
RESULTS AND DISCUSSION

The Al-Se-Cu Three layer film has been deposited on glass substrate by thermal evaporation technique at a pressure of 10–5 torr Trilayer thin film samples are carried out in vacuum chamber at 10^{-5} torr pressure, observed V-I Characteristics, and XRD.

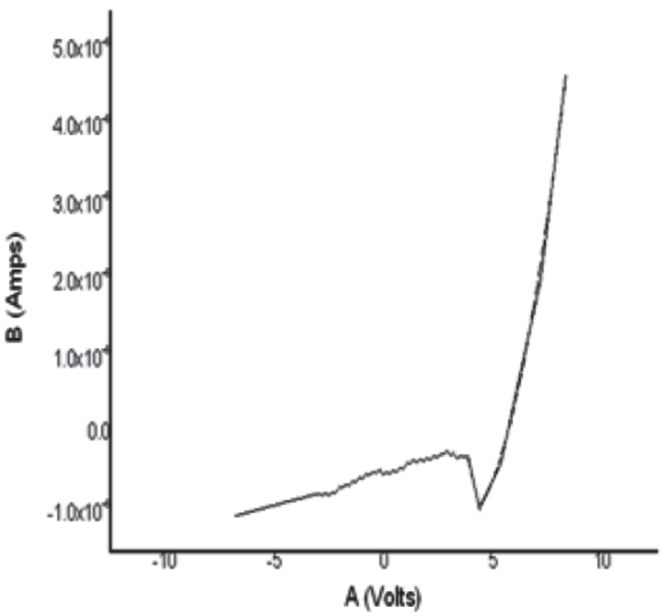
3.1 Electrical Measurements

In Ideal PN Junction a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased. By applying a Negative voltage (reverse bias) results in The free charges being pulled away from the junction resulting in the depletion layer width being increased8. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode. Then the depletion layer widens with an increase in the application of a reverse voltage and narrows with an increase in the application of a forward voltage. This is due to the differences in the electrical properties on the two sides of the PN junction resulting in physical changes taking place. Voltage on the junction diode results in the depletion layer becoming very thin and narrow which represents a low impedance path through the junction thereby allowing high currents to flow. The point at which this sudden increase in current takes place is represented on the static I-V characteristics curve above as the “knee” point. We observed from study that cut in voltage is 4V.

Here we observed that this characteristic shows negative differential resistance as increasing the conduction band of se with decrease in dimensions. It forms a one dimensional RTD with Cu as emitter, Al as collector and Se as potential wall. As we applied voltage across the device,the electrons from Cu electrode Tunnel to the empty states in the conduction band of Se,these electrons get enough energy and jump to higher energy level and back and forth between two well and cause change in amplitude when energy of electrons are equals to the energy of quantized level, resonance of electron waves take place, which results maximum transition of electrons and results in decrease in current up to valley point of I-V curve



(a)



(b)

Fig4: Energy band diagram of RTD (a) I-V Characteristics of Al-Se-Cu Thin film (b)

3.2 Structural Analysis

3.2.1 XRD Analysis

The XRD diffraction analysis (Fig. 4) shows that the diffraction patterns of Al-Se-Cu Thin film. However, a small difference can be observed when the figure is enlarged The (111) peak in the as-deposited Al-Se-Cu film is observerd for Se. Different peaks of Cu isobserverd as it is diposited.

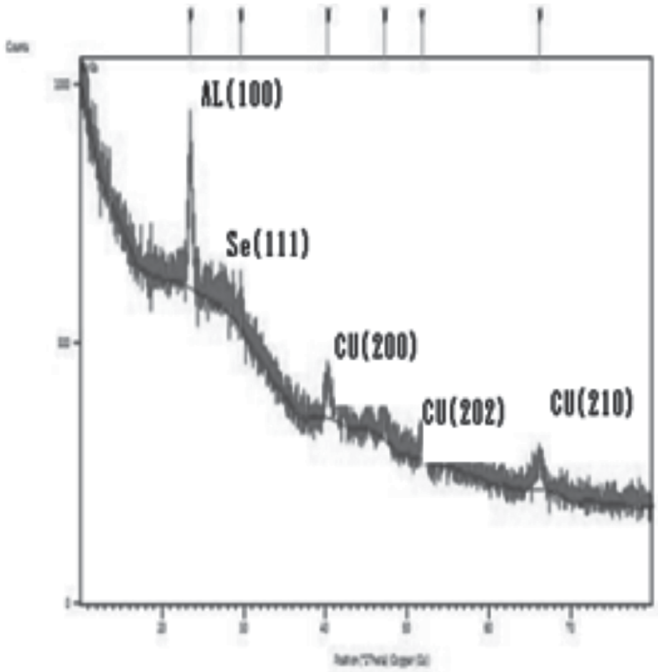


Fig5*:* Observed XRD patterns of Al-Se-Cu thin film

3.2.2 AFM analysis

The three layerd structures were charecterised by AFM to get the informationof quality of the sample surface. AFM Sample is analyzed to identify the growth of cu on surface of thin film.

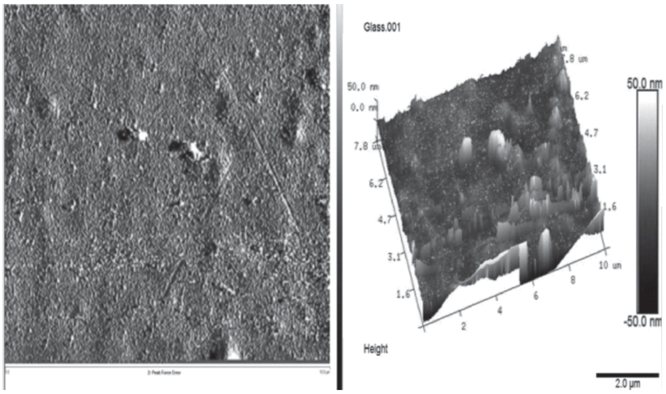


Fig 6: 2D and 3D AFM micrographs view of Al-Se-Cu thin film (sample)

CONCLUSIONS

On the basis of these results, we may say, in Al-Se-Cu Trilayer thin film V- I Characteristics forward current is found to be controlled by majority carrier tunneling, Al-Se-Cu(~200 nm.) film resulting diode's forward current is found to be controlled by majority carrier tunneling and negative differential resistance starts appearing and represents RTD(Resonant tunneling diode) Structure. V-I characteristic (Fig.4) shows negative differential resistance as increasing the conduction band of Se with decrease in dimensions. It forms a one dimensional RTD with Cu as emitter, Al as collector and Se as potential wall. As we applied voltage across the device, the electrons from Cu electrode Tunnel to the empty states in the conduction band of Se, these electrons get enough energy and jump to higher energy level and back and forth between two well and cause change in amplitude when energy of electrons are equals to the energy of quantized level, resonance of electron waves take place, which results maximum transition of electrons and results in decrease in current up to valley point (4-5 V)of I-V curve and negative differential resistance observed is $- 0.64*10^7$ ohms.

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