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TEMPERATURE VARIATION ON THE SURFACE CONDUCTANCE OF METAL-SEMICONDUCTOR CONTACTS

S. S. Oluyamo*, J. S. Ojo and E. O. Alaje+

Department of Physics, the Federal University of Technology (Akure)
*E-mail: oluyamos@yahoo.com

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ABSTRACT

The temperature variation on the surface conductance of different metal-semiconductor contacts had been carried out in this study at varied voltage ranges at temperatures 300 - 400K. The current in the samples increases with increase in voltage and temperature. Samples Sb/Si and Bi/Si showed linear relationship over specified voltage range *[i.e.* 0 - 60V), and seems to saturate at higher voltages. The Al/Ge sample was found to be ohmic over the given voltage range 0 - 0.50V. The surface conductance was found to increase with increase in temperature for all the samples and the plots of LnG against temperature give curvatures, which conforms with the three distinct regions of conductivity mechanisms in semiconductor materials at varied temperature. The difference in the direction of the curvature of the Al/Ge sample is attributed to the thickness and nature of the contacts between the Al and the Ge films. The study equally revealed that the samples behave more of semiconductor than of metal. Hence, temperature variation had effects on metal semiconductor film contacts.

Key words:- Temperature, conductance, metal - semiconductors.

INTRODUCTION

The importance of semiconductor devices in electronics and electrical technology had generated variety of researches on semiconductor based devices. This is because; some semiconductor-based devices have been known to function within different environmental condition[1]. Such conditions include temperature, impurity, carrier concentration, humidity, and pressure. Brooks[2] had shown that pressure affects the conductivity of semiconductors in that it produces phase transition and reduces the resistivity by several orders.

The electrical conductivity of semiconductors depend to a large extend on its Configuration. It had been shown that probe shapes and temperature affect the electrical properties of metal-semiconductor thin films[4,5] The nature of most surfaces is known[6] to play important role in the characteristic properties of semiconductor devices.

Furthermore, study on the electrical properties of binary alloy $Ali\text{-}_xSn_xSe$[7] and n-Si/Au Schottky junctions[8] revealed that the conductivities of the materials increase with increase in temperature and the energy gap of the samples also increases with increase in the concentration of Se in the alloy.

The present study investigates the effects of temperature on the surface conductance of metal - semiconductor differential

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+ *Present Address:* Department of Science Laboratory Technology, The polytechnic. Ire, Osun state

contacts at various voltage ranges. The study is undertaken because; most of the devices fabricate from semiconductor materials are subjected to varying temperature. An understanding of the influence of temperature on these materials would enhance prediction on their performance and use in electrical and electronic equipment.

EXPERIMENTAL

The experimental procedures in this work were carried out as in[4,5]. In particular, contacts between Sb/Si, and Bi/Si films were made with SI films of thickness 1000A^0 first deposited on the ultrasonically cleaned substrate while the Bi, Sb metals were deposited on the electrode widths as shown in fig.1 (a and b). On the other hand, Al film thickness 1000A^0 was first deposited on the substrate while Ge film of the same thickness was deposited on the Al film. Contacts were made on both ends of the film couple with Au film as shown in fig. 1c. The deposition was made with an Edward coating Unit model 306 maintained at a pressure of 5x10"^{3} torr. The deposition rate, which was 500A^0/ min, was determined with a film thickness monitor (Edward model FTM3). All the evaporate were of 99.999% purity (Ventron, Germany). The experiment was subjected to a closed controlled environment where the temperature could be varied. The current - voltage characteristics were obtained with a digital electrometer (Keithley type 160B) and a digital multivoltimeter (Hewlett-Packered type 3465A).

RESULT AND DISCUSSION

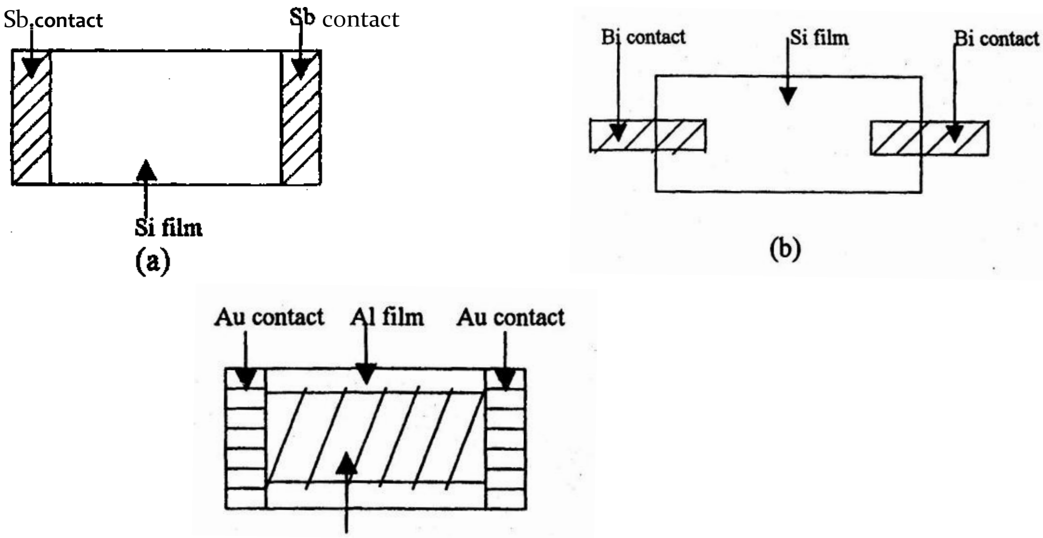
The results of the current - voltage measurements are represented in fig. 1 - 3. The current in the samples increaes with increase in voltage and temperature. Apart from Al/Ge samples, which was found to be linear throughout, Sb/Si and Bi/Si showed linear relationship over specified voltage range (10 - 60V). Above these ranges, there are deviations from linear relationships to rectifying characteristics and evidence of saturation was observed at higher voltages for these samples. The figures also showed that the saturation in the samples was more prominent at higher temperatures. Researches such as[8,9] had shown in previous works that Bi/Te and Ge samples deviate from linear relationship to rectifying characteristics at relatively higher fields.

Table 1 shows the values of the temperature and the surface conductance of the samples. The surface conductance's were found to increase with increase in temperature. This had been attributed by[4] to the usual expected increase in carrier density with increase in temperature and that the conductivity of a system increases with increase in thermal energy which enables some electrons within the valence band to gain energy. Traces of these properties can also be found in[7]-[11]-[12] for pseudo-binary alloys of $Al|._xSn_xSe$, Ge and $Sii\text{-}_xGe_x$ thin layers." The surface conductance (G) for all. the samples was obtained from the slope of the line of best fit of the current - voltage plots and using the relationship[5,13].

$$G = \frac{Ln2}{\pi} I/V = \frac{Ln2}{\pi} \text{ (slope of line of best fit)}$$

where the slope of line of best fit is obtained fron the ohmic region of the I - V plots in figures 2- 4 .

Figure 5 shows plots of LnG against temperature for all the samples. These plots produced curvatures within the voltage ranges 10 - 60V for Sb/Si and Bi/Si samples and 0.05 - 0.5V for Al/Ge sample, thereby conforming with the three distinct regions of conductivity behavior in semiconductor materials. Previous works by[13,14] in the study of (As2Se3)o**.95** TI0**.05** showed these three regions of conductivity at temperature range 140 - 300K.



Ge film

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Fig. (1a-c). Final configuration of deposited film samples.

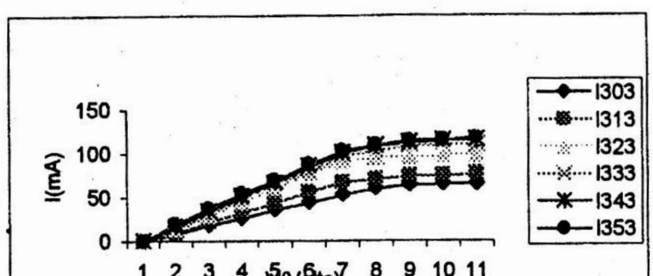

Fig. 2: Current(I) - Voltage(V) plots for Sb/Si samples

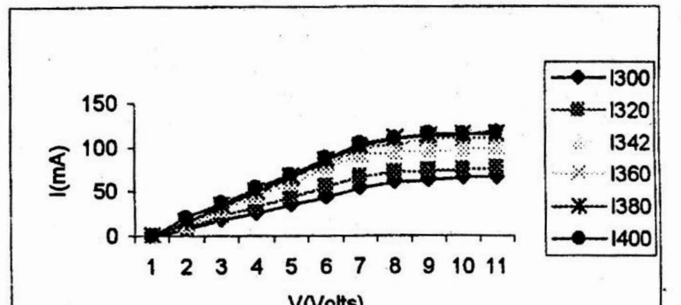

Fig. 3: Current(I) - Voltage(V) plots for Bi/Si samples

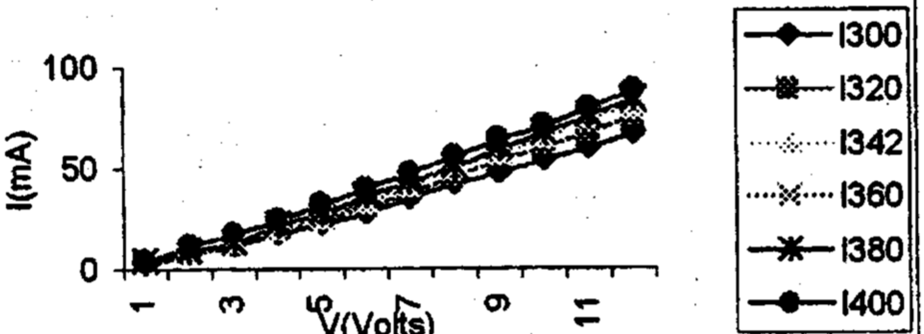

Fig. 4: Current(I) - Voltage(V) plots forAl/Ge samples

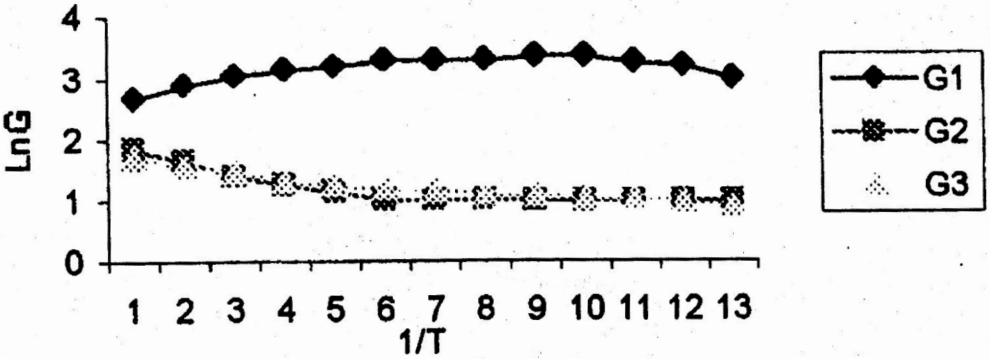

Fig 5: LnG versus 1/T plots for the samples

Table 1. Temperature (K) and the conductances of Sb/Si(G1), and Al/Ge(G3) samples.

T	G1	G2	G3
300	2.87	0.79	0.88
303	2.9	0.83	0.97
313	2.95	0.86	1.00
320	2.99	0.97	1.02
323	3.03	1.03	1.07
333	3.06	1.16	1.11
340	3.08	1.20	1.14
343	3.09	1.41	1.19
353	3.11	1.53	1.26
360	3.14	1.65	1.30
380	3.17	1.71	1.42
400	3.18	1.80	1.50
420	3.2	1.85	1.83

Furthermore, figure 5 also revealed that the shape of the curvature for Al/Ge sample is in the reverse direction to that of the other samples. This could be attributed to (i) the nature of the contacts (ii) the thickness of the sample. In this type of sample, the rates of thermally assisted hopping of excited electrons to neighboring states are Very small and is more likely that electrons will be able to find a state of similar energy by tunneling beyond nearest neighbors to more distinct sites. In addition, the shape of the graph of LnG versus 1/T indicates that the samples behave more like semiconductors than metals.

CONCLUSION

The investigation in this study indicates that the samples are ohmic within specified voltage ranges at temperatures 300 - 420K except for the Al/Ge sample which was found to be ohmic within the voltage range 0.05 -0.50V for the study. The surface conductance for all the samples increases with increase in temperature. In addition, the plots of LnG against temperature showed curvatures, which conforms with the three distinct conductivity regions for semiconductor materials. However, the Al/Ge sample showed that the shape of the graph depends among other factors, on the thickness and nature of the contacts. The findings in this study is in agreement with previous works[7,10,14] in the study of Al|.$_x$Sn$_x$Se, (As2Se3)**o**.9sTlo**.**05 alloys and Ge samples respectively. The study also revealed that the samples behavior are more of semiconductors than of metal.

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