Study Optoelectronic Properties of Ag_2O Heterojunction Prepered by Thermal Oxidation Technique

Khalid Z. Yahia*

Received on: 4/9/2007
Accepted on:3/7/2008

Abstract

Highly (101)-oriented p-Ag_2O thin film with high electrical resistivily was grown by thermal oxidation (TO) on clean monocrystalline p-type Si without any post- deposition annealing. From optical transmittance and absorptance data, the direct optical band gap was found to be 1.4eV. The electrical and photovoltaic properties of Ag_2O/Si isotope heterojunction were examined in the absence of any buffer layer. Ideality factor of heterojunction was found to be 3.9. Photoresponse result revealed that there are two peaks located at. 750 nm and 900nm .

Keywords Ag_2O/si; heterojunction ;thermal oxidation ;photovoltaic

الخلاصة

تم ترسيب غشاء رقيق من اوكسيد الفضة باتجاهية (101) ومقاومة كهربائية عالية على طبقة من السليكون احادية البلورة من النوع مانح بطريقة التأكسد الحراري بدون أي تلدين مسبق. من النتائج النفاذية البصرية والامتصاصية وجد ان فجوة الطاقة للانتقال المباشر كانت 1.4eV اما الخواص الكهربائية والفولتائية وجد ان المفرق Ag_2O/Si الهجـين له عامل المثالية 3.9 اما نتائج الاستجابية الطيفية فوجد قمتـان تقـع عنـد الطـولين الموجيين 900nm,750nm

Introduction

Silver oxide (Ag_2O) is a p-type semiconductor with direct band gap around 1.4eV that is used in photography[1], optical memory[2], and as solar energy converters[3]. Many techniques have been used to grow Ag_2O films; furnace thermal and anodic oxidation of silver[5] thermal evaporation,[6] reactive electron beam[7],and reactive dc magnetron sputtering [4]. No data have been reported on Ag_2O made by thermal oxide (TO) technique using furnace system .

The TO process has a number of advantages over other methods such as:
1. being simple and cheap.
2. having good controlled over working conditions 3.exhibits highly oriented films.

2. Experiment

In this study the substrate material used has an area of 25mm2,and is a mirror-like (111-oriented)p-type

* School of Applied Sciences, Univ. of Tech.

https://doi.org/10.30684/ etj.29.5.10
University of Technology-Iraq, Baghdad, Iraq/2412-0758

silicon Wafer with electrical resistively of 1-3Ωcm. The Si substrate is dipped in HF(5%) diluted acid for 10s and then in DI water rinse for 5 min. High purity silver film of 100nm thickness was deposited onto clean Si and glass substrate by thermal resistively technique Ag2O film is obtained by thermal oxidation of silver film in static air using tube quartz furnace . Figure I shows TO system. the temperature-time oxidation cycle is shown in Figure 1 the condition used in this study to prepare Ag_2O was 300°C/15min.Ohmic contacts are made by vacuum **evaporation of Au and AI on Ag_2O and Si consequently**, since the Au/Ag_2O contact has good ohmic characteristic.

Figure 2 displays the cross-sectional view of the final heterojunction.

Seebeck coefficient measurement was carried out to investigate the conductivity type of the Ag2O film.

The X-ray diffraction (XRD) spectrum of the film recorded with X-ray diffractometer operates with 1.5417A monochromatized CuKα radiation with Ni filter. The electrical dark resistively at 300k of Ag2O film was measured using a keithly 616 digital electrometer . A double-beam spectrophoto-meter (Shimadzu) was used to measure the transmission and absorption spectra (in the normal incidence mode) of Ag_2O film deposited on film substrate in the spectral range 500 to 1000 nm

I-V and C -V measurements of fabricated Ag_2O/ Si were examined using a potential sweeper and LCZ meter (100 kHz), respectively. A monochromator was employed to investigate the spectral response of the Ag_2O/Si heterojunction after making power calibration. Photovoltaic properties were measured at different illumination levels.

Results and Discussion

Ag_2O film characteristics

The XRD spectrum of 420 is shown Fig. 3. It is clear that the grown film has a good degree of crystallinity at highly (101)-oriented crystallites of Ag2O with hexagonal structure Moreover. neither Ag peaks nor other suboxides of silver peaks have been detected despite the high cooling rate (7C°/s). The evaluated lattice constant of this film is 3.3 A°. close to the bulk Ag2O ASTM data card 19-1155 (3.072A°). suggesting a better crystallinity. These results confirm the formation of stoichiometric . Ag2O thin film The grain size (GS) calculated from the schrrer formula is found to be 37nm. A recent study show that the Ag2O prepared by dc magnetron sputtering is of a cubic structure with preferred orientation along (111) (see Ref. 4).

The optical band gap of the Ag2O film was calculated from the transmission and absorption spectra. Figure 4 displays the transmission as function of wavelength. it is obvious that the film gives good transparency characteristics at spectral range 500-1000nm this behavior is seems to Window. The band gap of .Ag2O measured from the plot of the square of αhv versus photon energy hv(where α is the absorption coefficient) by extrapolating the linear part of the curve toward the photon energy axis is found to be the value of the optical band of Ag2O strongly depends on the preparation method .

The Ag2O film exhibits good transparency characteristics and smooth surface and is depicted in Figure 5, the Figure shows a photograph of Ag thin films before mid after oxidation which exhibits good bandpass characteristics.

The film exhibit, good adhesive properties to the substrate.

Electrical and photovoltaic properties of Ag_2O /Si.

Fig. 6 shows dark I-V characteristics of Ag_2O /Si heterojunction, it is clear that the heterodiode this rectification (I_f/I_r>40 at 9 V). The forward current exhibits high series resistance due to high series resistance due to match lattice constant between Ag2O and Si (the lattice mismatch is calculated to be 48%).

The illuminated I-V under (different light levels is depicted in Fig.7 increasing intensity of light result in the increase in the photocurrent, indicating good linearity characteristics Figure 8 shows the measured Isc-Voc of the heterojunction.The ideality factor β was , calculated from Fig.8
and found to be 3.9 at V < 0.24V. The large β value suggests that it the recombination in these device occurs primarily in the junction interface[8] .

Figure 9 show the C-2-V plot of Ag2O/Si HJ at 20Hz. the intercept of the linear part to the x-axis(0.81v)essentially equal to the diffusion potential within Ag2O side .

Figure 10 displays the spectral responsivily curve of Ag2O H.J..there are two distinct peaks located al 750 and 900nm furthermore the spectral response curve exhibits two steep falloffs. The one at λ=800nm is due to parasitic light absorption in Ag2O through band -band absorption , while the other at near 1000nm which is due to the Si band gap the Fig.(11) photocurrent characteristics of Ag2O-Si heterojunction using 1mW He-Ne laser and diode laser the Fig. shown photocurrent of laser He-Ne more than laser diode because of He-Ne wavelength near the peak photoresponse of the heterojunction.

The value of spectral responsivity is low compared to those common silicon base transparent conductive oxides heterojunctions. E.g. SnO2/Si ,In2O3 ,ZnO/Si ,and CdO/Si may be due to
1-high resistivity of Ag2O contributing to high series resistance.
2-large lattice mismatch between Ag2O and Si which produce traps charges at recombination centers.

Conclusions

Despite the large lattice mismatch, isotope abrupt Ag2O/Si 11.1 with encouraged photovoltaic characteristics was obtained using the TO technique. The structural and optoelectronic properties of Ag2O/Si in were studied. The values of both Voc and Isc show that the single phase Ag2O film fabricated by TO is attractive to c-Si solar cell applications. Annealing and doping films to enhance the photo-voltaic properties are underway.

References

1. Rollins T. L. and Wcichmai F. L., Phys. Status Solid.. 7.5 (1996) 233.
2. Kreeingold F. I. and Kulinkin, B. S. Son Phys. Semicond. 4 (1971) 2022.
3. Tominaga J.; .J. Phys.: Condens. Matter 25 (2003) .
4. Barik U. K., S. Srinivsan; C. L. Nagendra and Subrahm A. unyam; Solid Films 429 (2003) 129.
5. Hecht,D. P. Borthen and H. Strehblow; Sin-f. Sri. 365 (1996) 263.
6. Petteresson L.A. A. and Snyder, P. G. Thin Solid Films 270 (1995) 69.
7. Barik U. K. and A. Subrahmanyam, in Proc. 11th Int. Workshop Phys. Semiconductor Devices. eds. V. Kumor and Basu P. K., 11-I5 December 2000, New Delhi, India, pp:12.
8. Song, D. ,I. Zhao, A. Wang. P. Widcnborg, AV. Chin and Abcrle A. G., 17th Ear. PV Conf. (Munich, 2001)

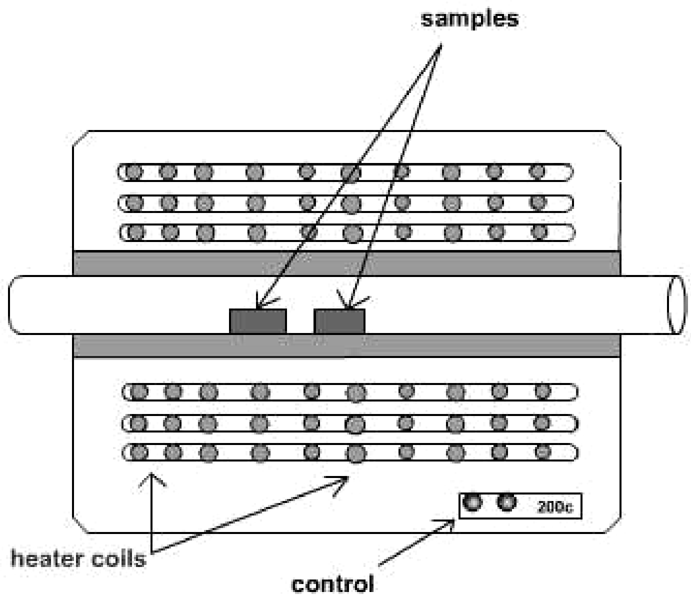


Fig.1 Schematic diagram of furnace system.

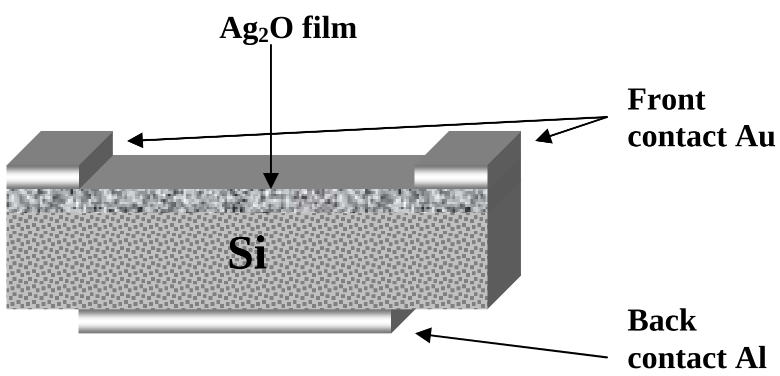


Fig.2 Cross-section view of the final HJ.

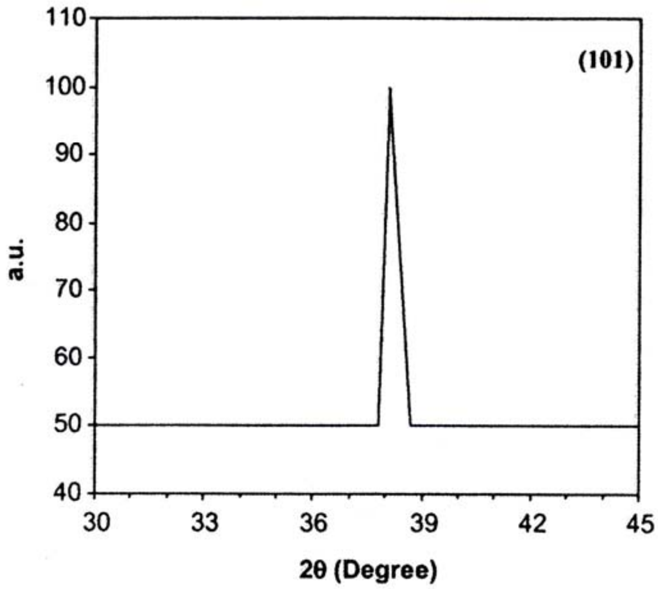


Fig.3 XRD pattern of Ag_2Othin film.

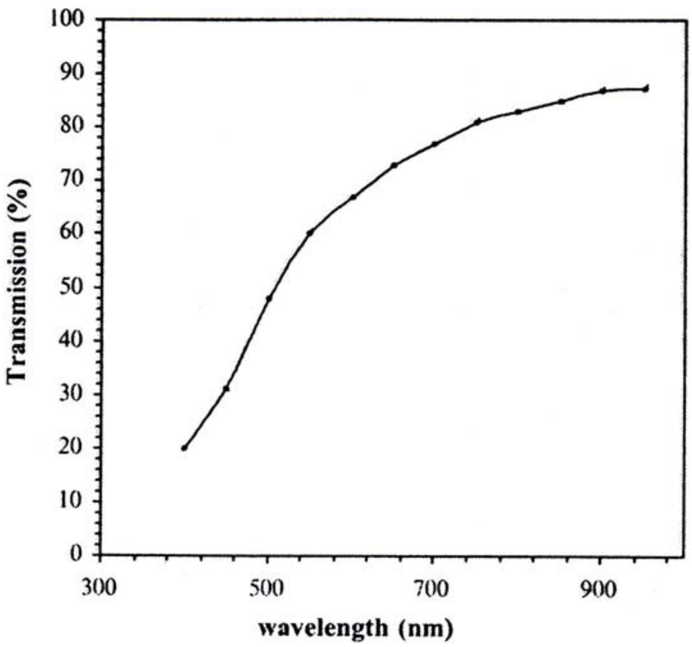
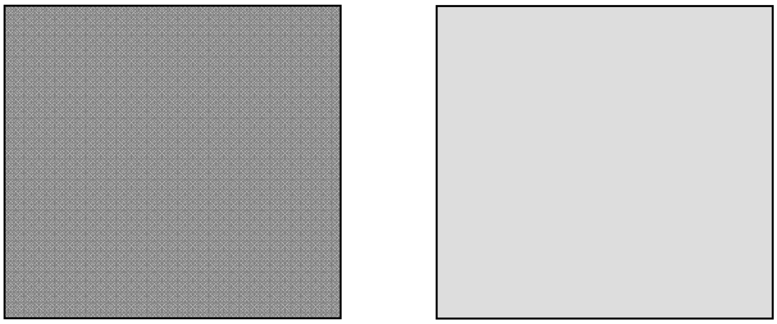


Fig.4 Transmission spectrum of Ag2O film.



A B

Fig.5 (A).Photograph of Ag before thermal oxidation and (B). Photograph Ag after thermal oxidation thin films .

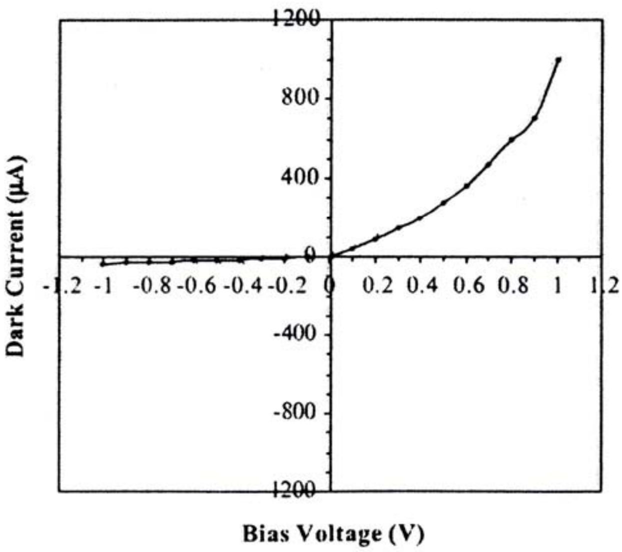


Fig. 6 I-V characteristics of Ag_2O/p-Si isotope HJ.

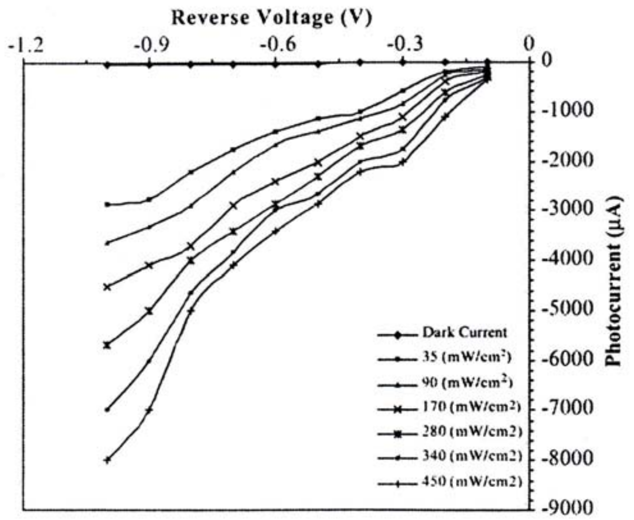


Fig. 7. I-V characteristics under illumination conditions.

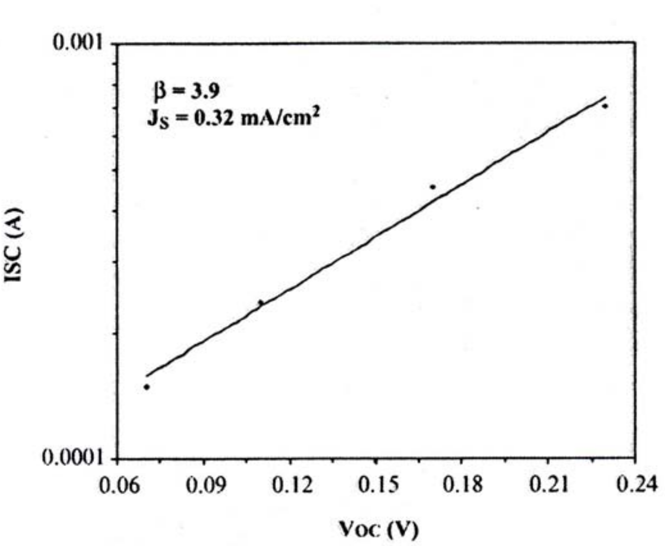


Fig. 8 Isc-Voc curve under different illumination condition

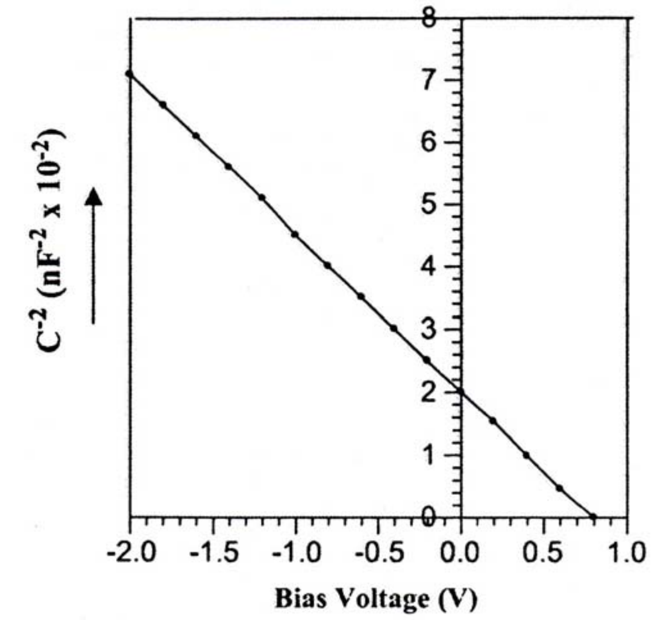


Fig.9 C^{-2} –V of Ag_2O/Si H.J

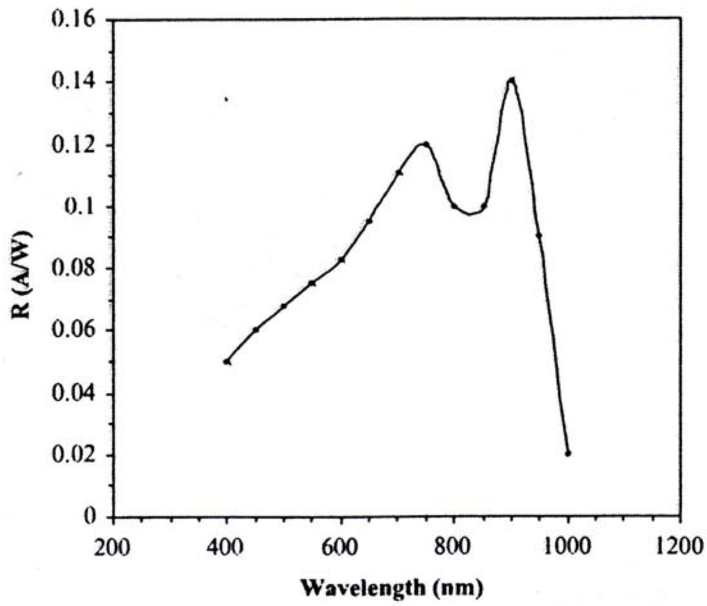


Fig.(10) show responsivity as function of the wavelength

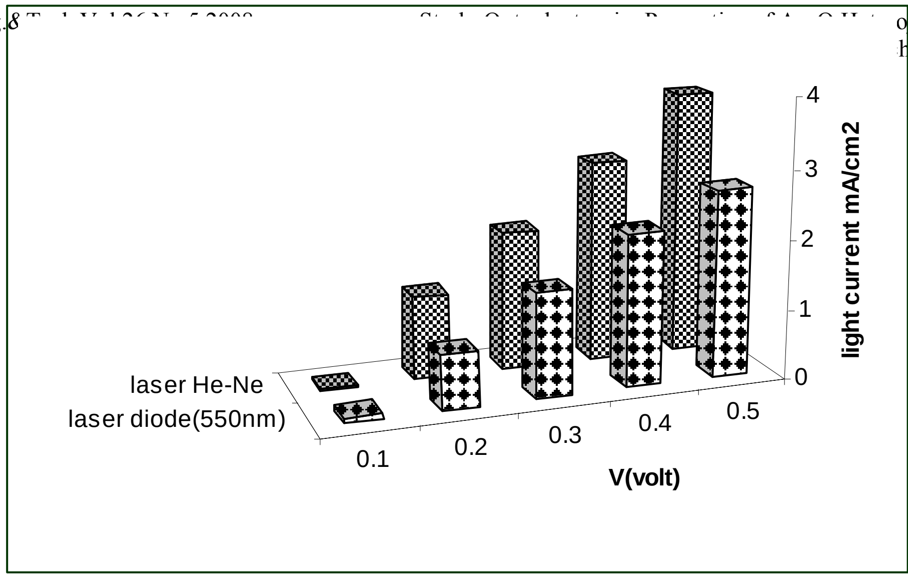


Fig. (11) light current characteristics of Ag_2O-on-Si heterojunction using 1mW He-Ne laser and 1mW diode laser(550nm).