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Original Research Paper

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STUDY OPTOELECTRONIC PROPERTIES OF AG2O HETERO-JUNCTION PREPARED BY PLD

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ABSTRACT Highly (101)-oriented p-Ag2O thin film with high electrical resistivity was grown by pulse laser deposition on clean mono-crystalline p-type Si without any post-deposition annealing. From optical transmittance and absorbance data, the direct optical band gap was found to be 1.4eV. The electrical and photovoltaic properties of Ag2O/Si isotope hetero-junction were examined in the absence of any buffer layer. Ideality factor of hetero-junction was found to be 3.9. Photo-response result revealed that there are two peaks located at 750 nm and 900nm.

KEYWORDS : Ag2O/si; heterojunction, PLD; photovoltaic

Introduction

The metal oxides play a very important role in many areas of physics, chemistry and materials science [1]. Metal elements can form a large diversity of oxide compounds like silver oxide, titanium oxide, vanadium oxide, tantalum oxide, tungsten oxide, iron oxide, copper oxide, tin oxide, zinc oxide etc [2]. The metal oxides, including the nano-metal oxides, have a variety of applications almost spanning the entire gamut of strategic to the day to day devices and absolutely mundane to novel functional materials and devices [3]. To name a few areas of the metal oxides are: microelectronics, non-volatile memories, biomedical devices, sensors, piezoelectric devices, magnetic devices, super conducting magnets and magnetic materials, thermal barrier and anti-corrosion coatings, heterogeneous catalysis, energy conversion and storage devices etc. The metal oxide is presently a few Billion dollars industry with a consistent and rapid growth [4].

The properties of PLD films critically depend on the oxygen partial pressure, substrate temperature. The Ag2O films were deposited by PLD of pellets silver oxide target [5]. Crystallographic structure, surface morphology, chemical bonding configuration, optical properties was systematically studied and reported the results.

It is well known that in metal oxides the oxygen vacancies and the bonding nature of oxygen to the metal ions play a major role in determining the electrical and optical properties of the thin films [6]. Thus, the aim of the present investigation is to study the role of oxygen in the electrical and optical properties of silver oxide (Ag2O) thin films prepared by pulse laser deposition. The growth parameters are: Oxygen pressure, Substrate temperature and Number of pulses.

Silver-oxygen system (Ag-O) was studied extensively in the past due to its important industrial applications. Silver-oxygen contains several defined compounds including Ag2O, AgO, Ag3O4 and Ag2O3 [7]. Among these oxides, the most stable is Ag2O. In the past decade, silver oxide was applied as cathode material in zinc silver oxide button cell batteries for better performance in voltage regulation with longer storage life, read out layer in high density optical storage devices and sensing of carbon monoxide gas [8]. Peyser et al. reported strong photoactivated emission of nanoscale Ag2O for excitation with a wavelength shorter than 520 nm that can be applied for blue optical lasers. Kim et al. [9] realised Ag2O as a mask layer in magneto-optic disk. Her et al. [10] incorporated silver oxide films into super resolution near field structures in optical memories. Thin films of silver oxide were deposited by several techniques such as thermal oxidation of silver films [11], thermal evaporation, pulsed laser deposition, sol-gel process, chemical vapour deposition [12], electro deposition, DC sputtering and RF sputtering.

Results and Discussion

Silver oxide particles Figure (1) shows the absorbance of a gelatin matrix embedded sliver oxide nanoparticle film in the wavelength range between 250 and 900 nm. Trace A was obtained from a luminescent film. The sample was activated to yield maximum visible fluorescence from a 1mm2 activated areas.

Trace B was obtained from a non-activated area of the same sample. The increase in absorbance around 300 nm can be attributed to the absorption of the gelatin matrix itself, as evidenced from spectra taken of a pure gelatin film (not shown).

The maximum at 265 nm in spectra A and B most likely originates from silver oxide nanoparticles, because a pure silver oxide thin film also exhibits an absorbance maximum at this wavelength as can be seen from trace D in the inset of Figure (1). Trace C results from the difference of traces A and B. This spectrum exhibits maxima at 290 nm and 425 nm, as well as a shoulder around 610 nm.

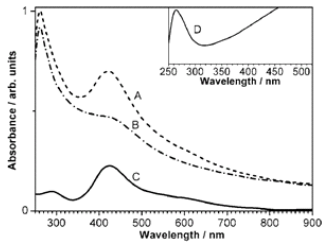

Figure (1): Absorbance spectra of a gelatin film with embedded silver oxide nanoparticles. Trace A (- - -): activated film. Trace B (-.-.-): nonactivated film. Trace C (—): difference spectrum of A and B. Trace D (inset): absorbance of a pure Ag2O nano

Silver oxide has been studied extensively for the applications in electrical, optical and magneto-optical data storage industries. During the past years, the silver oxide electrode applied as a battery material has been developed to achieve better performance in voltage regulation with longer storage life [13] Owing to its larger optical band gap (2.5–3.1 eV), silver oxide is transparent in the infrared and visible regions to realize a transparent electrode and anti-reflective coating for applications in the opt-electrical field. Furthermore, the silver oxide can be applied in optical and magneto optical data storage. The reflectivity of the silver oxide is higher than 70% over a very wide wavelength range. This has the advantage for the material to be applied in the short-wavelength optical data storage to replace the commonly used organic storage material. Using AgxO as the storage material of CD-R disks was first suggested by Tominaga et al. [14], also pointed out that AgxO could be used as a readout layer in a new type of optical disk to produce a metallic probe as a non-transparent aperture. AgxO can be rapidly decomposed into Ag and

oxygen in a small area heated by a focused laser beam to the temperature above the threshold value. The decomposed Ag aggregates and produces a non-transparent metallic area. Therefore, small marks can be recorded and reproduced through the near-field light around the Ag area. Kim et al. [14] pointed out that Ag O could act as a mask layer in a new magneto- x optical (MO) disk. Heated by a focused laser beam to the temperature above the threshold value, the decomposed Ag component or their clusters generated in AgOx film can enhance MO signals by approximately 100 times of those of conventional MO disks. Recently, Peyser et al. [15] reported strong photo-activated emission of nano-scale AgO for excitation with a wavelength shorter than 520 nm, which proved that AgO can be applied to blue optical lasers. Most of the applications of the silver oxide are based on the thermal decomposition process.

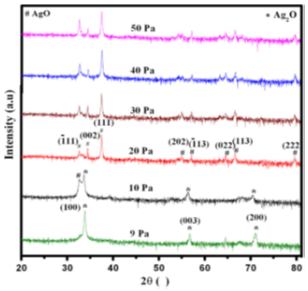

Figure (2) XRD patterns of silver oxide films prepared by PLD technique at (a) 9 Pa, (b) 10 Pa, (c) 20 Pa, (d) 30 Pa, (e) 40 and (f) 50 Pa oxygen chamber pressure.

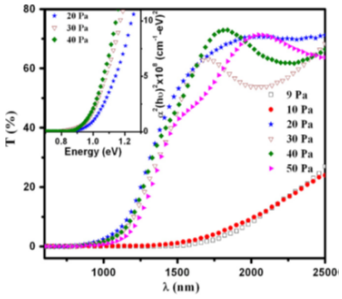

Figure (3) Optical transmittance spectra of silver oxide films prepared from 9 to 50 Pa oxygen chamber pressures and the inset of figure shows the Tauc plot for the films deposited from 20 to 40 Pa oxygen chamber pressures.

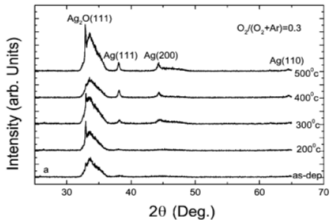

Figure (4) X-ray diffraction patterns of AgxO sample prepared at the O2 gas ratio of 0.3

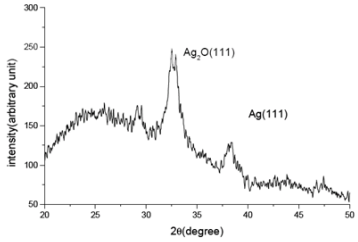

Figure (5) X-ray diffraction patterns of AgOx film prepared at oxygen pressure ratio of 0.5 the chemical AgO and Ag2O

Silver particles dispersed silver oxide film: a dual function write once recording material

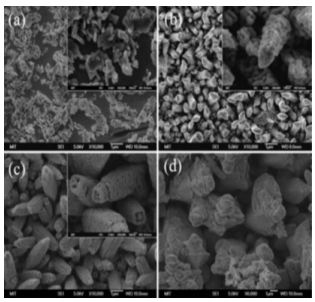

Figure (5) SEM morphology of AgxO electrodes prepared under different current densities from 0.001 M AgNO3 + 0.1 M Na acetate solutions at a pH value of 7.8: (a) 1 mA cm-2, (b) 5 mA cm-2, (c) 20 mA cm-2 and (d) 50 mA cm-2

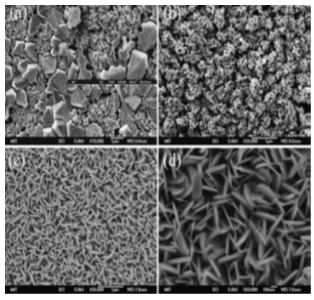

Figure (6) SEM morphology of AgxO electrodes prepared from a 0.05 M AgNO3–0.1 M Na acetate solution at a pH value of 7.0: (a) i ¼ 5 mA cm2; (b) i ¼ 1 mA cm-2; (c and d) i ¼ 0.1 mA cm2.

Oriented silver oxide nanostructures synthesized through a template- free electrochemical route Figure (7) shows the three dimensional atomic force micrographs of films formed at different oxygen partial pressures. The micrographs showed different morphology of surface grains depending on the oxygen partial pressure. The films formed at low oxygen partial pressure of 8x10-3 Pa showed irregular shape of grains the root mean square roughness of 4.05 nm. The films were not uniform with many stick up particles, may be the presence of silver clusters due to low oxygen partial pressure. At oxygen partial pressure of 2x10-2 Pa, the formed films were uniform with root mean square roughness of 4.50 nm. At high oxygen partial pressure of 9x10-2 Pa, the films were grown with larger sized grains and showed root mean square surface roughness of 8.74 nm [14].

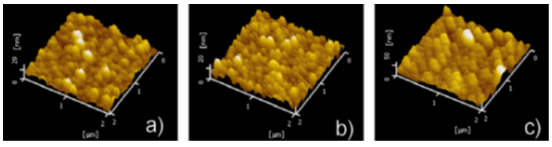

Figure (7) Atomic force micrographs of Ag2O films formed at different oxygen partial pressures: (a) 8x10-3 Pa, (b) 2x10-2 Pa and (c) 9x10-2 Pa.

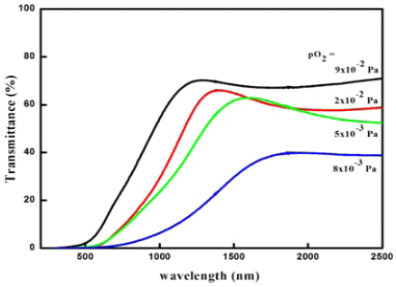

Figure (8) Optical transmittance spectra of Ag2O films formed at different oxygen partial pressures.

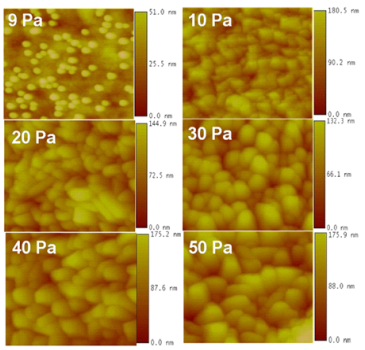

Figure (9) AFM images (1x m×1x m) of silver oxide films prepared from 9 to 50 Pa oxygen chamber pressure.

It is obvious that the film gives good Transparency characteristics at spectral range 500- 1000nm this behaviour is seems to Window. The band gap of Ag2O measured from the plot of the square of h versus photon energy hv(where 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 band pass characteristics. The film exhibit, good adhesive properties to the substrate. Electrical and photovoltaic properties of Ag2O /Si.

Figure (10) shows dark I-V characteristics of Ag2O /Si heterojunction, it is clear that the heterodiode this rectification (If/Ir>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 Figure (4-5) increasing intensity of light result of the increase in the photocurrent, indicating good linearity characteristics,

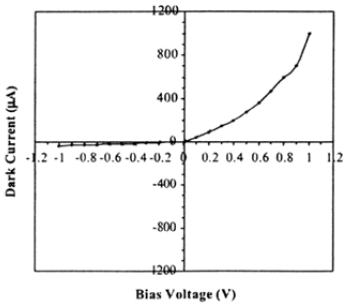

Figure (10) I-V characteristics of Ag2O/p-Si isotope HJ.

Figure (11), displays the cross-sectional view of the final heterojunction.

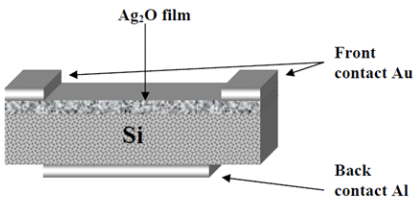

Figure (11) Cross-section view of the final HJ.

figure (12) shows I-V characteristics under illumination conditions, Figure (13) shows the measured Isc-Voc of the heterojunction. The ideality factor was, calculated from Figure (14) and found to be 3.9 at V < 0.24V. The large β value suggests that the recombination in this device occurs Au/Ag_2O contact has good ohmic characteristic.

I-V and C -V measurements of fabricated Ag2O/ Si were examined using a potential sweeper and LCZ meter (100 kHz), respectively. A monochromator was employed to Investigate the spectral response of the Ag2O/Si heterojunction after making power calibration. Photovoltaic properties were measured at different illumination levels.

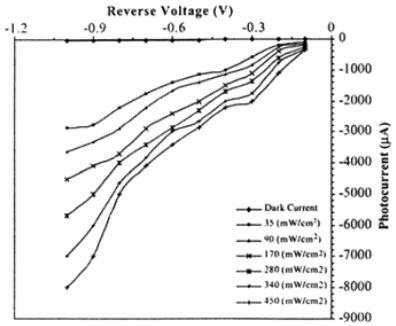

Figure (12) I-V characteristics under illumination conditions

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 schrer 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) [4].

The illuminated I-V under (different light levels is depicted in Figure (12) increasing intensity of light result of the increase in the photocurrent, indicating good linearity characteristics Figure (13) shows the measured Isc-Voc of the heterojunction.

The ideality factor was, calculated from Fig.8 and found to be 3.9 at V < 0.24V. The large value suggests that the recombination in this device occurs primarily in the junction interface [8].

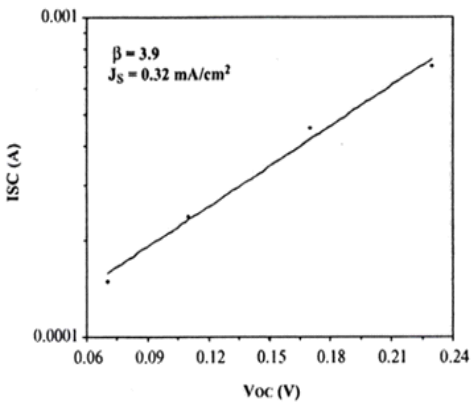

Figure (13) Isc-Voc curve under different illumination condition

Figure (14) shows 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.

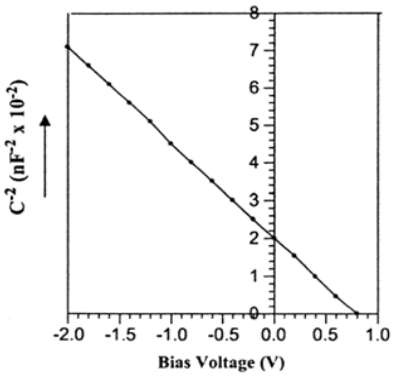

Figure (14) C-^{2} –V of Ag2O/Si H.J

Conclusions

Despite the large lattice mismatch, isotope abrupt Ag2O/Si 11.1 with encouraged photovoltaic characteristics was obtained using the PLD 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 two is attractive to c-Si solar cell applications. Annealing and doping films to enhance the photovoltaic properties are underway.

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