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ORIGINAL PAPER

Fabrication of High Responsivity for MgO NPs/PSi Heterojunction Device by Sol-Gel Technique

Aseel M. Abdul Majeed[1] · Itab F. Hussein[1] · Rana O. Abd Al-Jalil[1]

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Abstract

In this work, porous silicon was preparation by electrochemical etching and the MgO thin film by sol-gel technique. The structural properties of MgO NPs were studied using XRD and the morphology properties by field emission scanning electron microscopy. The electrical properties; spectral responsivity, detectivity of the photodetector were measured. The Spectral responsivity of MgO/p-PSi/Si photodector was found to be around 0.39 at 550 nm and 0.56 A/W at 800 nm and the specific detectivity of MgO/Psi/Si was found to be $6*10^{10}$ W^{-1} cm $Hz^{1/2}$. The photodetector shows a photovoltaic behavior with a maximum Voc. of 0.25 V and I_{Sc}. of $7.6*10^{-3}$ A.

Keywords MgO/PSi · Photodetector · Detectivity

1 Introduction

Nanoscience has emerged in recent years in the introduction of science techniques. Nanotechnology plays a major role in the industrial revolution. The true properties of nanoscience are determined by their size and shape [1]. Metal oxide nanomaterial's have been attracted due to have many potential application like catalysis electro- optical devices, sensors, water purification and, superconductors Therefor are used in electronic devices due to its low heat capacity and high melting point [2]. It is very important point to studied of magnesuim oxide nanoparticles that a high surface area for observation in adsorption materials. Different MgO structures, like nanoparticles, nanorods, nanowires and nanosheets have been prepared successfully and many kinds have been used to fabrication MgO nanostructures like radio frequency (R.F.) magnetron sputtering [2], spray pyrolysis [3], hydrothermal method [4], sol-gel method [5]. In this work, gel has become a good method is chosen for the fabrication MgO nanoparticles with thin size distribution and high surface area is necessary to solve trouble such as low reactivity and catalytic action. MgO is the best dielectric layer due to its excellent properties such as has high dielectric constant (9.8), large band gap (7 eV) and has higher breakdown field (12Mv/cm), low optical loss and low refractive index (˜ 1.7), which can suitable of optical modes in large ferroelectric [2].

2 Experimental Part

2.1 MgO Nanoparticles Synthesis

Magnesium oxide nanostructure were prepared by sol-gel method at 0.2 M of $Mg(NO_3)_2.6H_2O$, 0.2 M sodium

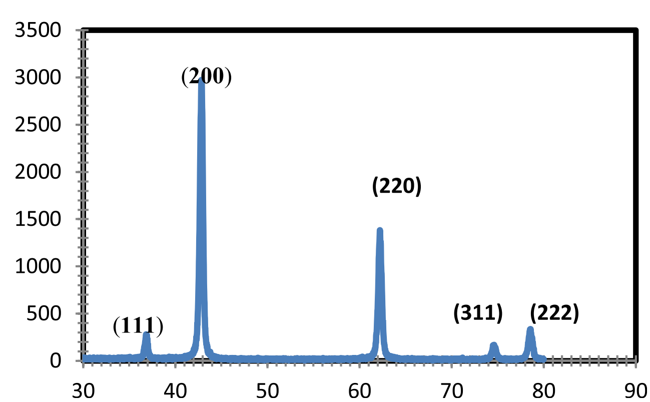

Fig. 1 X-Ray diffraction of MgO NPs

✉ Aseel M. Abdul Majeed
aseelalaziz@yahoo.com

Itab F. Hussein
itabfadhil@yahoo.com

[1] Physics Department, College of Science, Mustansiryah University, Baghdad, Iraq

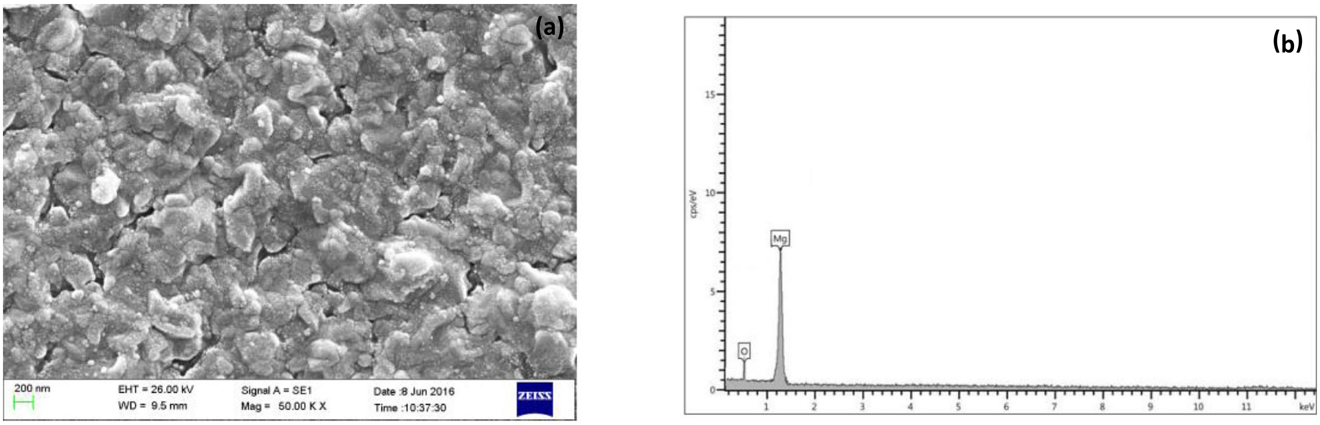

Fig. 2 **a** FESEM image of MgO NPS, **b** EDX spectrum of MgO

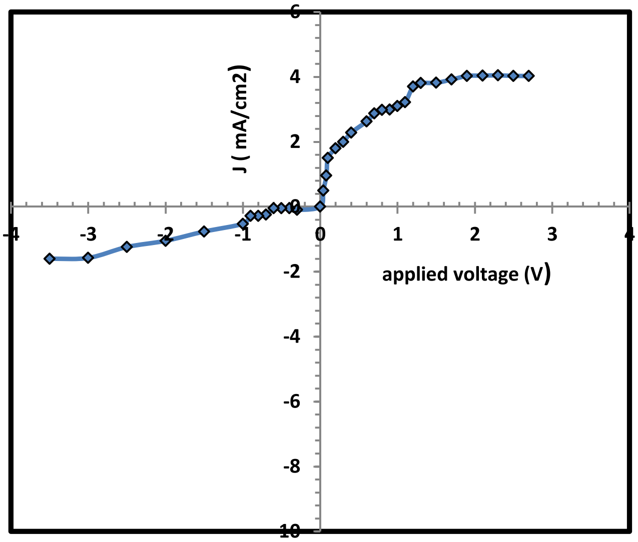

Fig. 3 Shows (J-V) characteristic of MgO NPs./p-Psi/Si device

hydroxide NaOH and using urea dissolved in 100 ml distilled water, both solution were mixed under magnetic stirring for 15 min. at room temperature. After washing by double distilled water and ethanol, the precipitate dried at 100 °C. Finally the calcinations were carried out at 600 °C for 5 h.

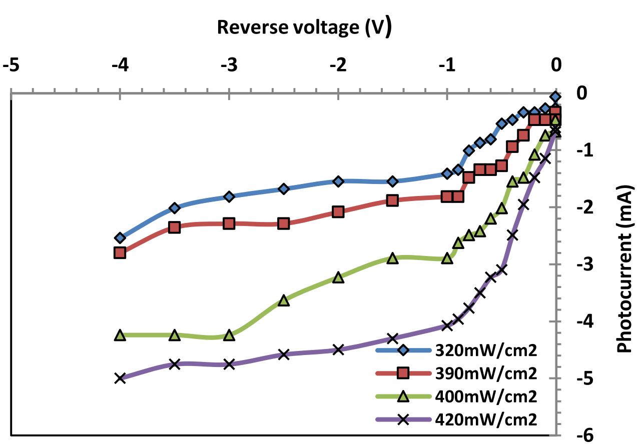

Fig. 4 Illuminated (I-V) characterization of MgO /p-PSi/Si device as a function of the visible light intensity.

2.2 Preparation of Porous Silicon

P-type of single crystal silicon with resistivity (0.5–2)Ω.cm and (100) orientation, homogenous of PSi layer were formed on the surface by electrochemical method, the process was carried out at 30 min. and current densities 20 mA/cm^2 by using at (1:1) mixture of HF 40% and methanol 99.9%. Also MgO nanoparticles deposition on Psi MgO/p-Psi/Si by drop casting. The morphology and optical properties and detector parameter of device have been measured.

3 Result and Discussion

In order to specific the particle size and the nanostructure properties of the MgO nanomaterial, the powder XRD analysis were performed and shown in Fig. 1. The bragg diffraction peaks at 2θ values of 37°, 43°, 62.25°, 74.8° and 78.83°, According to the standard JCPDS No (98–000-5910) XRD pattern of MgO nanoparticles are cubic structure and all peak are sharp with narrow broadening. The Crystalitte size of MgO can be calculated by scherrer equation was about 30 nm and same as reported by [6–8].

The FESEM is shown in Fig. 2a. It is clear that the characterization of MgO nanoparticles formed highly agglomerated and uniform size distribution; the average grain size was 30 nm. Figure 2b is shown the quantitative analysis of MgO NPs. Was done by EDX. It is clear strong peak that only of Mg and O and there is not any other peak in the EDX. This means high purity of the MgO NPs [9].

Figure 3 shows the J-V dark characteristics in forward and reverse direction of MgO/p-PSi/Si photodetector. These characteristics are important to describe the device performance and the device parameters depending on it. The forward current of Al/MgO/p-PSi/Si/Al device has two regions, the first is

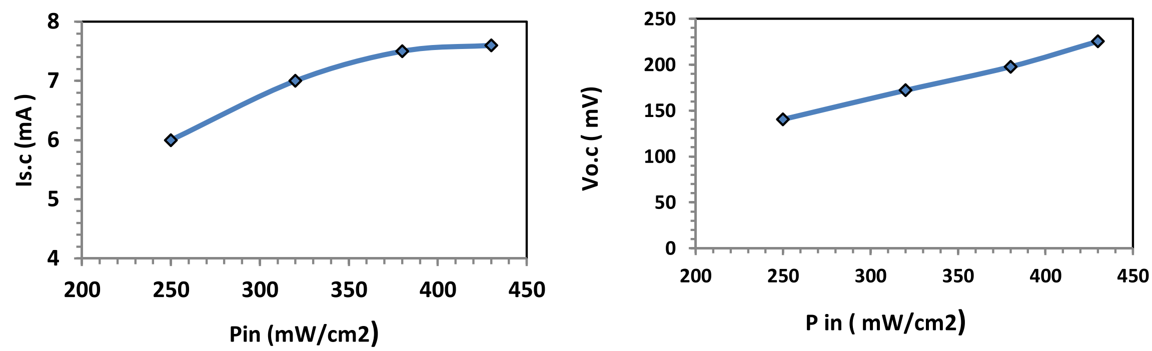

Fig. 5 **a** short circuit current, **b** open ciruit voltage for MgO/PSi/Si device

known as recombination current and the second region is the diffusion current. It is clear that the increasment is not sharp which give an indication that this current is mixed of diffusion and recombination components [10].

Figure 4 shows the I-V properties of MgO/Psi/Si device different illuminations. It is noticed that the photocurrent in reverse bias only. When the MgO/PSi/Si device is visible light illuminated (tungsten lamb), the hole-electron pairs are generated, that take place in the minority carrier which able to diffuse to the edge of the depletion region before recombination take place and Increasing the intensity it is caused to increasing photocurrent. This can be followed to the number of absorbed photons become greater and a large number of electron-holes pairs are generated. The MgO/PSi heterojunction and Psi/Si heterojunction, this is good and agreement with published [11, 12].

Figure 5 show the relation between Isc. Current and Voc voltage of MgO/PSi/Si heterojunctions with the white light power. From obtained result it is observed that the relationship is linear and reach maximum value beyond which both values tend to saturated and become constant agreement with published [13].

Figure 6 displays the spectral responsivity for Al/ MgO/PSi/Si/Al device with −3 V bias. It is clear, there are two regions of peak response, the first region is located at visible represented MgO/Psi and the second located at NIR represented PSi/Si. The maximum value of resposivity of MgO/PSi/Si was found o.56 A/W at (λ = 800 nm). The responsivity of Al/MgO/PSi/Si/Al device can be expressed by the equation [14].

$$\text{Reponsivity} = \mathrm{R(MgO/PSi)}_{\text{heterojunction}} + \mathrm{R(PSi/c\text{-}Si)}_{\text{heterojunction}}$$

Figure 7 represents the Spctral detectivity as a function of wavelength for MgO/PSi/Si device. It is found the peak of detectivity for photodetector was located at 800 nm at the maximum value is around $6*10^{10}\ \mathrm{W^{-1}cmHz^{1/2}}$.

4 Conclusions

Magnesuim Oxide/PSi/Si photodetector was investigated by electrochemical and Sol- gel methods. Magnesuim oxide NPs deposited on porous silicon by drop castle. An average particle size of MgO nanoparticles was found to b 30 nm by FESEM. XRD pattern revealed the good crystalline of MgO. The spectral responsivity of MgO/PSi/Si device have a good photoresponse in the visible and near IR regions. The responsivity was 0.39 A/W and 0.56 A/W respectively.

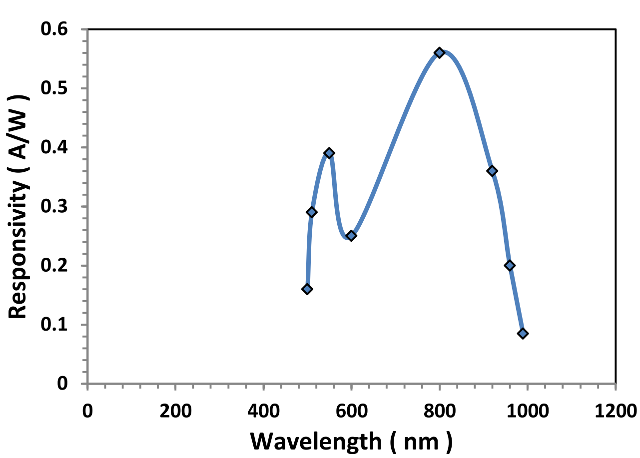

Fig. 6 Spectral responsivity for MgO/Psi/Si

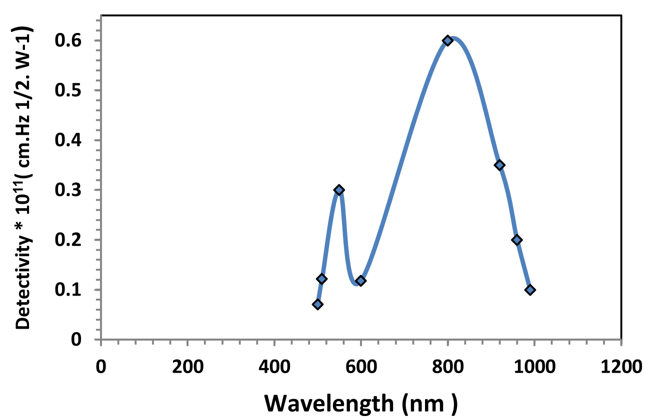

Fig. 7 Specific detectivity for MgO/PSi/Si device

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