Synthesis and characterization of Silver doped TiO_2 nano films for Solar Cell Applications

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1 ABSTRACT

Utilization of Solar Energy is based on the ability of semiconductor particles to function as photo catalysts by promoting various oxidation and reduction reactions under sunlight. For the improvement of its catalytic capability, Silver doped TiO_2 nano films of thickness 15nm were developed on p-Si (100) substrate by Pulsed Laser Deposition (PLD) method. XRD, AFM and Raman Studies are made to characterize the surface are reported**.**

2 INTRODUCTION

The widespread use of solar photovoltaic technology for terrestrial and domestic applications is limited due to its high cost per unit watt. Thin film and hence nano film based solar cell is one of the best options. Nano particles (Ag or Au, with particles sizes in the range of 20 to 100 nm) are deposited on the solar cell surface, due to surface plamon resonance excites and enhances the electromagnetic field near the metal surface where the absorption of photon increases[1]. The maximum absorption wavelength of plasmonic particles has been found to be greatly dependent on factors such as size, shape, and dielectric environment [2]. This property is exploited in Photo voltaic cell to improve photo current through its spectral response. Silver doped nano composite thin films show that they are nano crystalline in nature, highly transparent, homogeneous with no visible pinholes and suitable for solar cell application [3].

In our study, Silver doped TiO_2 thin films are prepared by Pulsed Laser Deposition (PLD) technique on p-Si (100). Dependence of various parameters are studied at different annealing temperatures suitable to solar cell applications.

3 EXPERIMENTAL

3.1 Materials and Preparation of Ag doped TiO_2

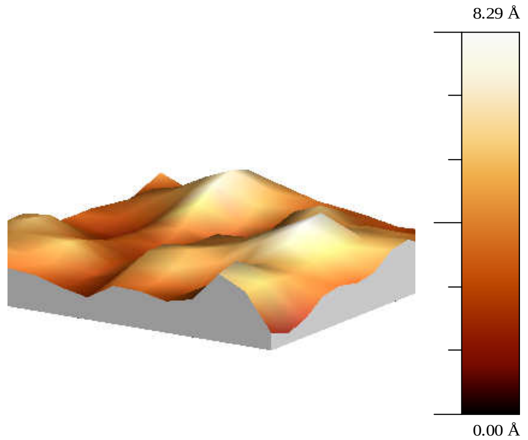
TiO_2 Powder (Molecular Weight 79.9, Purity 99.9%) was mixed with Ag_2O(Molecular Weight 231.749, Purity 98.9%) and ground for 6 hours by wet ball mixing using acetone/alcohol as solvent and pressed to target at hand pressure. The target having dimensions of thickness 2mm and diameter 24mm were prepared after sintering 1200° C for 8 Hours. Target was mounted on pellet with silver epoxy by heating for 2 hours. Target along with pellet was fixed in PLD chamber. Si Substrate was arranged on sample holder in PLD chamber. Film of TiO_2 mixed with Ag_2O was deposited by using rotating arrangements in PLD chamber by PLD technique. The base pressure was bought down to $3x10^{-6}$ Torr and thin film a deposited at a working pressure of $1x10^{-4}$ in an ultra pure oxygen atmosphere. The target was ablated with KrF exclaimer laser pulse (248 nm) that was synchronized with rotational motion. Films deposited under Laser power of 230 mJ with repetition rate of 10 Hz and duration of 10 minutes.. Post annealing was performed in oxygen atmosphere at 435°C for 105 minutes with pressure of $1x10^{-4}$. Substrate was cooled for 90 minutes gradually by decreasing the temperature in presence of oxygen atmosphere by reducing the heater current of 0.5 ampere step by step interval of 10 minutes.

4. Results and discussion

To evaluate the performance of Plasmon resonance effect and to enhance the efficiency of photochemical cells, thin films of TiO_2 is doped with 2% Ag (By molecular weight) particles on p-Si. We found that the photo response in the visible region is increased and the photo response in the UV region decreased. These results suggest that Plasmon resonance effect contributes to the enhancement of photocurrent, and indicates the possibility of improving the energy conversion efficiency with Silver doping. The Characterization of the film is to study 1. Surface morphology 2. Optical Properties and 3. Electrical properties.

4.1 Surface Morphology

4.1.1 AFM Analysis



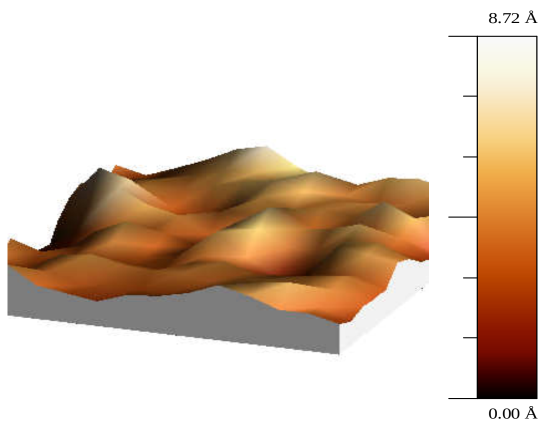


Figure 1.AFM Images of Silver doped TiO_2 on p-Si (100) at annealing temperatures a) 435°C and scan size 195.3 nm×195.3nm with Grain size of 20nm: b) 496 ° C and scan size 97.7 nm×97.7nm with Grain size of 20nm.

Parameter	Hole Analysis	Hill Analysis	Intervals analysis
Numbers of	1	19	19
First Neighbors Distance,nm	0	32.9395	32.94
Area, nm^2	32715 (85.76%)	5432.16 (14.24%)	5432.16 (14.24%)
Volume, nm^3	5373.42	414	-
Total length Perimeter, µm	1.22	1.22	1.22
Area Perimeter Ratio, nm	27.02	4.47	4.47
Bearing Ratio, nm^2	32721.9 85.76%)	5433.04 (14.24%)	5433.04 (14.24%)

Parameter	Hole Analysis	Hill Analysis	Intervals analysis
Numbers of	612	78	78
First Neighbors Distance, nm	8.09	18.10	18.10
Area, nm^2	32844.5 (13.14%)	217155 (86.86%)	217155 (86.86%)
Volume, nm^3	7433.42	57856	-
Total length Perimeters, µm	16.70	16.64	16.64
Area Perimeter Ratio, nm	1.96728	13.06	13.06
Bearing Ratio, nm^2	33283.3 (13.26%)	217660 (86.70%)	217660 (86.70%)

Table 3.1.1(a) Flooding Analysis of Silver doped TiO_2 on p-Si (100) at annealing temperature 435°C scan size (195.3 nm×195.3nm) (b) at annealing temperature 496°C scan size (97.7 nm×97.7nm)

AFM Images of Silver doped TiO_2 on p-si (100) at different annealing temperatures are shown in the figure 1. For the sample of Annealing Temperature 435° C, Various surface parameters such as Surface Roughness (RMS), Surface roughness (AVG), Average height and Grain size are 1.4404nm, 1.1709nm, 4.1912nm, 20nm.

For the sample of Annealing Temperature 496° C, various surface parameters such as Surface Roughness(RMS), Surface roughness (AVG), Average height and Grain size range are 1.1709nm, 1.012nm, 2.7879nm, 10nm- 35nm.

Table 3.1.1(a) and table 3.1.1(b) shows that as the deposition temperature increases Grain size varies from 5 nm to 30 nm and bearing ratio also increases. i.e. porosity increases. Porosity and roughness also depend on deposition temperature.

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4.1.2 XRD Analysis

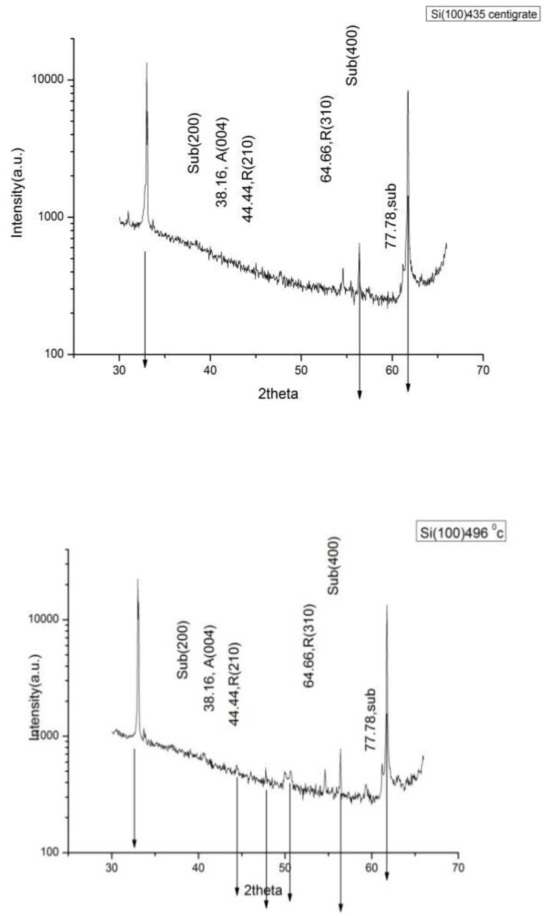

Figure 2.XRD Images of Silver doped TiO2 on p-Si (100) at annealing temperatures a) 435°C b) 496 ° C.

XRD analysis of thin film of silver doped TiO_2 on p-Si shows that the intensity patterns almost maintains its value at different annealing temperatures.

Figure shows the XRD pattern of silver doped TiO_2 on p-Si at different annealing temperatures ie, at 435°C and 496°C. The intensity variation at different angles of diffraction for sample annealed at 435°C is (8499:61.85°; 633.114:56.52°); (426:54.56°); (464:45.11°; 416:54.60°; 80.028:45.05°C) showing the presence of Si, TiO_2 and Ag. The intensity variation at different angles of diffraction for sample annealed at 496°C is (12779.066:61.827°; 761.17:56.41°); (514:54.72°); (526.521:47.88; 550.044:44°C) showing the presence of Si, TiO_2 and Ag.

4.2 Optical Properties

4.2.1 Raman Analysis

The Raman images (Jobin Yvon Horibra LABRAM-HR visible (400 - 1100 nm) of two different sets are presented in Figure 3. Raman analysis of thin film of silver doped TiO_2 on p-si(100) shows that the intensity patterns almost maintains its value at different annealing temperatures. The results are shown in Figure 3 and Table I.

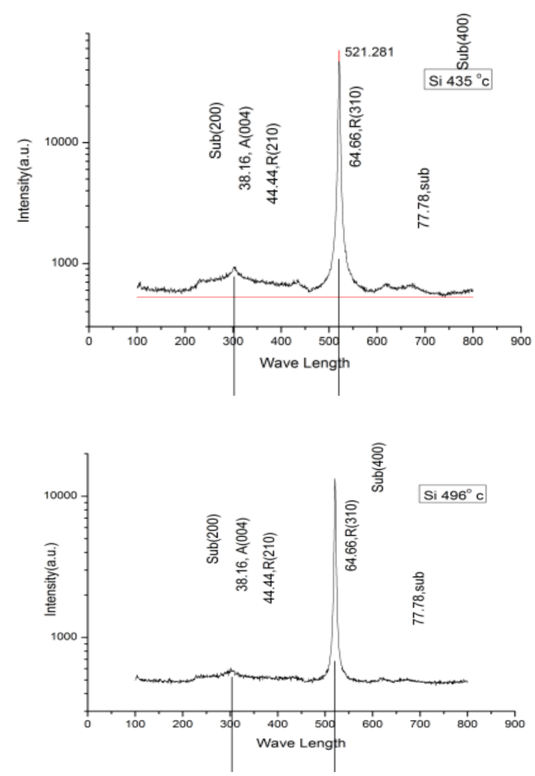

Figure 3. RAMAN Images of Silver doped TiO2 on p-si (100) at annealing temperatures a) 435°C: b) 496 ° C

Table I: Variation of optical properties of Silver doped TiO_2 on p-si (100) at annealing temperatures a) 435°C: b) 496 ° C

Property / Order of peak	**I**	**II**	**I**	**II**
Annealing Tempe-rature,°C	435	435	496	496
Wave Length, nm	302.26	521.28	303.95	520.62
Wave Number, cm^{-1}	33084.42	19183.51	32900.17	19207.87
Intensity, A.U	928.47	51073.40	605.29	13203.48
Frequency, THz	991.85	575.11	986.32	575.84
Energy, eV	4.11	2.38	4.09	2.39

Figure 3 shows that the Plasmon shifting of spectral response from ultra violet to visible range. Table shows the quantitative suppression in the intensity of spectral response in the UV region and enhancement in the intensity of spectral response in the visible region at at annealing temperatures (a) 435°C (b) 496 ° C.

4.3 Electical Properties–Resistance measurement

A silver doped TiO2 nano film on p-Si (100) has different resistance values at different annealing temperatures. Thin film with thickness range of 5-10 nm Annealed at 435° C has resistance of 0.43 MΩ. Thin film with thickness range of 20 nm Annealed at 496° C has resistance of 4.07 MΩ.

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