Effects of interfacial oxide layer thickness and interface states on conversion efficiency of $SnO_2/SiO_2/Si(N)$ solar cells

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Abstract. In this paper, we studied the effects of interfacial oxide layer thickness and interface state density on the open circuit voltage and efficiency of the $SnO_2/SiO_2/Si$ (N) solar cells. The results obtained by numerical simulation using Matlab programs are presented and discussed. The $SnO_2/SiO_2/Si$ (N) solar cells, in which the interfacial oxide layer thickness is optimized to 21 A°, have an average open circuit voltage of 0.62 V and a short circuit current of 36 mA/cm². The calculated conversion efficiency of the cells can be as high as 17.5 %.

Keywords: Solar cell, Heterostructure, Oxide layer, Efficiency, Simulation.

1. Introduction

There has been considerable interest in recent years directed toward the development of metal-insulator-semiconductor (MIS) solar cells. Very often in these structures, tin oxide (SnO_2), indium tin oxide (ITO), and zinc oxide (ZnO) were used in place of the metal electrode [1]. Among these, SnO_2 is chosen because of its high electrical conductivity [2] and its transparency in the visible and infrared light [3], therefore it acts as a window for sunlight. Further, its refractive index lies in between 1.9 and 2.0 and hence it can be used as an antireflection (AR) coating [4].

2. Results and discussion

A. *Effect of the interfacial oxide layer thickness on the open circuit voltage of the $SnO_2/SiO_2/Si(N)$ solar cells*

The results of calculation of open circuit voltage V_{oc} as a function of δ for different values of Φ_0 are shown schematically in figure 1. The increase in open circuit voltage with increasing the interfacial layer thickness δ in the initial stages is due to reverse current (J_S) reduction and hence to the thermionic emission current reduction (J_{TE}) which is shown in figure 2.

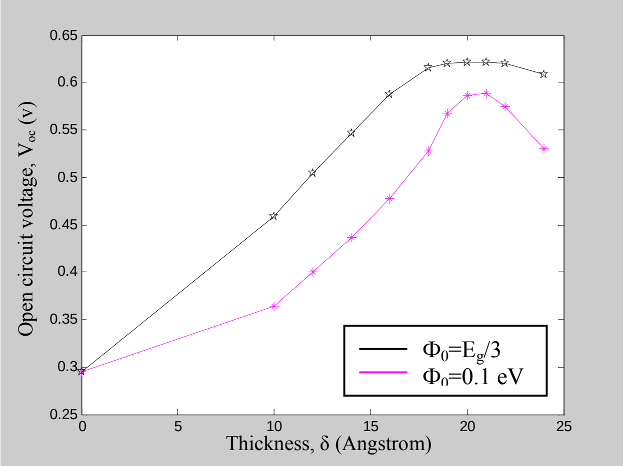

Figure 1. Variations of V_{oc} with interfacial oxide layer thickness δ at different values of Φ_0

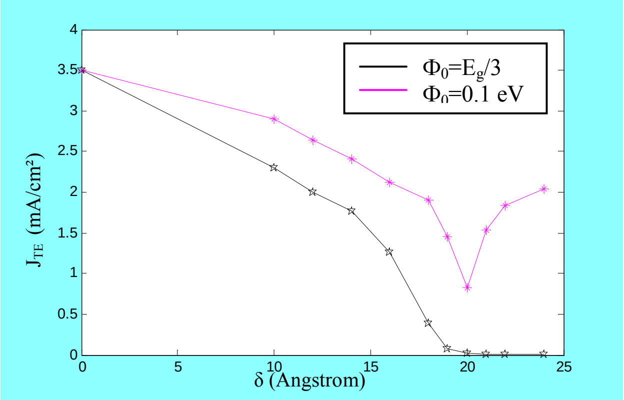

Figure 2. Variations of the thermionic emission current J_{TE} with interfacial oxide layer thickness δ at different values of Φ_0

B. Photovoltaic characteristics of *$SnO_2/SiO_2/Si(N)$ solar cell*

The current–voltage characteristics of the cell under illumination are computed for different values of interfacial oxide (insulator) thickness δ and presented in figure 3.

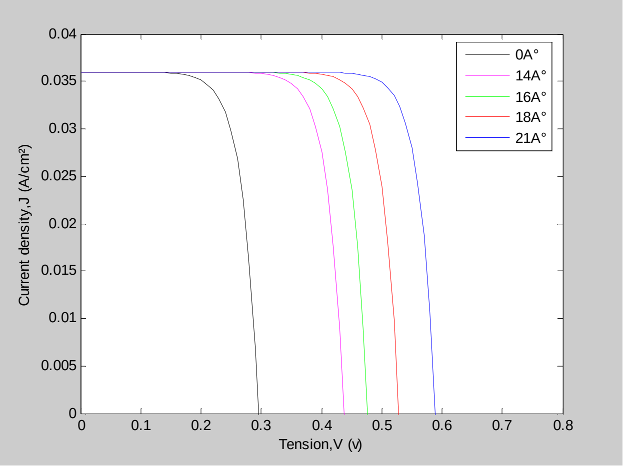

Figure 3. Illuminated J – V characteristics for the $SnO_2/SiO_2/Si(N)$ solar cell at different values of insulator thickness δ when Φ_0=0.1 eV under optimum conditions.

C. Effect of the interfacial oxide layer thickness on the efficiency of the $SnO_2/SiO_2/Si(N)$ solar cells

The results of calculation of conversion efficiency of the cell for different values of the interfacial layer thickness for specific values of interface state density and Φ_0 are shown in figure 4. The efficiency initially increases with δ due to an increase in open circuit voltage V_{oc}. When Φ_0=0.1 eV, the decrease in efficiency, after a certain optimum, is mainly due to a decrease in the fill factor FF for higher values of δ. In Table 1 we give the calculated values for fill factor FF for two cases: Φ_0= 0.1 eV and Φ_0= E_g/3 eV.

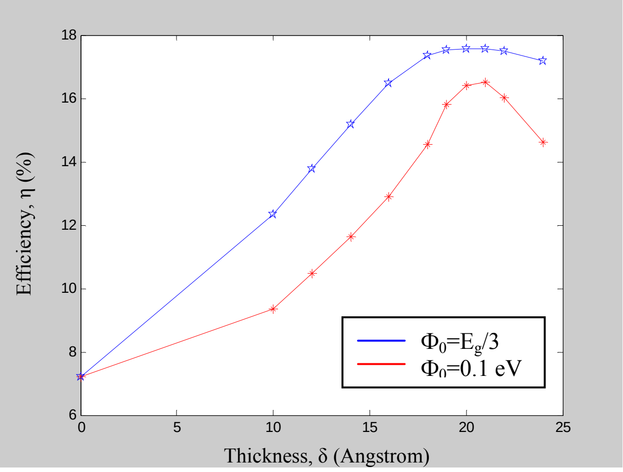

Figure 4. Variations of the efficiency with interfacial oxide layer thickness δ at different values of Φ_0

TABLE 1: The calculated values for fill factor FF for different values of the interfacial oxide layer thickness δ for specific values of Φ_0, under optimum conditions.

δ (A°)	FF (Φ_0=0.1eV)	FF (Φ_0=E_g/3eV)
0	0.68	0.68
10	0.71	0.75
12	0.73	0.76
14	0.74	0.77
16	0.75	0.78
18	0.76	0.78
19	0.77	0.78
20	0.78	0.78
21	0.78	0.78
22	0.77	0.78
24	0.76	0.78

The improved fill factor and the increase in the solar conversion efficiency of the cells make such optimized oxide layers, important components in the solar cells fabrication. The $SnO_2/SiO_2/Si$ (N) type solar cells can be made by a low cost processing like APCVD (Atmospheric pressure chemical vapour deposition) or Spray pyrolysis [2]. These cells can be used in the fabrication of solar panels as clean energy converters.

3. Conclusion

The inclusion of an interfacial oxide layer (SiO_2) between SnO_2 and Si leads to the improvement of the open circuit voltage and efficiency of the solar cells by reducing the dark current. Such improvement allows the use of the $SnO_2/SiO_2/Si$ (N) type solar cells as clean, efficient and economical energy converters. The optimum oxide layer thickness for maximum efficiency is found to be 21 A°. The calculated efficiencies of the cells can be as high as 17.5 %. Combining the high–efficiency, lower cost processing, we believe the $SnO_2/SiO_2/Si$ (N) type solar cells have good potential to meet the goal of large-scale terrestrial applications.

References

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