단결정 실리콘 태양전지를 위한 실리콘 질화막의 밴드갭과 결함사이트
Band Gap and Defect Sites of Silicon Nitride for Crystalline Silicon Solar Cells

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Abstract : In this paper, silicon nitride thin films with different silane and ammonia gas ratios were deposited and characterized for the antireflection and passivation layer of high efficiency single crystalline silicon solar cells. As the flow rate of the ammonia gas increased, the refractive index decreased and the band gap increased. Consequently, the transmittance increased due to the higher band gap and the decrease of the defect states which existed for the 1.68 and 1.80 eV in the SiNx films. The reduction in the carrier lifetime of the SiNx films deposited by using a higher NH_3/SiH_4 flow ratio was caused by the increase of the interface traps and the defect states in/on the interface between the SiNx and the silicon wafer. The silicon and nitrogen rich films are not suitable for generating both higher carrier lifetimes and transmittance. These results indicate that the band gap and the defect states of the SiNx films should be carefully controlled in order to obtain the maximum efficiency for c-Si solar cells.

Key Words : Solar cell, Antireflection coating, Passivation, Band gap, Defect states

1. 서 론

In this paper, we describe the results of the research performed concerning the relationship of the band gap and defect states of SiNx films to the antireflection and defects of the SiNx and the passivation at the interface between the SiNx and the silicon substrate. First, the refractive index and the band gap of the SiNx films prepared using the plasma enhanced chemical vapor deposition method were examined as a function of the ammonia/silane (NH_3/SiH_4) gas flow ratio. Then, the effect of the defect states on the transmittance of the SiNx thin films with different refractive indexes was determined by the photoluminescence and the absorption spectra. The carrier lifetime of the silicon wafers passivated by using the SiNx films with different refractive indexes was also investigated. Finally, the SiNx films with different refractive indexes were examined for the estimated effect of the passivation and antireflection on the electrical parameters of the c-Si solar cells.

2. 결과 및 토의

As the flow ratio of the NH_3 to SiH_4 increased, the optical transmittance increased. Notably, a transmittance of higher than 90% was obtained by the SiNx film deposited using a flow ratio of NH_3 to SiH_4 higher than 2. As the NH_3 flow rate increases, the defect states in the N-rich SiNx films rapidly decreases and the defects states in the SiNx films almost disappear. The D_{it} increases as the flow rate of NH_3 to SiH_4 increases due to the increase of the Si-N bonding. The extreme cases of silicon and nitrogen rich films are not suitable to generate a high carrier lifetime on a silicon substrate. The J_{SC} and FF of the c-Si solar cells using a stoichiometric SiNx film as the antireflection and passivaton layer are 34.84 mA/cm^2 and 77.77%, respectively. The c-Si solar cell with the stoichiometric SiNx film achieved an increase of energy conversion efficiencies. The transmittance and the carrier lifetime, which depend on the band gap and the trap states of the SiNx films and the interface defect sites between the SiNx and the silicon, are the points for special consideration for the fabrication of high efficiency c-Si solar cells.

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