Investigation of morphological, optical properties of multi-layer coatings for so...

Science, Physics

For Solar Energy Multi-Coatings (SEMCS) applications we investigated the influence of surface roughness with the number of layer on the optical and structural properties, hence, improved transmittance, reduced reflectance, and increased band gaps for single-, double-, and triple- coatings of semiconductors, more over the decrease in crystallite size and change in lattice parameter due to more strain effect on peak broadening of crystal structure, our experimental observation is supported by simulation based on the roughness with the energy gaps and refractive indices, Film morphology was studied by Atomic Force Microscopy (AFM), and Scanning Electron Microscopy (SEM), optical properties studied by Uv-visible spectroscopy, and structural properties investigated by X-Ray Diffraction (XRD).

Keywords: multi-layer coatings; surface morphology; strain; structural properties.

Introduction

Anti- Reflection (AR) coating has been used in various applications such as solar cells, anti-glare coatings for lenses, and was first used to military optical instruments to decrease light quantity reflected from the lenses surfaces. These AR coatings were initially one layer of CaF_2 and then MgF_2. magnesium di-fluoride (MgF_2) has high transparency (T) and low refractive index (n) and has been used as ARCs to reduce reflection losses. Anti-Reflective Coating (ARC) gives significant optimization in solar cell efficiency. Antireflection coating techniques have been offered such as single layer, double layer, multi-layer, graded-index layer [8] and stacked index layer structures. It has been declared that one layer coating is minimizing reflectivity in a narrow spectral range, and reflectivity could be decreases by making a double or even multilayer (ARCs). ARCs design by many thin layers of different compound to optimize the transmission across the wavelengths region absorbed within the solar cell. Due to the high refractive indices of semiconductors, high reflection losses must be minimized by (ARCs) for multi-Junction solar cells. Among the various possible combinations of DLAR coatings, combinations such as MgF2/ZnS, MgF2/TiO2, SiO2/SiNx, and MgF2/CeO2 have already been reported.

The most efficient ARC in practice is the magnesium fluoride/zinc sulfide (MgF2/ZnS) double layer, with an effective reflectance of 3. 3 %. We prepared broadband ARCs (350–1100 nm), and compare antireflection effects among single layer (ZnS), double layer (MgF2/ZnS), triple layer (MgF2/ZnS/MgF2) and quadruple layer (MgF2/ZnS/MgF2/ZnS) ARCs by optical, morphological and structural properties, and we focused to study the characteristics of AR coatings surface roughness depending (by experimental and mathematical equations) on the reflectance as well as the energy gabs of AR coating layer, the thicknesses of the films were measured using a spectroscopic ellipsometer and transmittances of the single-and the multi-layer AR coatings on glass substrate have been tested using a spectrophotometer.

Experiment

The films were prepared by evaporation method from tungsten and molybdenum crucibles onto optical fiats positioned at a distance from the source 20 cm, the evaporation time was controlled and did not exceed (2) minutes for the production of the films. This was achieved by using crucible volts up to 100v. The density of thin film is influenced by the nature of the processes occurring during evaporation at the substrate-film interface. The slides was cleaned chemically and washed by di-water and then scrubbed and dried with grease-free paper. The operational pressure for the system was 10¬-5 mbar. The mass of the deposits each layer about 0. 5 to 1. 5 mg, and was determined with a semi-micro balance. For the bottom layer, a ZnS thin film was deposited on glass substrate first, and then second layer MgF2 deposited on the ZnS layer, the third layer was ZnS deposited and finally, MgF2 deposited upper layer, and all coated layers characterized by Uv-vis, SEM, XRD and AFM.

Results and discussion

The transmittance chart of the multilayer coatings MgF2/ZnS are shown in Fig. 1, it can be seen that, the transmittance of single layer ZnS is lower than double layer MgF2/ZnS for wide range of visible and near infrared region (400-1100) nm, and obviously showed enhancement in transmittance with triple layer (MgF2/ZnS/ MgF2) occurred almost in Uv-visible range (370-700) nm, but a degradation in transmittance with quadruple layer namely (MgF2/ZnS/ MgF2/ ZnS) in some of wavelengths (400-600) nm due to materials with surface in-homogeneity (irregularly patterned anti-reflective surface) have refractive of indices which that depend on the surface roughness because the incident light has scattered by nanoscale containments at times, Garnett; Means that the surface nature effects on quantity of scattering radiations and refractive index and then effect on transmittance of material.