Optimization of Hydrogenated Amorphous Silicon Thin Films and Fabrication of Solar Cells on Flexible Substrates at Low Temperature

Abstract:

Solar energy is one of the alternatives for renewable energy generation. It is extracted directly in the form of electrical energy from solar radiation using photovoltaic (*PV*) solar cells. The *PV* market is dominated by crystalline-silicon based solar cells. However, thin-film solar cells are becoming increasingly important, because these are deposited at relatively low temperatures and as such offer the possibility to produce flexible and light-weight solar panels. The flexible substrates have additional advantages such as bendable, less weight, non-breakable, low cost and compatibility with roll-to-roll printing process along with the ease of handling and transportation etc. A few commonly used flexible substrates are polyethylene terephthalate (PET), polyethylene naphthalene (PEN), polyimide (PI), polytetrafluoro-ethylene *(*PTFE), stainless steel (SS) and paper etc. RF-PECVD technique has finite advantage to deposit amorphous silicon layers at low T_s with good opto-electronic properties as well as fabrication of solar cells. For the device fabrication, we have studied the influence of different deposition parameters on the microstructural and optoelectronic properties of each layer. Solar cells were fabricated on flexible (Polyimide, PET and photo paper) and rigid corning 1737 glass substrates using individual layer deposition parameters corresponding to device quality films for the intrinsic and doped amorphous silicon films. Influence of *i*- layer thickness on solar cell efficiency was studied. The values of V_{oc}, J_{sc}, *FF* and η (%) fabricated solar cells on flexible PI substrate are similar to those on conventional Corning substrate. We have observed that with increase in *i*- layer thickness, η (%) was increased due to more absorption of photons in the cells on Corning and PI substrates. Whereas in the solar cells fabricated on PP, best cell efficiency (1.54 %) are obtained for lower thickness (200 nm) of *i*-layer. The influence of hydrogen plasma treatment (*HPT*) at *n/i* and *i/p* interface layers along with *a-SiC:H*(*p*) as window layer on performance of solar cells has been investigated. The performance of *n-i-p* solar cells on flexible PET, PI and rigid Corning substrate was slightly improved after *HPT*, before the deposition of *i*- layer and *a-Si:H*(*p*) layer due to improvement of *n/i* and *i/p* interface layer. The performance was further improved when *a-Si:H*(*p*) was replaced with *a-SiC:H*(*p*) layer which also acts as window layer. Our results point out the importance of wide band gap *a-SiC:H*(*p*) as window layer along with *HPT* at the interfaces for better performance of the solar cells.