Abstract

The objective of this work was the development of high-efficiency thin-film amorphous silicon (a-Si:H) based p-i-n solar cells using plasma enhanced chemical vapor deposition (PECVD) technique and reduce the light-induced degradation effect. The influence of interfaces on the performance and stability of the a-Si:H solar cells were undertaken. A wide band gap amorphous and microcrystalline oxygen alloyed materials have been prepared to improve the interfacial properties of the solar cells. Deposition parameters leading to device quality doped and intrinsic materials are identified. The optical, electrical and structural properties of the film are characterized in detail to establish standard baseline materials for the development of solar cells. The wide bandgap buffer layer has been introduced at the p/i interface. The influence of buffer on the performance of solar cell has been investigated experimentally. Numerical simulation has been performed to get more insight into the effect of buffer at p/i interface. The other most important interfaces such as TCO/p, i/n and n-layer/ metal interfaces have also been improved to increase the charge collection and reduced the shunt leakage current. The results show that the a-Si:H solar cells fabricated after interface engineering exhibit high performance not only in the initial state but also after light introduced degradation effect. A microcrystalline silicon oxide (μc-SiO:H) based back reflector layer has been developed to implement light management/trapping scheme. As a most important process variation the carbon dioxide flow ratio (CO_2/SiH_4) has been controlled carefully to achieve better electrical and optical properties of a back reflector layer. Light absorption has enhanced by introducing an optimized back reflector layer in a thin a-Si:H solar cell. As a result the photocurrent and efficiency of the solar cell has improved. Finally, to identify the different origins of instability in a multilayer solar cell structure a 1000 hours light soaking experiment were carried out. Light-induced degradation effect in the amorphous silicon layers and solar cells of different architecture have been investigated. The experimental results indicate that the light-induced changes in a solar cell is not a purely bulk degradation phenomenon but the interface effect has also contribute to the instability of the device.

Key words: Band offset, Barrier height, leakage current, PECVD, rear reflector, light induced degradation, interface degradation, interface recombination, parasitic absorption.