Form 2

Dissertation Abstract

Report no.	(Course-based) No.1136	Name	A.T.M. Saiful Islam
Dissertation title	Junction Property of Crystaline-Si/Organic and Metal Oxide for Photovoltaic Application （結晶 Si 系太陽電池応用のための Si/ 有機・金属酸化物接合特性に関する研究）		

Solar cells based on the crystalline silicon (c-Si) p-n junction are dominating 80% of the market because of their high efficiency and long-term stability. Most recently, Kaneka Corporation (Japan) has achieved a power conversion efficiency (PCE) of 26.63% in the c-Si solar cell with a practical size of 180 cm^2. However conventional c-Si solar cells require high-temperature diffusion of dopants and plasma-enhanced deposition of the passivation layer, both of which add complexity and cost to the manufacturing system. An alternative approach is to use organic semiconductors that do not require high temperatures to be processed and are inexpensive, but they are less efficient because of their low absorption level.

This work investigates another alternative approach that combines the c-Si with a solution-processed highly transparent conducting polymer poly(3,4-ethylene dioxythiophene):poly (styrenesulfonate) PEDOT:PSS to form Organic/c-Si heterojunction solar cells, which are easy to deposit without plasma enhancement. Recently, the PCE of low temperatures and low pressures processed PEDOT:PSS/n-Si solar cells on the plain substrate has reached 13.4% efficiency. For further improvement, high passivation of the textured Si substrate by PEDOT:PSS is required. The negatively charged PEDOT:PSS by chemical mist deposited (CMD) providing high passivation for the dangling bonds of the Si substrate, because of that an 80 nm thick CMD coated PEDOT:PSS/n-Si shows a lifetime value of 700~900 μs with improved uniformity, that value is 2~3 times higher compared to the conventional spin-coating process. Thus, the CMD samples exhibit high built-in potential. In this study, the PCE of 16.1-18.2% is established with front- and back- PEDOT:PSS/n-Si solar cells on a textured substrate.

However, the junction property dominating between Schottky and the p-n junction at the PEDOT:PSS/n-Si interface is not well known. To this purpose, capacitance-voltage, current density-voltage and external quantum efficiency (EQE) of the PEDOT:PSS/n-Si solar cells with different donor doped Si substrates are studied. This reveals that a strong inversion appears at that interface without the need of additional doping. Moreover, the Schottky and p-n junction model analysis suggests that the carrier transport in the PEDOT:PSS/n-Si junction is dominated by diffusion of the minority carrier. In addition, the band diagram derived from these findings confirms the appearance of a p^+n junction at the PEDOT:PSS/n-Si interface.

A solution-processed titanium dioxide (TiO_2) has been demonstrated as a hole blocking layer (HBL). The PCE of the PEDOT:PSS/n-Si solar cell is increased from 11.23% to 13.08% on the plain substrate by introducing a 2 nm thick TiO_2 between the Si and the cathode. This originated from the improved carrier collection at that corresponding interface, confirmed by the EQE spectra at the far-infrared region. Additionally, transient reverse recovery (under dark condition) was introduced to study the surface recombination velocity (S) at the Si/TiO_2/Al junction, which is a measure of interface properties. A surface recombination velocity of ~375 cm/s is observed in a 2×2 cm^2 optimized PEDOT:PSS/n-Si solar cell with a double layer TiO_2 HBL at the Si/cathode interface. This value is comparable with the already reported ALD processed Al_2O_3 and CVD processed TiO_2. The solution-processed TiO_2 can effectively improve the interface properties of Si/cathode junction.