Area7: Performance and Reliability of PV Modules

Carrier Dynamics in the Potentially Induce Degraded Photovoltaic Modules

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Potential induced degradation (PID) is considered as a principle cause of the massive power loss in megawatt PV systems [1]. Although, approaches for preventing PID through macroscopic analysis are derived enormously from the cell, module and system level [2], however, a complete understanding of PID is not clear yet pointing out the importance of study on a microscopic level. Na ions that reach the Si surface and/or enter to the bulk through stacking fault under high potential stress, increases the defect states at that regions and free carriers are recombined and/or trapped in these defect states. Consequently, the formation yield of free carriers that reach to the interface before deactivating to the ground state is decreased significantly in PID affected solar cells and hence the power conversion efficiency becomes extremely low. Therefore, it is important to know how the rate of carrier generation and recombination is affected by various physical factors involved in PID solar cells. In this study transient absorption (TA) spectroscopy has been employed to analyze the carrier generation and recombination dynamics in the fresh and PID accelerated tested single crystalline Si (sc-Si (P)) PV modules.

TA spectroscopy is recognized as a powerful tool for observing charge carrier generation and recombination in photovoltaic devices directly. Recently, TA spectroscopy has been utilized to study the carrier dynamics in polymer based thin film solar cells [3], quantum-dot-sensitized solar cell [4], FeS_2 [5] solar cells, CdS/CdTe thin film [6] and polymer heterojunction materials [7]. This study analyzed carrier dynamics in the fresh and PID tested sc-Si modules with the complementary analysis of current-voltage and electroluminescence (EL) image techniques. PID acceleration test has been carried out using "-1000 V" with respect to the front glass in the ambient condition of 85°C/85%RH. The Na migration under the PID test has been investigated using SIMS and EDX analysis. In EL image, the Na accumulated area is shown either over illuminated or dark compared to the fresh module. The carrier lifetime in these areas is comparatively lower the fresh solar cells and also the high response time to the imposed light is observed in PID module.

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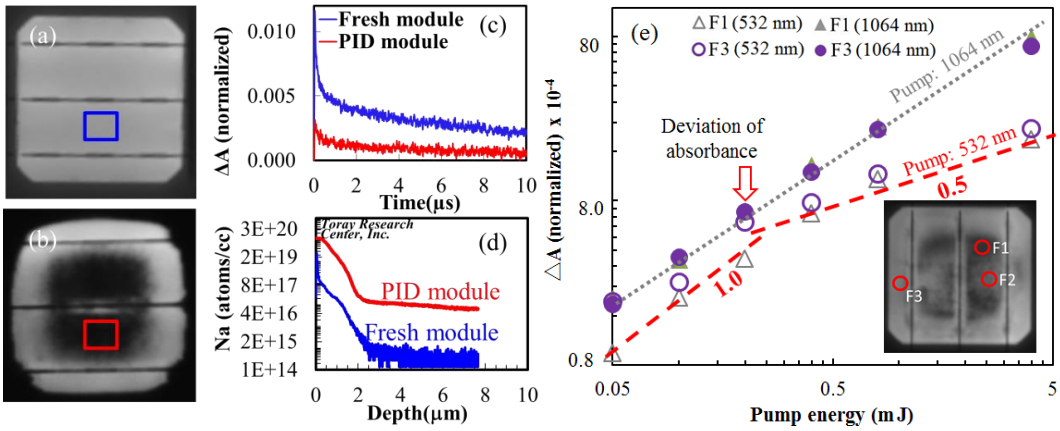

Figure 1: (a) and (b) EL image of fresh and 300 hrs. PID tested modules respectively, (c) and (d) TA spectra and SIMS profile of Na of the modules (a) and (b) on their selected areas, and (e) change of bleaching w. r. to the two different pump wavelength of 532 nm and 1064 nm, (Inset: EL image of the corresponding 200 hrs. PID tested module)