Area 7: Performance and Reliability of PV Modules

SODIUM DISTRIBUTIONS AT THE SURFACE OF SILICON NITRIDE FILM AFTER POTENTIAL INDUCED DEGRADATION TEST AND RECOVERY TEST OF PV MODULES

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Potential induced degradation (PID) of p-type crystalline Si photovoltaic (PV) modules has been widely discussed with Na migrations from cover-glass and surface contaminations of solar cell [1]. In additions, recoveries of PV properties are also investigated by applying the opposite bias to the PV modules [2]. However, understanding in the PID mechanism by the Na migration is still not clear. In our research, we focused on Na distributions at the surface of solar cell in PV modules with variations of PID test and PID recovery test conditions. The changes in the Na distributions at the surface of SiN_x films of solar cells by the test conditions were compared with the PV properties.

In order to analyze the Na distributions and PV properties, mini-PV modules were prepared with vacuum lamination of p-type c-Si cell (12 × 12 mm), cover-glass (18 × 18 × 3.2 mm), EVA encapsulant and back-sheet. Al method was used for PID test and PID recovery test (shown in Figure 1) with the conditions of ±2000 V, 85°C, <2%RH while the test durations were changed from 6 to 48 h. I-V characterizations were conducted using solar simulator (AM 1.5, 100 mW/cm^2). The atomic concentrations including Na distributions were characterized using X-ray photoelectron spectroscopy (XPS, ULVAC-PHI, Quantera-SXM) with about 30 μm ϕ spot size.

Atomic concentration measurements at the surface of solar cell were conducted using the XPS with the variation of PID recovery test durations. The XPS measurements were carried out between two finger electrodes from the center position of one finger electrode to the half position between them (about 0.7 mm). Figure 2 shows Na/Si ratio at the surface of SiN_x film of solar cells after 12 h PID test and 6 - 48 h PID recovery test. The atomic ratios of Na/Si were decreased as the PID recovery test durations were increased. After 24 h PID recovery test, Na/Si became below the value before PID test. However, only very slight recovery of the conversion efficiencies of the PV modules appeared even after the 48 h PID recovery test was conducted. It is suggested that Na around pn junction or Na at around the SiN_x film with the concentration below the detection limit of XPS affected the recovery of PID.

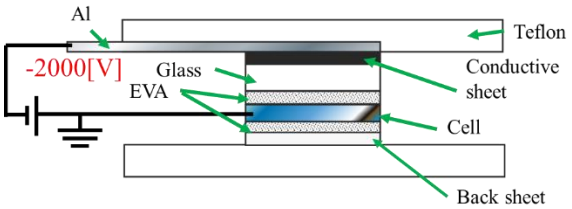

Figure 1: Schematic setup of PID recovery test.

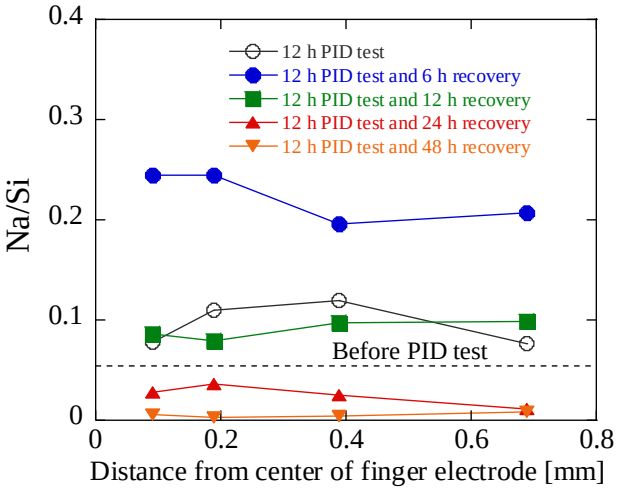

Figure 2: Na/Si ratio at the surface of SiN_x film of solar cells after PID test and PID recovery test.

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References:
[1] V. Naumann *et al*., SOLMAT 120 (2014) 383.
[2] D. Lausch *et al*., Energy Procedia 55 (2014) 486.