POTENTIAL-INDUCED DEGRADATION BEHAVIOR OF N-TYPE REAR-EMITTER C-Si PHOTOVOLTAIC MODULES PRESTRESSED IN DAMP-HEAT TESTS

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The market share of n-type crystalline silicon (c-Si) photovoltaic (PV) cells is expected to increase in the near future, because of their high potential for achieving high energy-conversion efficiencies. To utilize these cells, the reliability and long-term stability of the modules are of great importance. We have reported that n-type rear-emitter (n-RE) c-Si PV modules exhibit potential-induced degradation (PID) by applying a negative bias, which is mainly characterized by a reduction in the open-circuit voltage ($V_{oc}$) [1]. In this work, we performed PID tests of n-RE PV modules undergoing prior damp-heat (DH) tests to elucidate the influence of moisture on the PID of n-RE PV modules.

We fabricated PV modules containing 20x20-mm²-sized n-RE c-Si PV cells with SiNₓ/SiO₂ passivation stacks by using a laminator. The modules were composed of conventional tempered cover glass/ethylene-vinyl acetate copolymer (EVA)/cell/EVA/backsheet. The n-RE PV modules were, in advance, stressed in a DH chamber for 0–3000 h at a temperature of 85 °C and a humidity of 85% RH. After the DH tests, PID tests were performed by applying −1000 V to the cell with respect to an Al plate placed on the cover glass surface at a temperature of 85 °C and a humidity of <2% RH.

Figure 1 shows the PID-stress duration dependence of the short-circuit current density ($J_{sc}$), the $V_{oc}$, the fill factor (FF), and the maximum power ($P_{max}$), normalized by their initial values, of n-RE PV modules undergoing prior DH tests. FF greatly decreases after the 3000-h DH test. This degradation may be due to the hydrolysis of EVA by water vapor entering the module to produce acetic acid, which corrodes grid electrodes and increases the series resistance of n-RE cells [2, 3]. $V_{oc}$ of the n-RE PV modules decreases and then strongly saturates by the PID tests, as in the previous study [1]. The saturation values of $V_{oc}$ are independent of the duration of the prior DH tests. Furthermore, only the n-RE PV modules undergoing prior DH tests exhibit a gradual decrease in $J_{sc}$. This may be due to the emergence of optical loss in the EVA and/or the front SiNₓ film, since the reductions in $J_{sc}$ are not accompanied by $V_{oc}$ drop.

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References