Potential-induced degradation and recovery process for thin-film Si photovoltaic modules

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Introduction
- PID mechanism in thin-film Si PV modules differs from that in c-Si modules.
- Very few papers have been published although thin-film Si PV modules were installed in many PV plants.
- Some kinds of degradation were observed in thin-film Si PV modules at AIST PV plant (Saga prefecture).

Study on PID phenomena for thin-film Si PV modules by indoor PID test

Fig. 1 Appearance of degraded thin-film Si PV modules at AIST PV plant.

Results
1. PID phenomena for thin-film Si PV modules progress slowly and decrease in shunt resistance is not observed.
   - \( I_{sc} \) and FF decreased in the initial stage of the PID test, but the decrease seems to be saturated. \( Foc \) decreased after PID test over 150 h and no saturation tendency is observed.

Fig. 3 Normalized \( I_{sc} \), Voc, FF, Pmax as a function of PID test time.

2. Recovery phenomena are observed by +1000 V application.
   - Due to annealing effect during PID test, some PV parameters were over 1.

3. PV parameters drastically decrease in very short period during the second – 1000 V application.
   - Some spots appeared after the second -1000 V application.
   - Pmax increased and some spots disappeared by the +1000 V application.

4. Origin of spots
   - Deterioration in the delamination layer.
   - Delamination was observed in TCO layer at the spot.

Fig. 4 Photograph of the example of the linear delamination observed after PID test over 150 h.

Fig. 5 I-V characteristics on the PID-stress duration under illumination (a) and dark (b).

Discussion
- About relationship between delamination and humidity
  - Excessive delamination was observed by PID test with humidity (85°C85%RH).
- Why is degradation accelerated after \(+1000\) V application?
- What is difference between spot-like delamination and linear delamination?

Conclusions
- PID phenomena for thin-film Si PV modules progressed slowly and decrease in shunt resistance was not observed.
- Delamination was observed similar to that seen outdoor.
- Recovery phenomena were observed by reverse voltage application, except in the case that linear delamination appeared.
- +1000 V application before PID test accelerated PID.
- Spot-like delamination disappeared by +1000 V application.

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