Test Sequence development for evaluation of Potential Induced Degradation on Thin-Film Modules

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Abstract/Summary:

Only high reliability and stability of a t hin-film module ensures a good energy yield during its life- time. Obviously the actual standards (IEC 61646, IEC 61730-2 and IEC draft 62804 for only c-Si) are insuf ficient, considering that returns from the field as well as laboratory test results (beyond IEC-testing) show d egradation of IEC certified modules. Accordingly, also thin-film modu les can show degradation effects due to Potential I nduced Degradation (PID), such as TCO-Corrosion and power de gradation. This work presents results obtained with thin- film modules under Bias-Damp-Heat (BDH) conditions in in- and outdoor tests. To investigate the PID effe cts, thin- film modules are tested in BDH-tests at relevant par ameters of humidity and temperature. Variations of the mounting structure are investigated for ?c-Si modules reveal ing the PID stability of backrail mounted modules. Results with CIGS modules tested at positive and negative bias wi th varying humidity show that the polarity is deter mining the level of the leakage current but the degradation is driven by other effects. To evaluate module life-times, in- and outdoor dete rmined leakage currents are compared and analyzed c onside-ring weather data and indoor test results. Finally, modu le life-times are estimated by simula-tions basing on the investigations above

For more Information on the topic please contact the R&D Team of PI Berlin.

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DOI:

10.4229/28thEUPVSEC2013-4AV.5.46

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TEST SEQUENCE DEVELOPMENT FOR EVALUATION OF PID ON THIN-FILM MODULES

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→ The Approach

This work presents results obtained with thin-film modules under Bias-Damp-Heat (BDH) conditions in in- and outdoor tests. The development of a standard test for potential induced degradation (PID) for c-Si is in progress, however for thin-film technologies, there is no IEC standard draft submitted yet. The intention is to support the development of a standard for PID testing also for thin-film technology. Leakage currents (LCs) are measured outdoor for 30 days in Berlin in June. Those LCs are amended with indoor measured LCs in climate chambers to get values for every prevailing parameter range. So module life-times can be simulated for different places in the world. Module degradations are carried out in accelerated aging tests under BDH resulting in a specific degradation level of P80 (-20% to initial power) and the charge of the investigated module. Finally, the life-times are calculated by considering the indoor and outdoor measured LCs.

Design of Experiment

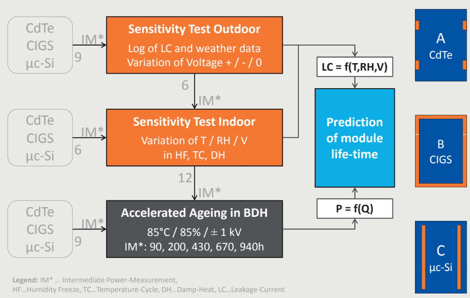

Fig. 1: Schematic of the test procedure: sensitivity test (orange), accelerated ageing (grey), and simulation for the prediction of module lifetimes (light blue). Three module technologies (shown far right) were investigated.

Outdoor Measured Leakage Currents

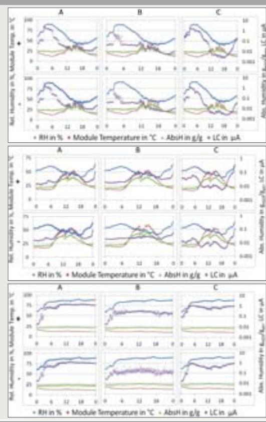

Figure 2: Outdoor LC for modules A, B and C under +/- bias measured on three different weather conditions. Depicted are relative humidity (RH), module temperature and absolute humidity (AbsH).

Top: rain in the morning, moderate temp.

Middle: sun and warm weather

Bottom: rain whole day long and cold

Sensitivity Analysis, relev. Parameters

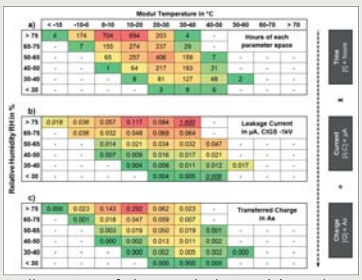

Figure 3: Illustration of charge calculation: (a) number of hours for which each parameter space of temperature and relative humidity prevails for a statistical year in Berlin; (b) measured leakage currents (from sensitivity tests) representative of a CIGS module, indicated as mean values for each parameter range; (c) charge for each parameter range, calculated by multiplying time in (a) and current in (b).

Parameter Dependent LC-Change

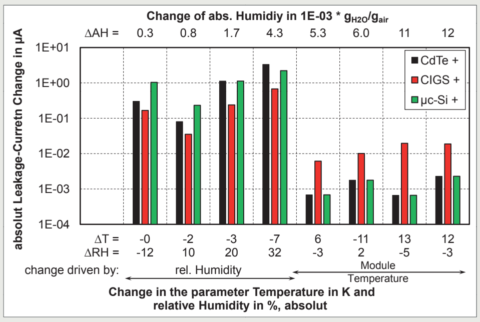

Figure 4: Analysis on the (abs.) change of outdoor LC for different changes in the parameters T and RH or AbsH (upper axis). The first data range is driven by humidity and the second by temperature. Results are measured on all types.
→ Leackage Currents are driven mainly by humidity.

Accelerated Ageing in BDH: ΔP = f(Q)

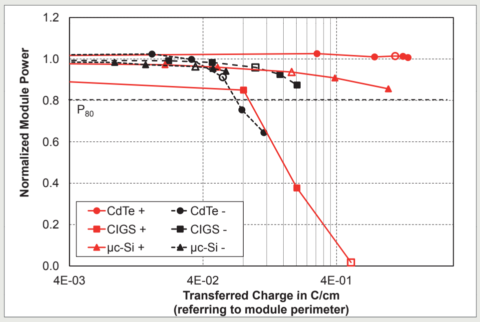

Figure 5: Degradation behavior of modules A, B and C tested in BDH as function of the transferred charge per perimeter. **P_{80} life-time** means: years till 80% of initial power remain. Empty form marks measurement after 430h

Simulation of Module Life-Times

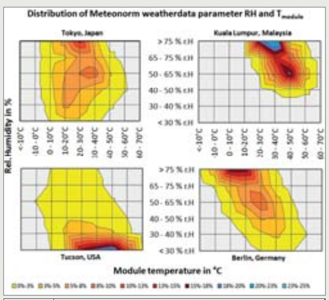

Figure 6: Analyzed meteonorm weather data for Tokyo (Japan), Kuala Lumpur (Malaysia), Tucson (USA) and Berlin (Germany). The simulation of life-times was done with analyzed data sets of these locations.

Module	PID-Module Life-Time (LT) in years (Module LT maybe limited by other mechanisms)			
	Kuala Lumpur	Berlin	Tokyo	Tucson
CdTe +	83	166	183	362
CIGS +	9	41	37	127
µc-Si +	51	135	157	1659
CdTe -	3	8	10	31
CIGS -	13	141	77	637
µc-Si -	20	21	39	294

Classification of the Results (in years):
< 25 ... PID critical
> 25 > 40 ... likely PID uncritical
> 40 ...means likely no PID

Table 1: Simulated module life-times with regard to PID for all investigated locations and module types (left), and suggested classification scheme for evaluation purposes (right).

Power Degradation Evaluation

Technology dependent **Preconditioning (PC) methods** in comparison to a flasher only measurement of PID stressed modules:
PC method from the CdTe producer of type A and a CIGS PC method for the modules of type B was used.

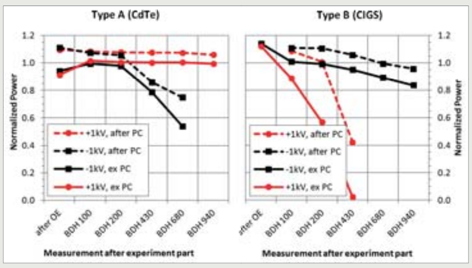

Fig. 7: Evolution of module power for type A and type B. For CdTe the PC result in an 10% improvement of power increasing up to 20% for higher module degradations. PC for CIGS improves the power measurement up to 12% (B-) and 40% (B+). The improvement effect is not constant.

→ Conclusions

- **The evaluation of PID degradation from accelerated aging tests is possible by correlating with outdoor LCs**
- **Simulating different weather conditions enables to distinguish life-times**
- **The results reveal a high humidity driven PID-effect for all thin-film modules**
- **Warm and dry climates seem to be very suitable to avoid PID of thin-films**
- **Module type A (CdTe) is very stable, if not installed under negative system voltages**
- **Module type C (µc-Si) shows negligible degradation under negative BDH test. Simulating its life-time 20% power drop in 20 years might be too critical**
- **In contrast, module B (CIGS) and module C (µc-Si) shows heavy degradation under positive BDH test but the simulated life-times are acceptable for moderate climates (exc. For hot, humid conditions like Kuala Lumpur)**

→ Outlook

- **The evaluation of preconditioning methods for power meas. methods is necessary and comparison to outdoor STC-power measurement has to be shown**
- **To avoid high temperature induced degradation mechanisms from 85°C tests through performing accelerated BDH tests at max. temperatures of 60°C**