Encapsulation Influence on the Potential Induced Degradation of Crystalline Silicone Cells with Selective Emitter Structures

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Abstract/Summary:

The encapsulation method of crystalline silicon modules plays an important role in the mitigation of potential induced degradation (PID) on module level. The focus on this work is to identify possibilities of mitigating PID for selective emitter cell technologies by the means of new module designs without the necessity of cell level modifications. In this paper we present different frontcover and encapsulation materials, which have been tested in different module layouts. We predominantly examined innovative laminate configurations allowing for higher transmission rates in the UV range and thus increasing short circuit currents (ISC) of selective emitter cells. We examined these performance (PMPP) enhancements consisting in higher optical transmission in relation to its resistance against PID. As a result of this assessment we show new module designs, which are both capable to improve module efficiencies while avoiding PID effects. Furthermore, different EVAs have been tested regarding their PID.

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

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ENCAPSULATION INFLUENCE ON THE POTENTIAL INDUCED DEGRADATION OF CRYSTALLINE SILICON CELLS WITH SELECTIVE EMITTER STRUCTURES

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→ Introduction

The encapsulation method of crystalline silicon modules plays an important role in the mitigation of potential induced degradation (PID) on the module level. The focus of this work is to identify possibilities of mitigating PID for selective emitter cell technologies by the means of new module designs without the necessity of cell level modifications.

In this paper we present different frontsheet and encapsulation materials, which have been tested in alternating module designs. We predominantly examined innovative laminate configurations allowing for higher transmission rates in the UV range and thus increasing short circuit currents (I_{SC}) of selective emitter cells. We examined these performance (P_{MPP}) enhancements consisting in higher optical transmission in relation to its resistance against PID. As a result of this assessment we show new module designs, which are both capable to improve module efficiencies while avoiding PID effects.

Transmission and I_{SC} simulation of different materials

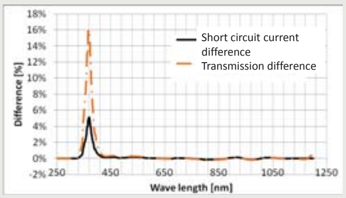

Fig. 1: Difference of short circuit current (black) and transmission (orange) between PVB and EVA embedded selective emitter cell with a glass front sheet.

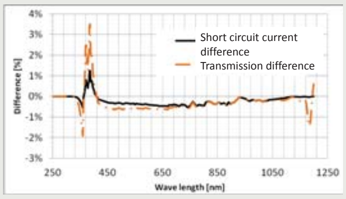

Fig. 2: Difference of short circuit current (black) and transmission (orange) between TPSE and EVA embedded selective emitter cell with a glass front sheet.

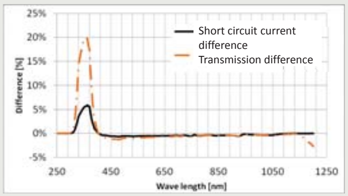

Fig. 3: Difference of short circuit current (black) and transmission (orange) between Ionomer and EVA embedded selective emitter cell with a glass front sheet.

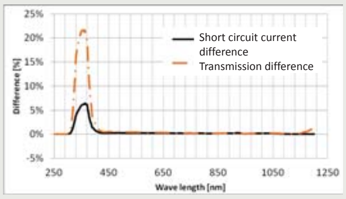

Fig. 4: Difference of short circuit current (black) and transmission (orange) between PDMS and EVA embedded selective emitter cell with a glass front sheet.

Tab. 1: Relative power degradation due to voltage stress of -50V against ground on different encapsulate materials.

Material composition	I_{SC} [W]	Normalized I_{SC} [%] (Measured)	Normalized I_{SC} [%] (Simulated)
Glass/EVA (Reference)	8.60	100.00	100.00
Glass/PVB	8.66	100.65	100.60
Glass/TPSE	8.54	99.30	99.31
Glass/Ionomer	8.25	99.50	99.95
Glass/PDMS	8.57	99.88	101.70
FEP/PDMS	8.83	102.65	103.50

UV stability of different embedding materials

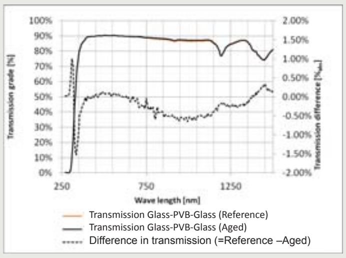

Fig. 5: Comparison of glass-PVB-glass sample transmission before and after a dose of 46kWh UV irradiation.

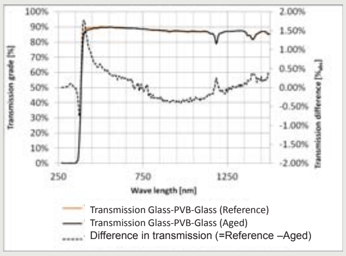

Fig. 6: Comparison of glass-TPSE-glass sample transmission before and after a dose of 46kWh UV irradiation.

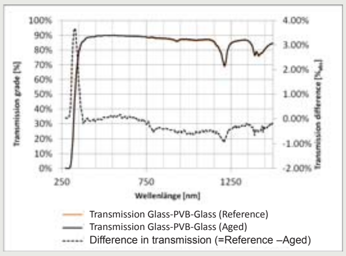

Fig. 7: Comparison of glass-Ionomer-glass sample transmission before and after a dose of 46kWh UV irradiation.

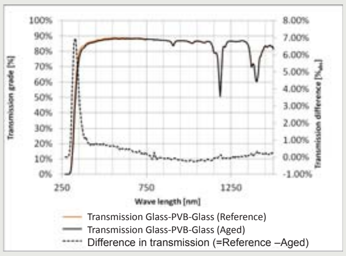

Fig. 8: Comparison of glass-PDMS-glass sample transmission before and after a dose of 46kWh UV irradiation.

PID resistivity of various materials

Tab. 2: Relative power degradation due to voltage stress of -50V against ground on different encapsulate materials.

Material type	Initial P_{MPP} [W]	P_{MPP} after PID [W]	ΔP_{MPP} [%]
EVA 1	0.66	0.05	-92.38
EVA 2	0.66	0.02	-96.57
EVA 3	0.66	0.03	-95.52
EVA 4	0.64	0.05	-91.98
PE1	0.65	0.65	-0.75
PE2	0.65	0.63	-3.74
TPSE	0.66	0.58	-12.53
Ionomer	0.66	0.61	-7.23
PVB	0.66	0.28	-58.13
PDMS	0.65	0.03	-95.34

PID behaviour of different EVA types

Tab. 3: Overview of four different EVA samples and their average power before and after 24 hours of PID treatment.

Material type	Initial P_{MPP} [W]	P_{MPP} after PID [W]	ΔP_{MPP} [%]
EVA 1	0.67	0.37	-45.45
EVA 2	0.67	0.08	-88.75
EVA 3	0.67	0.07	-89.77
EVA 4	0.67	0.56	-16.84

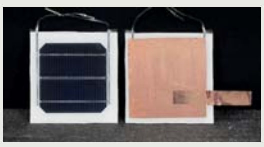

Figure 12: Bonding of the one-cell-mini modules with adhesive copper foil during the PID test, unprepared sample (left) and prepared sample (right).

→ Conclusion

The investigations show that in short and medium terms it is possible to generate a benefit from selective emitter cells in addition to the higher open circuit voltage within the module technology by changing the used materials. Alternative front sheets and encapsulates have been presented and tested for their initial performance. One aspect of long term stability - the UV resistivity - has been observed and the PID acceleration or deceleration of different embedding materials could be summarized. Furthermore, it could be shown that the variation in the PID behaviour is quite high within the material group of EVA, which is mostly used in the common module designs. What could not be shown in this work is how the materials behave under long term climatic outdoor stress and what the cost minimizing potential of deviating from the standard module version would be.