Influences of lamination conditions on device durability for EVA-encapsulated PV modules

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PV modules rely on their encapsulation to provide durability. The pottant, in the majority of cases this is EVA, is protected by foils and glass to minimise encapsulant related degradations. This paper investigates the effect of lamination temperature on encapsulation quality and its impact on module durability in accelerated ageing tests. A safety temperature margin is observed for each type of EVA used. Lamination temperature outside this margin may cause changes in chemical reaction rates and alterations of phase transition of polymers. This will then influence the chemical, mechanical, and optical properties of the encapsulation materials and affect the performance and durability of PV modules.

1 Abstract

2 Mini-module Structure and Materials

- Front glass: 2.9mm thick, low iron float, un-tempered
- Encapsulant: 600µm thick, fast cure and ultra-fast cure EVA
- Backsheet: tri-layer insulating polymer consisting PET/PET/primer layer
- Cell: 1.8W multi c-Si cells

3 Lamination and Ageing

- Curing temperature: 125°C, 135°C, 145°C, 150°C and 155°C
- Curing time: 10min (fast cure EVA), 7min (ultra-fast cure EVA)
- Damp-heat test at 85°C and 85% R.H.

4 Ageing of Pmpp, Isc, Voc and FF over 3000 Hours

- Ultra-fast cure (UFC) EVA samples
- Fast cure (FC) EVA samples

5 Ageing of Interfacial Adhesion and Bulk EVA

- Initial interfacial adhesion
- Ageing of interfacial adhesion
- Change of failed interface

6 Conclusions

- Mini-modules with UFC EVA showed clear safety margin of lamination temperature (145°C-150°C), where lower and higher lamination temperatures led to bigger Pmpp degradations
- Mainly contributed by Isc losses, which favours 145°C
- Voc degradation favours 135°C
- FF stable except some samples outside safety margin
- Mini-modules with FC EVA showed bigger Pmpp degradation at 135°C and 150°C
- Mainly contributed by Isc losses, but 135°C saw bigger losses in FF
- Voc degradation favours 135°C
- Higher interfacial adhesion at 145°C before ageing, but higher at 125°C after DH ageing
- Glass/EVA interfacial failure dominated at 135°C, while 125°C and 145°C saw mixed failures at glass/EVA and EVA/backsheet
- Gel content stable over DH ageing
- Optical losses happened largely in first 1000h