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

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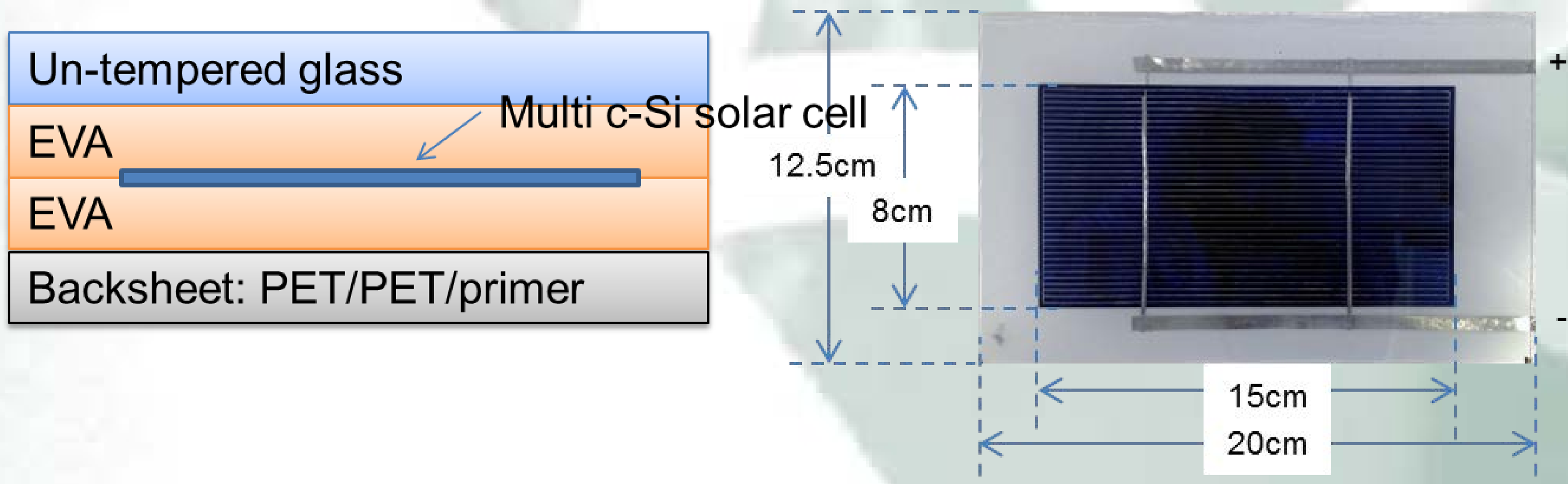
1 Abstract

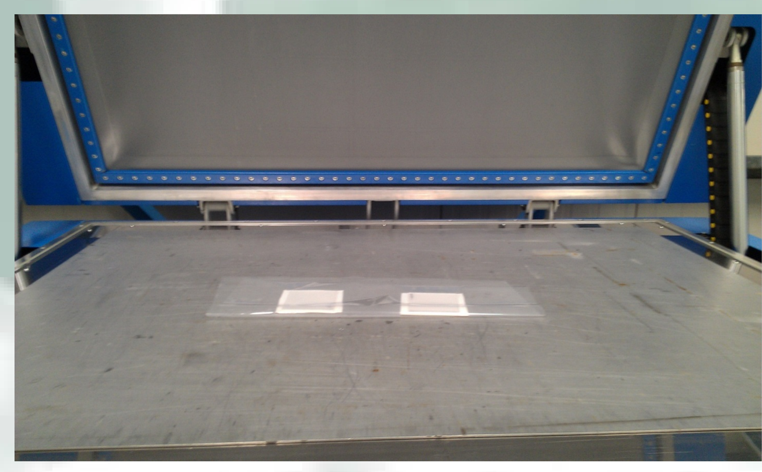
PV modules rely on their encapsulation to provide durability. The pottant, in the majority of cases this is EVA, is protected by foils and glass to minimise encapsulant related degradations. This paper investigates the effect of lamination temperature on encapsulation quality and its impact on module 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.

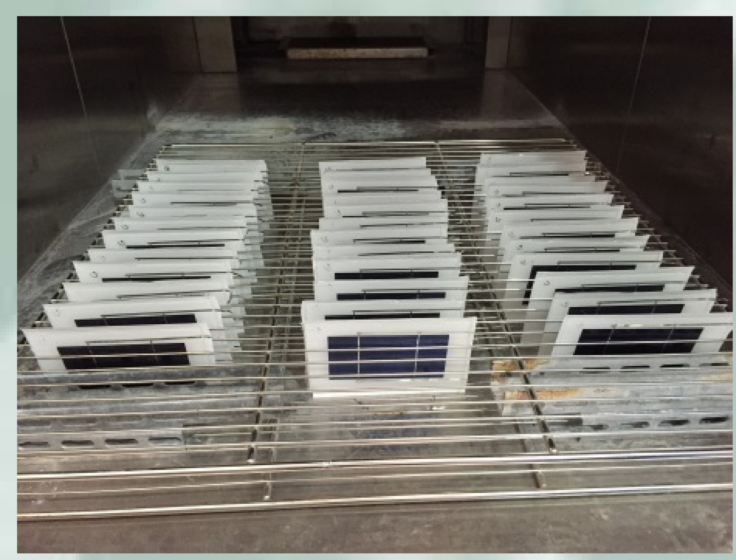
2 Mini-module Structure and Materials



- 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

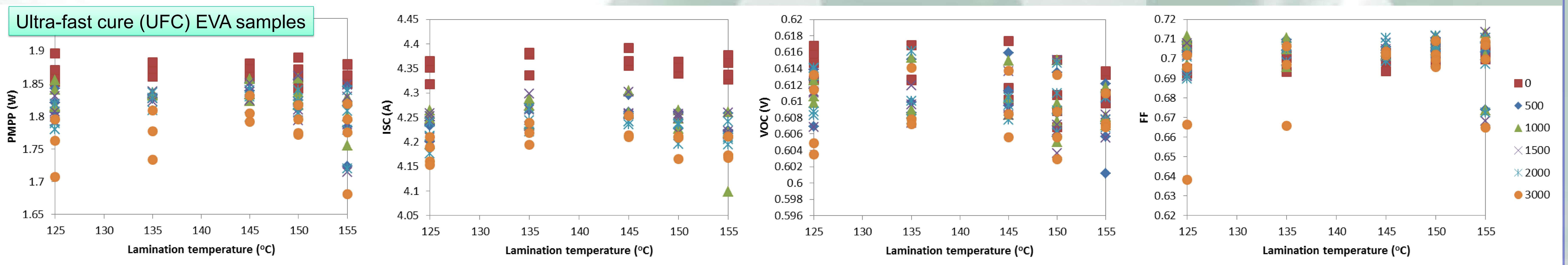
3 Lamination and Ageing

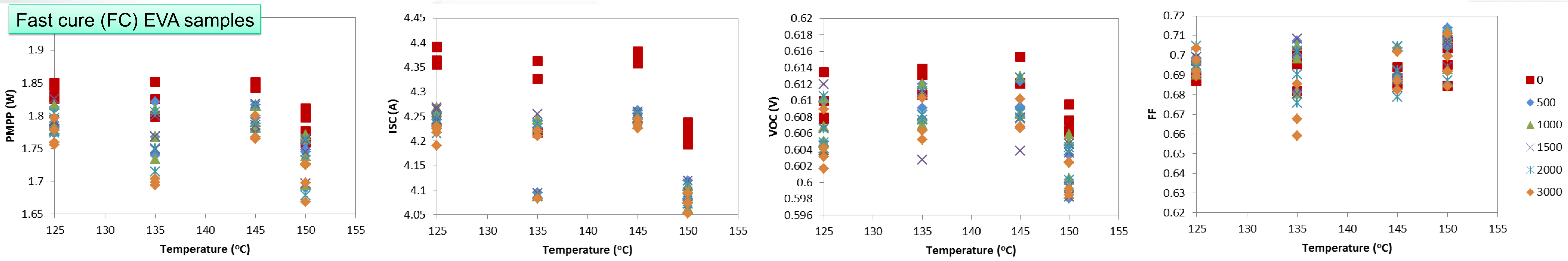




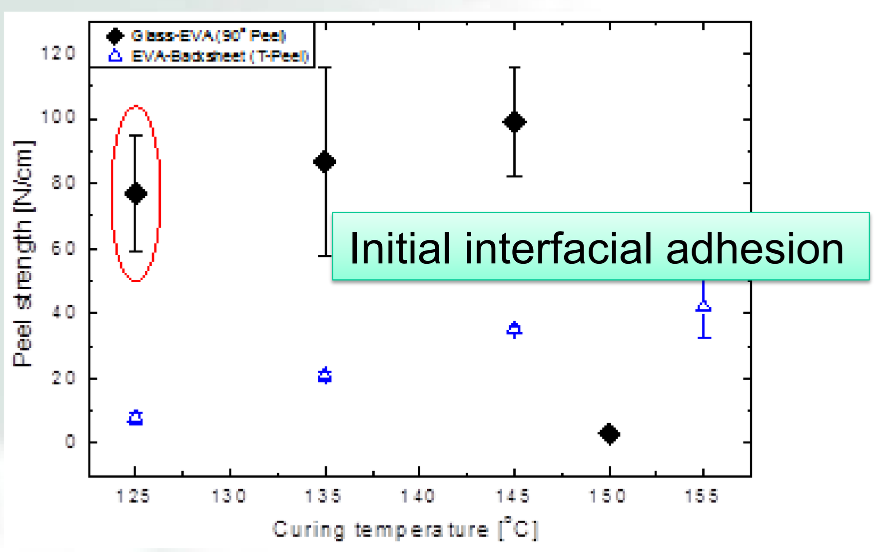
- Curing temperature
  - 125ºC, 135ºC, 145ºC, 150ºC and 155ºC
- Curing time
  - 10min (fast cure EVA), 7min (ultra-fast cure EVA)
- Damp-heat test at 85ºC and 85% R.H.

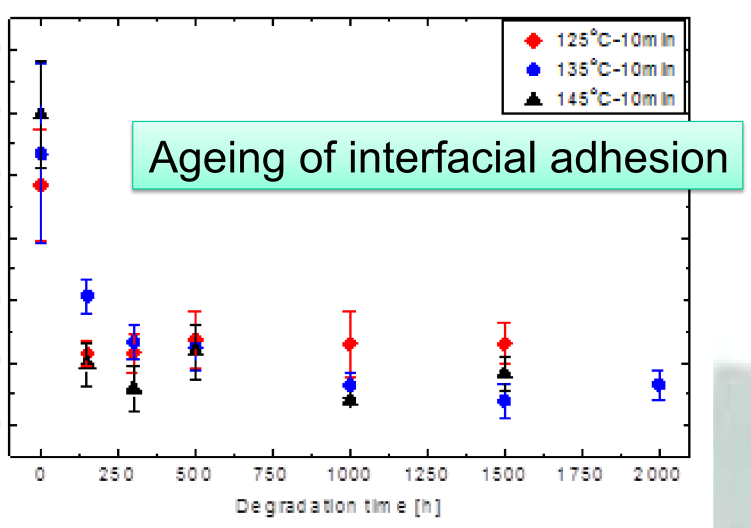
4 Ageing of P_{MPP}, I_{SC}, V_{OC} and FF over 3000 Hours

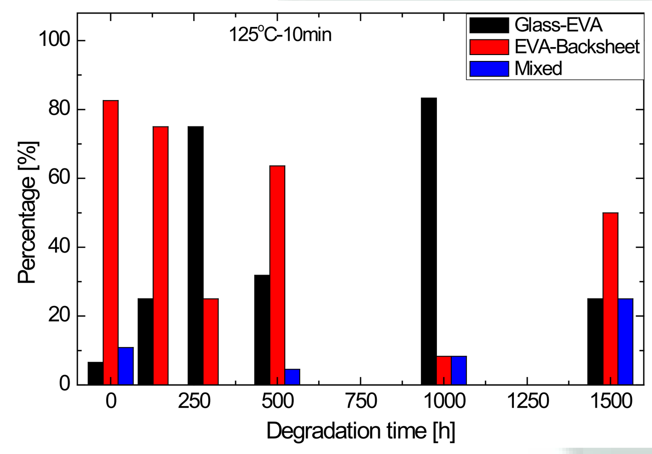


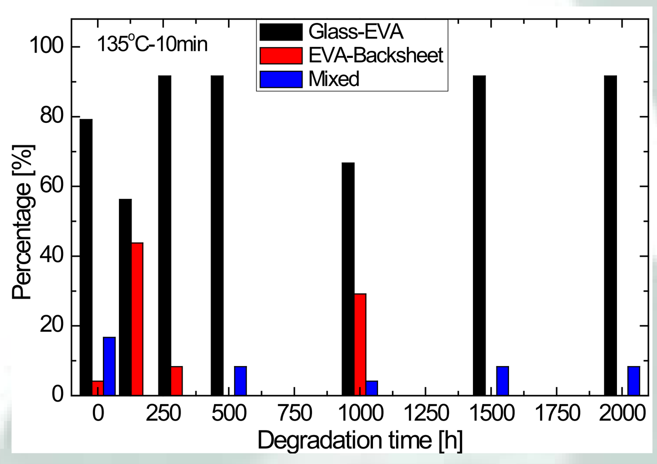


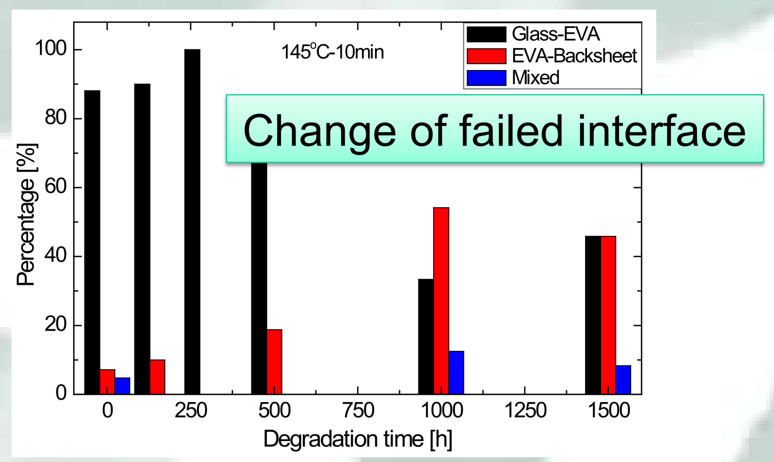
5 Ageing of Interfacial Adhesion and Bulk EVA

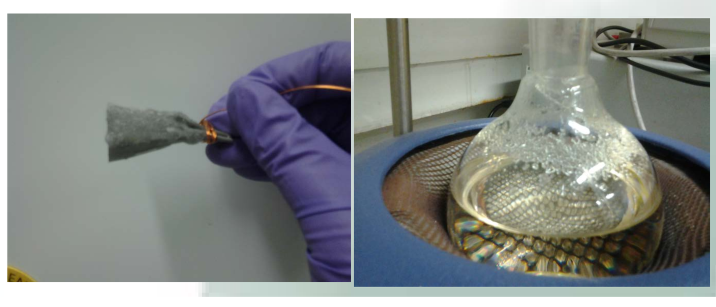


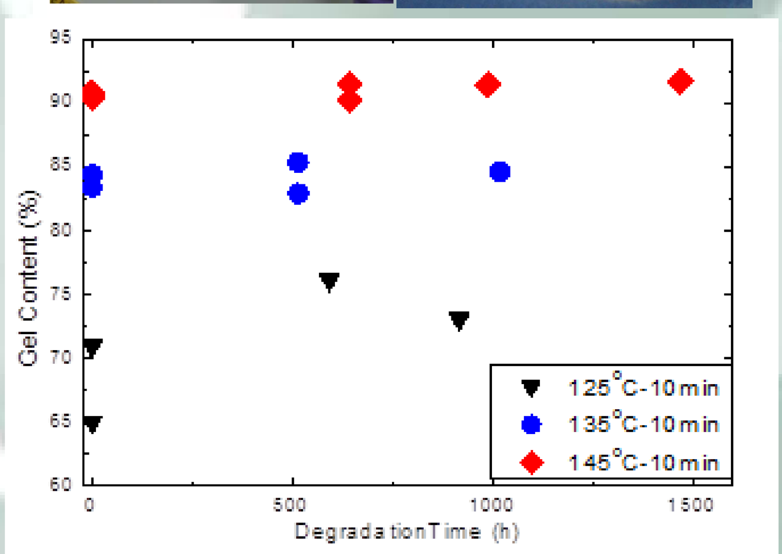


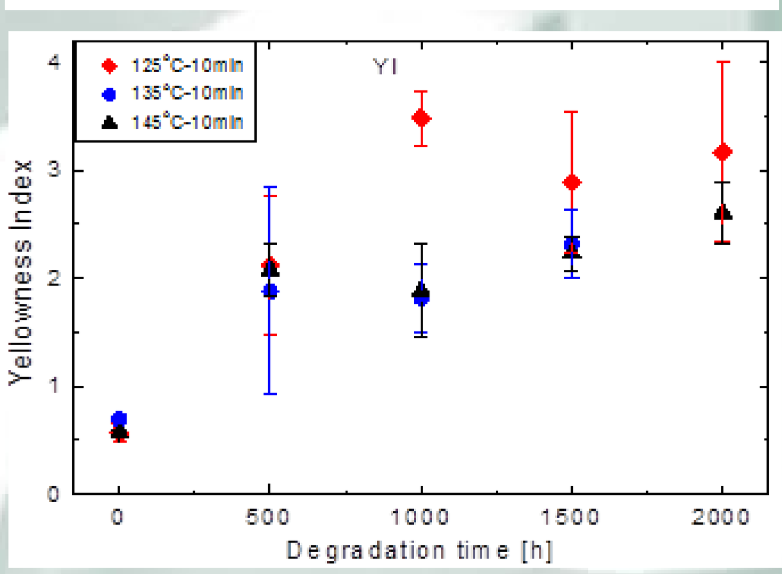












6 Conclusions

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

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