Area: Performance and Reliability of PV Modules

NON-DESTRUCTIVE HOMOGENEITY MAPPING OF ETHYLENE VINYL ACETATE CROSSLINK DEGREE IN COOPER INDIUM GALLIUM SELENIDE MODULE

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Crosslinked ethylene vinyl acetate (EVA) which is sandwiched between outer surface and solar cells is the common used material for encapsulation of photovoltaic (PV) products. In 25-year outdoor stressing, the material inside PV module will deteriorate associate with the decrease of mechanical strength of PV module. Here we proposed a fast, non-destructive and in-line compatible method to examination the crosslink degree of EVA which could be applied to both new products and aged products. In this technique, we use auto-scanning confocal Raman spectroscopy to map the crosslink degree homogeneity of EVA film in Cooper Indium Gallium Diselenide module. The apparatus appearance is shown in Figure. 1. The scanning range is about 1 m $\times$ 1.5 m, and the resolution of each step is 1 mm. The Raman spectrum is picked automatically when the module move to the assigned point each time. To transfer the spectrum signal to crosslink degree, we used the Differential Scanning Calorimetry (DSC) to build the calibration model. DSC analysis is confirmed to be useful for monitoring crosslink of EVA films with the various lamination time. Generally, the crosslink degree range of EVA can be detected from 65 to 90 %. Finally, we took the intensity of the peroxide vibration peak (~900 cm^{-1}) as a ratio for quantifying the progress of the crosslinking reaction. The homogeneity mapping of intensity ratio of peroxide vibration peak to carbonyl stretching vibration peak (~600 cm^{-1}) is shown in Figure. 2, which indicates the roughly EVA crosslinking distribution over the module. Here, we should note that the intensity ratio will be changed associated with EVA ingredient and fabrication.

In this work, the technique of measuring crosslink degree of EVA via Raman spectroscopy is demonstrated. The advantages of this method are fast, non-destructive and in-line compatible. In addition, compare to the common-used method like DSC or chemical extraction, the auto-scanning Raman spectroscopy could give the precise homogeneity mapping of crosslink degree of EVA over whole module area. It is believed such auto optical inspection has the potential to be used in quality management or failure mode analysis in product manufacturing.

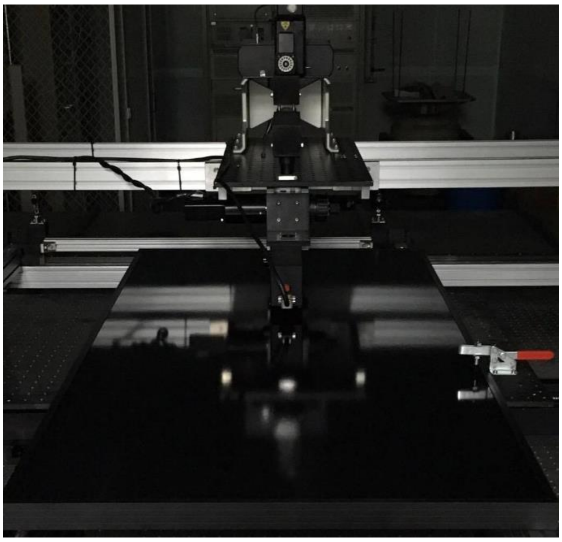

Figure 1: The apparatus of auto-scanning confocal Raman spectroscopy and CIGS module

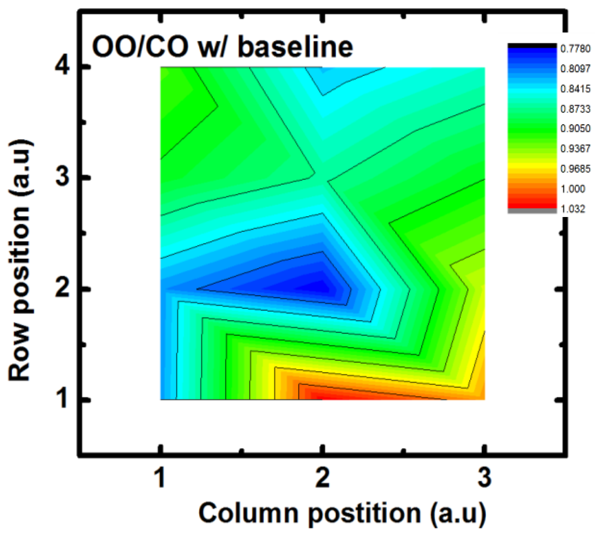

Figure 2: EVA crosslink degree homogeneity mapping by Raman spectroscopy