A Detail Study on Failure Mechanism of Si-Photovoltaic: Encapsulant to Solar Cells

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The study of failure mechanism of photovoltaic modules is the most important in determining the economic efficiency of the energy generation business. The investigation of the degradation on an encapsulant and cell level is important for the reliability of PV-modules because it could give information about the degradation process even before the electrical and optical properties of a module are changed. This study focuses on the failure mechanism occurred in standard silicon (mono/poly) photovoltaic provoked by the accelerated lifetime testing (ALT) under laboratory condition as well as in the PV field. A detail investigation of power degradation in Si modules has been conducted considering the number of points of view such as power loss, years in service, manufacturing quality, acetic acid formation and distribution through EVA encapsulant decomposition, Na ion migration to the cell surface, and local p-n junction quality and carrier lifetime decreased under the high potential aiming to predict the lifetime of a module. Therefore, the IV characteristics, Electroluminescence (EL), Dark Lock-in Thermography (DLIT) imaging, current density mapping, μ-PCD analysis, transient absorption spectroscopy (TAS), and IR and Raman spectroscopy analysis have been employed in this investigation.

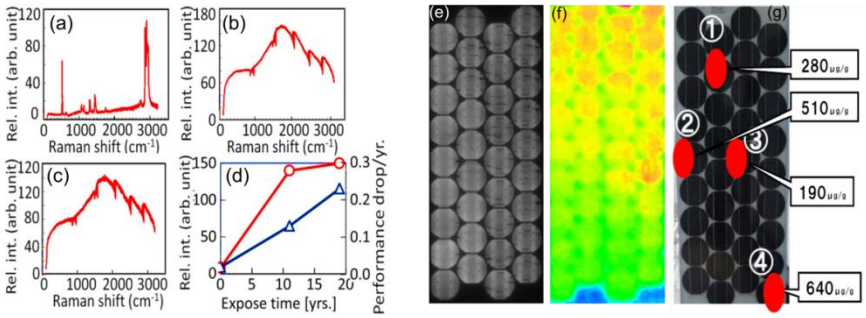

Figure 1: Encapsulant degradation has been observed from Raman fluorescence spectra of the field aged module, (a) not used but remaining in the room for around 3 years, (b) used 11 years in the field, (c) used 19 years in the field, (d) exposed time vs. Raman fluorescence intensity and module's performance drop, (e-g) EL and LIT image of 19 yrs. used module and points interest and measured acetic acid decompose from the EVA on that module

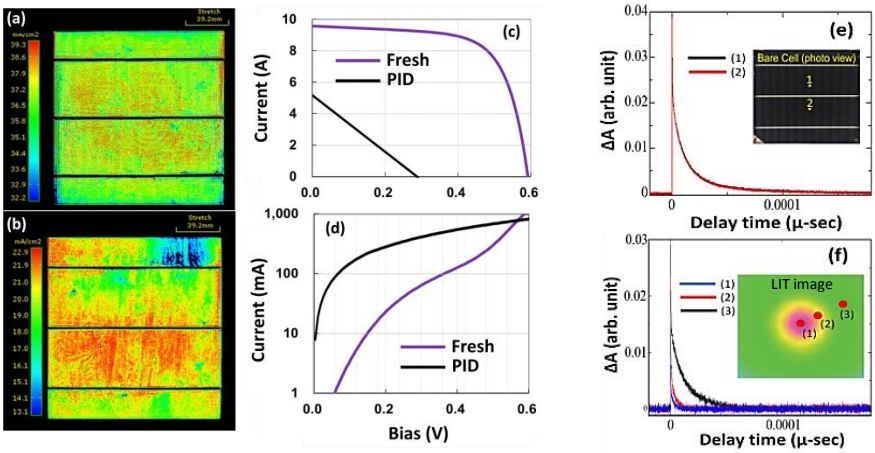

Figure 2: Single cell module degradation has been determined from the accelerated PID test, (a & b) current density mapping image of fresh and 100 hrs. of PID (-1000 V) poly-Si modules, (c & d) light and dark I-V characteristics of corresponding poly-Si modules and (e & f) transient absorption spectroscopy of mono-Si module for bare cell and PID module (pump: 532 nm laser, probe: continuous white light and the circle area on the inset figure (LIT image) is intentionally scratched before preparation of module and PID test)