Performance and Reliability of PV Modules

LIFETIME ESTIMATION OF SILICON PHOTOVOLTAIC MODULE USING LASER-BASED DIAGNOSIS TECHNOLOGY

Yasuaki Ishikawa¹, Mohammad Aminul Islam¹, Yasushi Takagi², Hirotaka Iida², and Hidenari Nakahama³

¹ Nara Institute of Science and Technology, Japan
² Nisshinbo Mechatronics Inc., Japan
Email: yishikawa@ms.naist.jp

The degradation ratio of power generation (DR) is usually 0.4-0.8%/year for crystalline Si photovoltaic module. Actual surveying of degradation of power generation has linear relation with respect to exposed time [1-3]. The DR is utilized to estimate an amount of generation power during 20 years to design a business model. Here, the DR is influenced by circumstances such as temperature and humidity, lifetime estimation at an installed site is extensively required. The photovoltaic module consists of solar cell generating power, and casing (EVA encapsulant) which protects from deterioration factors. To estimate a lifetime of photovoltaic module, we investigate diagnosis techniques which can analyze a state of solar cell (cell and electrodes) and casing, individually.

Destructive analysis and electroluminescence (EL) diagnosis were performed to investigate the cause of deterioration for aged degradation modules including potential induced degradation (PID) mode. We found that EL intensity was remarkably changed by thinning of silver fingers on the cell leading to increase a contact resistance between finger and cell, and peeling of solder parts at tab lines. The destructive analysis revealed that sodium accumulation at the cell surface starting from the finger electrodes and acetic acid formation owing to EVA deterioration occurred.

The degradation of EVA (de-acetic acid) in module was characterized by fluorescence intensity ratio \( \frac{I_{1800\text{cm}^{-1}}}{I_{2890\text{cm}^{-1}}} \) in Raman spectroscopy. Figure 1 shows dependence of DR on the fluorescence intensity ratio in field-aged modules. We found there are two linear lines: solid line showed modules encapsulated by standard cure, while dotted line by fast cure.

To check quality of mono-crystalline Si solar cells after PID test (85°C, 85RH%, -1000 V, 1500 h), we performed a microwave photoconductivity decay (μ-PCD) method which is laser-based technique and estimates an carriers’ effective lifetime of Si solar cell. Bare cell and module after lamination yielded 11μs as carriers’ effective lifetime, respectively. For the PID tested module, we found that remarkable deterioration of the effective lifetime occurred. The distribution of the effective lifetime value corresponded with a photocurrent mapping and EL image while Raman diagnosis did not present any deterioration, suggesting μ-PCD method also gives us a helpful information in terms of evaluation of cell quality.

Figure 1: Dependence of degradation ratio on fluorescent intensity ratio.

Figure 2: (left) EL image of PID-tested mono-crystalline Si module, (Right) photocurrent mapping measured by MP-50, and distribution of carriers’ effective lifetime measured by μ-PCD method (unit: μs).

[References]