

Materials Science & Engineering Doctoral Defense

Series Resistance Increase in Field Degraded PV Modules in Different Climatic Conditions

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abstract

Global photovoltaic (PV) module installation in 2018 is estimated to exceed 100 GW, and crystalline Si (c-Si) solar cell-based modules have a share more than 90% of the global PV market. To reduce the social cost of PV electricity, further developments in reliability of solar panels are expected. These will lead to realize longer module lifetime and reduced levelized cost of energy. As many as 86 failure modes are observed in PV modules [1] and series resistance increase is one of the major durability issues of all. Series resistance constitutes emitter sheet resistance, metal-semiconductor contact resistance, and resistance across the metal-solder ribbon. Solder bond degradation at the cell interconnect is one of the primary causes for increase in series resistance, which is also considered to be an invisible defect [1]. Combination of intermetallic compounds (IMC) formation during soldering and their growth due to solid state diffusion over its lifetime result in formation of weak interfaces between the solar cell and the interconnect. Thermal cycling under regular operating conditions induce thermo-mechanical fatigue over these weak interfaces resulting in contact reduction or loss. Contact reduction or loss leads to increase in series resistance which further manifests into power and fill factor loss. The degree of intermixing of metallic interfaces and contact loss depends on climatic conditions as temperature and humidity (moisture ingress into the PV module laminate) play a vital role in reaction kinetics of these layers. Modules from Arizona and Florida served as a good sample set to analyze the effects of hot and humid climatic conditions respectively. The results obtained in the current thesis quantifies the thickness of IMC formation from SEM-EDS profiles, where similar modules obtained from different climatic conditions were compared.