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Power degradation caused by snail trails in urban photovoltaic energy systems

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Abstract

In recent years, a discoloration defect called as the snail trials emerged on crystalline silicon solar module in urban photovoltaic energy systems. It resulted in power degradation, and caused a serious concern about effects of this phenomenon on crystalline silicon solar modules, but very few publications have dealt with this phenomenon. In this paper, the crystalline silicon solar modules with snail trials are investigated by I-V and P-V characteristics, electroluminescence (EL) technique, thermography analysis, and energy production in photovoltaic power plant. The obtained results show that the snail trails may affect output of power for crystalline silicon solar modules compared with reference module, the energy production measured was about 9.1% lower than the normal array.

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Keywords: Photovoltaic; power plant; reliability; Degradation; Snail trails

1. Introduction

The photovoltaic (PV) energy will provide a substantial contribution to low-carbon cities and urban energy. The crystalline silicon solar module is a workhorse for photovoltaic energy in a long time. It is a key system component that converts solar radiation directly to electricity. The reliability of crystalline solar modules is critical to the cost effectiveness and the commercial success of photovoltaic energy. In recent years, a discoloration defect called as the snail trials emerged on crystalline silicon solar module in photovoltaic power plant. This snail trail appearing as small, dark lines or partial cell-discolorations on PV modules, has drawn considerable attention from researchers and manufacturers in the solar industry Previous works focused on the elements and formation mechanism of snail trail. They argued that the snail trail is silver nanoparticle [1], silver oxide or silver carbonate nanoparticles [2] and the silver

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element is from the silver finger of solar cells [1-2]. Some authors think that the snail trail discolorations within the cells are strongly correlated with cell micro-cracks. Other authors think that there is no indication that they cause a significant decrease in module efficiency.

Because the thickness of crystalline silicon solar cells is only 190 um, and silicon is very brittle, cracks can be easily induced by vibrations, impact during transportation and installation. And heavy snow pressure also caused the cracks. According to the above authors, there are a lot of snail trials in every photovoltaic power plant. But there is no snail trial in some photovoltaic power plant. According to our investigations, the snail trials phenomenon is random. It is not directly correlated with cell micro-cracks. It indeed caused power degradation in urban photovoltaic energy systems. In this work, the relationship between snail trails and micro-cracks is studied. Electroluminescence and infrared thermometer are used to find out the influence of snail trails on cell structure and performance. In order to clarify the origin of silver element of snail trail, Scanning Electron Microscopy (SEM) and Energy Dispersive Spectrometry (EDS) were used to observe the morphology and silver element content difference of silver fingers between common modules and degraded modules affected by snail trails.

2. EXPERIMENTAL

2.1. Sample preparation

PV modules affected by snail trails in urban photovoltaic energy systems are prepared for study. Figure 1 shows the outdoor scene of urban photovoltaic energy systems affected by snail trails phenomenon.

Fig. 1. Phenomenon of snail trials in urban photovoltaic energy systems

2.2. EL analysis

Electroluminescence (EL) is a good means to exam whether the PV modules have the cells with micro-cracks or not. So the problem of micro-cracking in Silicon PV has recently been investigated in [3-7] with the aid of the electroluminescence (EL) technique.

2.3. SEM analysis and EDS analysis