Study on Influence of Tin Plating Layer of Solder Strip on Electrical Properties of Photovoltaic Modules

Xiankun Ren [1, 4], Yuying Ma [2, *], Chuan Jiang [3] and Xiaojun Yan [3]

[1] Shandong Linuo Solar Power Holdings Co., Ltd, Jinan 250103, China
[2] Shandong Vocational and Technical University of Engineering, Jinan 250200, China
[3] Shandong Linuo Solar Power Technology Co., Ltd, Jinan 250103, China
[4] Shandong Linuo Photovoltaic High Tech Co., Ltd, Jinan 250103, China

Abstract. With the continuous development of social economy, the cost reduction and efficiency increase of enterprises are very important for the development of enterprises. Starting from the packaging materials of photovoltaic modules, this paper mainly studies the influence of welding ribbon with different tin layer thicknesses on the performance of photovoltaic modules, and compares the resistivity of welding ribbon with different thickness of tin layers. The experimental results show that with the reduction of the thickness of the tin-plated layer on the non-soldering surface of the welding ribbon, the resistivity of the welding ribbon decreases, and the output power of the photovoltaic module is effectively improved.

Keywords: Photovoltaic; Modules; Tin layer; Welding ribbon; Resistivity.

1. Introduction

Solar energy is the cleanest, safe and reliable energy source in the future, and the photovoltaic industry is increasingly becoming another explosive industry [1-3]. The solar cell module is the core part of the solar power generation system and the most important part of the solar power generation system. The quality and cost of solar cell modules will directly determine the quality and cost of the entire system.

The photovoltaic cells inside the solar module are connected in series to form an array, which is then encapsulated by glass, backplane, ethylene-vinyl acetate copolymer (EVA), silica gel and other protective materials. Photovoltaic modules are installed and constructed to form a module array system to convert light energy into electrical energy [4]. The structure of the photovoltaic module is shown in Figure 1. The efficiency of photoelectric conversion is the most important point for converting light energy into electrical energy. The higher the photoelectric conversion efficiency, the higher the utilization rate of sunlight and the greater the power generation under the same irradiation area.

The power generation principle of photovoltaic modules is the process of converting the absorbed solar energy into electrical energy by the solar cells in the module. In photovoltaic modules, the photovoltaic ribbon mainly plays the role of electrical connection, and transmits the current collected by the main grid of the solar cell through the photovoltaic ribbon. The power loss of photovoltaic modules mainly includes optical loss and electrical loss [5]. The optical loss is mainly caused by the shading of photovoltaic ribbons, the transmittance and optical mismatch of packaging materials such as glass and EVA. The electrical aspect mainly refers to the power loss caused by the resistance loss in the module, including the resistance of the welding tape, contact, and junction box, and is also affected by the current mismatch of the cell and the influence of the design version of the module. For photovoltaic practitioners, it is an important task to reduce production costs and increase the power generation of modules by continuously increasing the power of modules. Photovoltaic ribbon is an important part of photovoltaic modules. It is made of high-quality oxygen-free copper and tinned on both sides. Photovoltaic modules connect the cells through ribbon welding, and collect the current generated by the battery and output it to the outside through the junction box. Therefore, the resistance and welding performance of the ribbon itself will have a certain impact on the power of the photovoltaic module.

* Corresponding author: yyyjbd@163.com

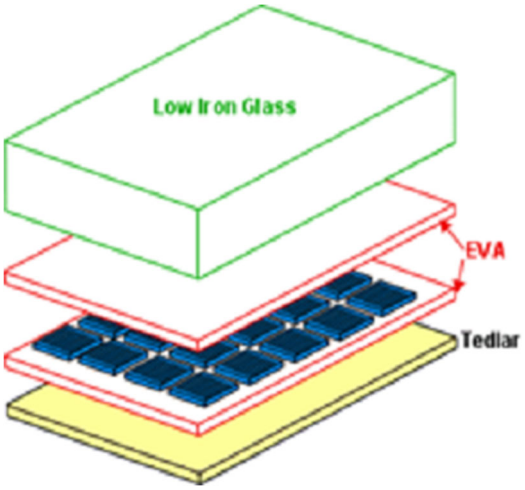

Fig. 1 The stacking sequence of packaging materials for photovoltaic modules

In this paper, an experiment is carried out on the thickness of the tin-plated layer on the non-soldering surface of the photovoltaic module welding strip, and the resistivity of the welding strip with different tin-plated layer thicknesses is tested. The PV modules were packaged with different thicknesses of tin-coated ribbons to encapsulate the modules and the encapsulation efficiency of the PV modules was collected. The influence of the thickness of the tin-coated ribbons on the output performance of PV modules was discussed.

2. Experimental section

In this experiment, the welding tape produced by Taicang Juren Photovoltaic Materials Co., Ltd. was selected, and the ZY9987 digital micro-ohmmeter was used for the resistivity test. The photovoltaic modules use P-type monocrystalline PERC cells with a size of 182 mm × 182 mm and a conversion efficiency of 22.8%. The component package layout design is shown in Figure 2.

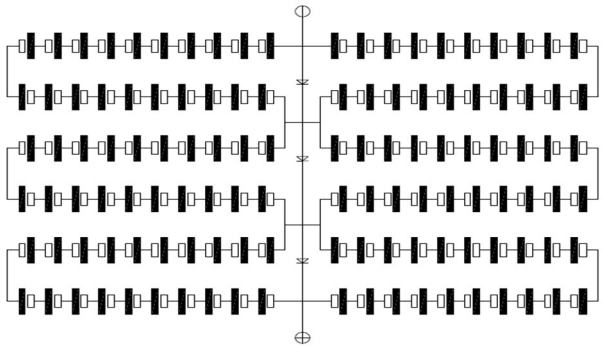

Fig. 2 Schematic diagram of electrical connection of experimental components (back)

3. Results and analysis

At present, the specifications of photovoltaic ribbons on the market and the thickness of the tinned layer are different. In order to study the influence of the thickness of the tinned layer on the resistivity of the ribbons, three types of ribbons are selected for experiments. The structures and parameters of the ribbons are shown in the table 1, and the cross section of the ribbon is shown in Figure 3.

Table 1 Specification and parameter table of welding strip for experiment

Experiment	Total thickness	Soldering surface tin layer thickness	Thickness of tin plating on non-soldering surface
A	0.3mm	20-25um	20-25um
B	0.3mm	20-25um	10-15um
C	0.3mm	20-25um	1-5um

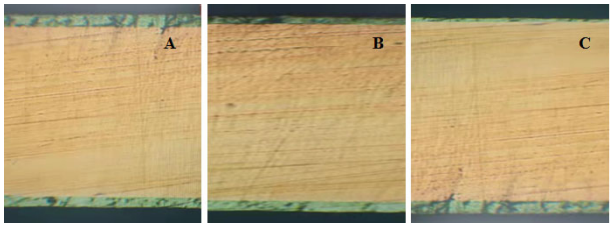

Fig. 3 Cross-sectional views of solder ribbons with different tin plating thicknesses

3.1 Influence of the thickness of the tinned layer on the resistivity of the ribbon

The resistivity test was carried out on the ribbon with different tin-plated layer structures, and the test results are shown in Figure 4. As can be seen from the figure, as the thickness of the tin-plated layer on the non-welding surface of the ribbon gradually decreases, the resistivity of the ribbon gradually decreases. This is mainly because the tin-plated layer of the ribbon is a tin-lead alloy, and the resistivity of tin and lead is much higher than that of copper, so as the tin-plated layer with high resistivity is thinned, the resistivity of the ribbon gradually decreases[6,7].

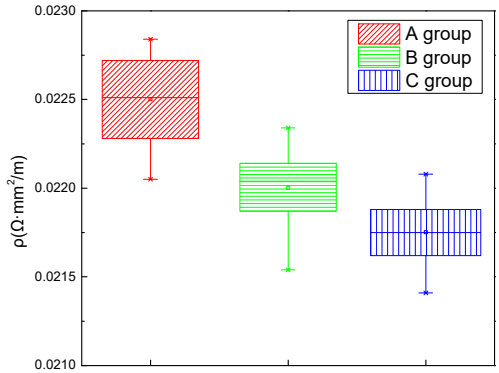

Fig. 4 Distribution of resistivity test of test ribbons in groups A, B and C

3.2 Influence of the thickness of the tin plating layer on the encapsulation power of photovoltaic modules

In order to avoid the influence of other factors on the power of photovoltaic modules, on the basis of ensuring the consistency of cells and packaging materials, single-crystal silicon photovoltaic modules were prepared by using the above three kinds of welding tapes, each type of photovoltaic module was 20 plates, and the photovoltaic modules were packaged The output power test was carried out for three groups of experiments, and the test results are shown in Figure 5. The data in the figure shows that as the thickness of the tinned layer of the solder ribbon decreases, the output power of the module shows an upward trend. This is because the thinning of the tin plating layer reduces the resistivity of the solder ribbon, which reduces the series resistance of the photovoltaic module and improves the output power of the photovoltaic module.

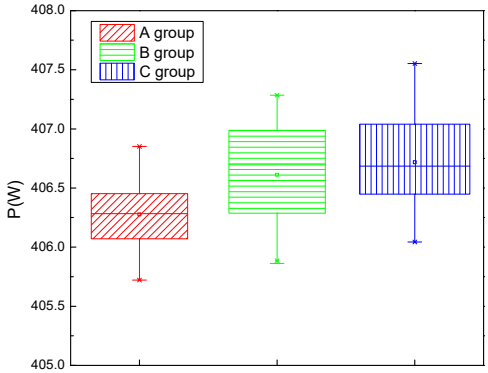

Fig. 5 Package power test distribution of test components in groups A, B and C

4. Summary

This paper takes the welding strip for photovoltaic module materials as the research object, designs welding strips with different thicknesses of tinned layers, compares the resistivity of the welding strips with different structures and the output power of photovoltaic modules, and draws the following conclusions: The thinning of the thickness of the tinned layer on the surface reduces the resistivity of the soldering strip, and the output power of the photovoltaic module gradually increases.

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