RESEARCH ARTICLE

Research on Reliability of Packaging Materials for PVT Modules

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Abstract: This paper studies the difference in heat transfer and adhesion performance of glass fiber substrate thermal conductive double-sided adhesive, PVC substrate double-sided adhesive, and PET substrate double-sided adhesive to thermal conductive materials and polymer materials in photovoltaic and thermal integrated modules. Studies have shown that the use of glass fiber-based thermally conductive double-sided adhesive to bond polymer materials and thermally conductive materials can achieve the normal use of PVT modules under weather-resistant conditions. Research has shown that glass fiber-based thermally conductive double-sided adhesive has better adhesion than other materials., Initial viscosity, static shear force, thermal conductivity, etc., can realize the normal use of PVT modules under weathering conditions.

Keywords: PVT; Adhesion; Initial viscosity; Static shear force; Thermal conductivity.

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0 Introduction

"Photovoltaic/Thermal integrated system (Photovoltaic/Thermal)" has attracted the attention of the industry as "multiple utilization of the same energy". In the actual operation of the power grid, the photoelectric conversion efficiency of the photovoltaic module decreases with the increase of the operating temperature. In order to maintain the module temperature at a low level without reducing its photoelectric conversion efficiency, but also to make use of the excess heat, users can use a solar photovoltaic and photo thermal integrated system, that is, a PV/T system, instead of a single Photovoltaic power generation system. Taking the "photovoltaic + solar thermal" cogeneration model as the entry point of the transition period, it can not only retain the original characteristics of photovoltaic power generation to the greatest extent, but also using the original resource advantages and engineering experience to package thermal power services, Its advantages in market competition are more obvious, and it can also promote synergy between different types of energy.

With regard to PVT systems, universities, research institutions, and photovoltaic and solar thermal manufacturers have all carried out a lot of research and development work. The difficulty of system development is mainly concentrated in the combination of PV-modules and solar thermal collector plates. The first is the reasonable allocation of the limited irradiation area, and the second is the output of the power generation and heating power of the integrated photovoltaic and solar thermal modules.

Figure 1 shows the structure of photovoltaic and thermal integrated modules currently on the market. There are two main ways to achieve: One is the module-metal tube method. A copper or aluminum tube is installed behind the photovoltaic module and wrapped with insulation cotton. The water or refrigerant in the copper tube will take away the heat generated by the photovoltaic module. The second is the module-heat exchange plate method. The separate or integral module heat exchange plate is attached or laminated on the back of the module, and then the heat from the back of the module is taken away by water or refrigerant such as Freon. Compared with the module-metal tube method, this method has higher heat exchange efficiency and can significantly reduce the temperature of the module and increase the power generation. Compared with the module-metal tube method, this method has higher heat exchange efficiency and can significantly reduce the temperature of the module and increase the power generation. However, the split heat exchange plate has a problem of liquid leakage. For the integral heat exchange plate, since both metal and glass are rigid materials, the metal heat exchange plate has relatively large deformation stress during the lamination process and subsequent use. This leads to problems such as laminating process problems and peeling off during subsequent use, which affects the process effect and use effect.

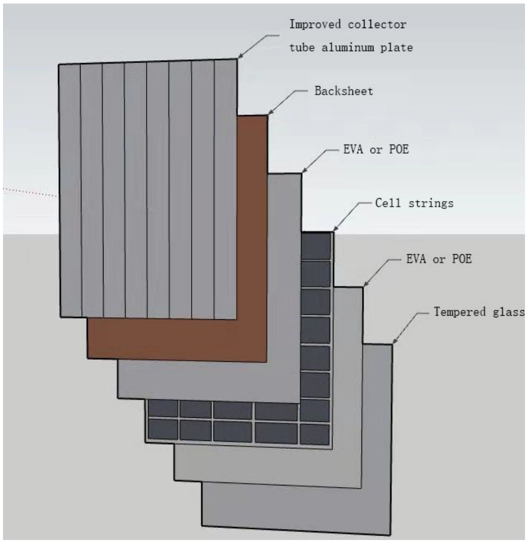

Figure 1 The stacking sequence of packaging materials for PVT modules

PVT components need to achieve rapid heat transfer. If only relying on the gap air (thermal conductivity of 0.023W/mk) to transfer heat, the temperature control of the components in a short period of time cannot be met, and heat waste will occur at the same time.In order to better realize the rapid heat conduction of the photovoltaic module itself, this paper used different substrate double-sided adhesives for performance testing, and the optimal material for PVT module encapsulation is obtained.

1 Experimental section

1.1 Experimental equipment and materials

The equipment and materials required for the experiment are shown in Tables 1 and 2.

1.2 Experimental program

Initial adhesion test: The initial adhesion test platform is shown in Figure 2. The test platform adopts a tooling with a 30° inclination angle. The bottom of the tooling is pasted with double-sided tapes of different substrates, and a 20mm diameter steel ball is freely rolled from the top of the tooling to measure the rolling distance of the steel ball on the double-sided tape.

Table 1 Details of experimental equipment

Number	Equipment	Model	Factory	deviation
1	Electronic tensile testing machine	WDS-05	Jinan Sida	±3N
2	PCT（pressure cooker test）	ZH-PCT-45	Zheng Hang	0
3	High and low temperature test chamber	H-PTH-10350K	Horad	±1℃
4	High temperature and humidity test chamber	HT27E	Hance Technologies	±1℃
5	Steel ball (Φ=20mm)	/	Linuo	/
6	Bracket（∠=30°）	/	Linuo	/

Table 2 Details of experimental materials

Number	Model/Material	Factory	Size / mm
1	Glass fiber substrate thermal conductive double-sided adhesive	Jinan Yongqiang Adhesive Products Co., Ltd.	0.2
2	PVC substrate double-sided tape	Jinan Yusenxu Packaging Materials Co., Ltd.	0.15
3	PET substrate double-sided tape	Jinan Yusenxu Packaging Materials Co., Ltd.	0.2
4	Photovoltaic module (350mm*350mm)	Shandong Linuo Photovoltaic High-tech Co., Ltd.	4.4

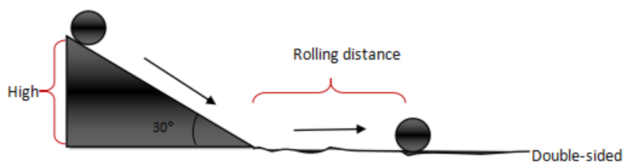

Figure 2 Schematic diagram of initial viscosity test

Adhesion test: The double-sided adhesives of different substrates were respectively fixed on the end of the acrylic sheet and the end of the photovoltaic module back sheet, and peeled at a speed of 100mm/min, as shown in Figure 3. During the process, the peeling phenomenon was observed and the peeling data was recorded.

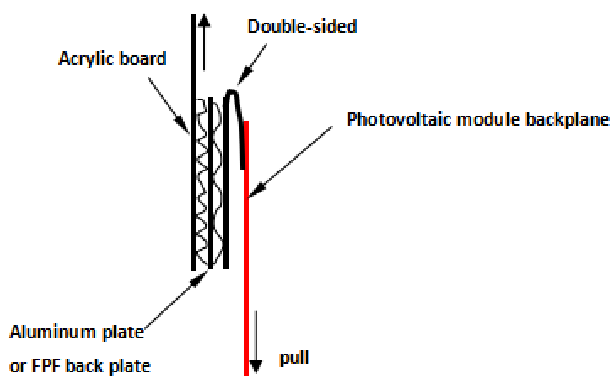

Figure 3 Diagram of adhesion test

Static shear test: The double-sided adhesives of different substrates are sandwiched between the back plate and the aluminum plate, and fixed to make them sag naturally. As shown in Figure 4, a 1kg weight is hung at the lower end, and the displacement distance after 144 hours is observed and recorded.

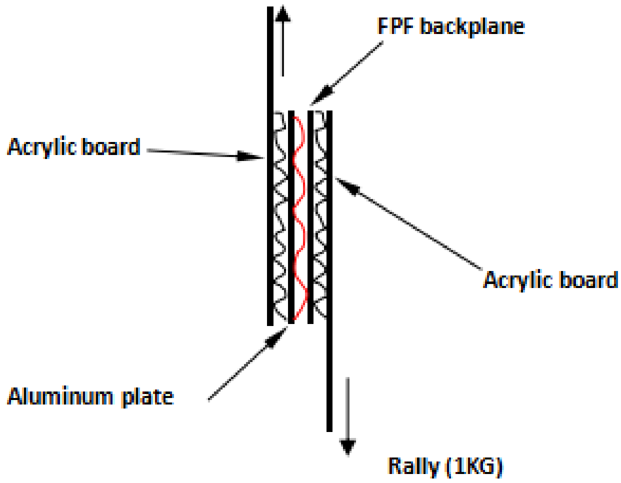

Figure 4 Schematic diagram of static shear test

Thermal conductivity test: Use double-sided tapes of different structures to paste the microporous aluminum plate on the small glass to make a sample, and place it in the freezer at -20°C for 1 hour. After taking the sample out of the freezer, the glass surface directly touches the 70°C water surface, and the infrared tester is used to detect the temperature transmission speed (the time it takes for the surface temperature of the microporous aluminum plate to reach 30°C).

2. Experimental results and analysis

2.1 Initial adhesion test

The rolling distance of the steel ball on the double-sided tape of different substrates is shown in Table 3. It can be seen from the table that the rolling distance of the glass fiber substrate is the shortest, followed by the PVC substrate, and the PET substrate has the longest rolling distance. It shows that the initial adhesion of the glass fiber substrate thermal double-sided adhesive is the best, because the shorter the rolling distance, the stronger the initial adhesion of the sample.

2.2 Adhesion test

We test the peel strength of double-sided tapes on different substrates to meet the application environment and usage requirements of PVT products. According to the experimental program in Table 4, experiments are carried out to verify the performance of the material under different environmental conditions. The test data is shown in Table 5. According to the comparative analysis of adhesion data, the peeling performance of the glass fiber substrate thermal double-sided adhesive is better than that of other substrate double-sided adhesives. There is little difference in the performance of the double-sided tape between the PET substrate and the PVC substrate, but they are far from meeting the needs of PVT module packaging.

Table 3 Rolling distance of steel ball

Number	Material	Rolling distance
1	Glass fiber substrate	150mm
2	PVC substrate	300mm
3	PET substrate	500mm

2.3 Static shear test

The tensile force of 1kg was applied to the experimental samples of double-sided tapes with different substrates, and the dislocation distance after 144H is shown in Table 6. The displacement of the glass fiber substrate is significantly greater than that of the PVC substrate and the PET substrate, which indicates that the cohesion for the PVC substrate and the PET substrate is greater than the glass fiber substrate thermal double-sided adhesive. It shows that the internal stress release period of these two substrates is long, which is not conducive to the release of the deformation force of the aluminum plate. Therefore, the glass fiber substrate thermal double-sided adhesive has excellent performance in static shearing force, and it is more in line with the environmental requirements of PVT modules.

2.4 Thermal conductivity test

An infrared tester was used to test the temperature transmission speed of the double-sided adhesives on different substrates. The test data is shown in Table 7. Through data comparison, we found that the glass fiber substrate double-sided adhesive has the fastest thermal conductivity, which indicates that the glass fiber substrate has the best thermal conductivity. According to the statistical data of the thermal conductivity of the material (same specifications), the thermal conductivity of the glass fiber substrate double-sided adhesive is 1.5 w/m·K, the thermal conductivity of the PVC substrate is 0.18 w/m·K, and the thermal conductivity of the PET substrate is 0.2 w/m·K, the theoretical calculation is consistent with the experimental results. Therefore, the glass fiber substrate can bet-

Table 4 Adhesion test plan

Number	Experiment content	Details
1	Peel off on the same day at room temperature	Test at room temperature after pressing and bonding
2	Peel off after 4 days at room temperature	Test after 4 days at room temperature (23℃ -25℃) after pressing and bonding
3	Peel off after high temperature storage	Test after 30 minutes in a drying oven at 80℃
4	Peel off after low temperature storage	Test after 48 hours in the freezer at minus 20℃
5	Peel off after aging test	PCT test after 24 hours

Table 5 Comparison of peel force test data

Number	Material	Normal temperature（N/cm）	After 4 days（N/cm）	Store at 80°C for 30 minutes （N/cm）	Store at minus 20°C for 48 hours（N/CM）	PCT experiment 24 hours （N/CM）
1	Glass fiber substrate	20.75	19	25.4	16.5	15.2
2	PVC substrate	4.8	8.5	3	6.85	4.2
3	PET substrate	4.8	6.25	7.25	4.9	4.2

Table 6 Displacement of double-sided tape on different substrates

Number	Material	Displacement
1	Glass fiber substrate	2mm
2	PVC substrate	0.1mm
3	PET substrate	0.2mm

ter meet the temperature control requirements and can be used as a thermal conductive material in PVT photovoltaic modules.

Table 7 Comparison of temperature transmission speed

Number	Material	Time to reach 30°C /s
1	Glass fiber substrate	5
2	PVC substrate	10
3	PET substrate	11

3 Conclusion

The demand for photovoltaic-thermal integrated modules (PVT) is concentrated in the remote western and Gobi areas where the environment is harsh. Therefore, the material must have higher weather resistance. Based on the requirements of IEC61215 and IEC61730 standards, this paper conducts comprehensive verification by comparing the double-sided tapes of different substrates from various manufacturers, and draws the following conclusions: The glass fiber substrate is more suitable for PVT module thermal conductive material paste and meets the demand for mass production, because it has better performance than other materials in terms of adhesion, initial tack, static shear force, and thermal conductivity.

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