

# Research Progress of Border for Solar Photovoltaic Modules

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**Abstract**—With the sustainable development of economy, solar energy has been widely used as a clean energy, photovoltaic industry has been rapid development. This article summarizes the summary and classification of solar photovoltaic modules frame; Comparative analysis is mainly focused on the aluminum frame, stainless steel frame and composite frame etc. The advantages and disadvantages of solar energy photovoltaic component frame; Aluminum frame, with its good performance, the advantage, low cost and large-scale application. Also expounds on the role and structure and fixed way and way of surface treatment of aluminum frame, and the structure of different, contrasted the fixed way and surface treatment method, analyzes its advantages and disadvantages. Finally this paper summarizes the present status of solar photovoltaic modules border, summarizes the problems that exist in the solar photovoltaic modules border, and explains the causes of the problem; Put forward the photovoltaic component frame will towards lightweight, refinement, high strength, the direction of integration.

**Keywords**—Solar;PV modules;Border;Encapsulation; aluminum;

## I. INTRODUCTION

The growing economy, energy supply will receive a larger, more severe test, to save on energy, environmental protection, known for solar will be widely welcomed. Solar has the characteristics of renewable and environmental protection, so many countries, including China, the solar energy industry as a new focus on the development. With the wide spread use of solar energy, photovoltaic industry rapid development, as of the end of 2014, China's total installed capacity reached 30GW, second only to Germany, in 2030 this figure is expected to reach 270GW,described prospects. Although in the solar photovoltaic system, the cost and technical difficulty of the components of the border are not large,

but the role of the border is very important<sup>[1]</sup>. Border can not only protect the glass on the solar panel, and also to facilitate the connection between the fixed components, while the Border and seal assembly binder constitute, as an assembly the connection carrier building or stent, and its performance will affect the solar energy life of components. Currently, the vast majority of domestic production of the aluminum alloy frame, the technology is relatively mature. Now is to study some of the composite materials Border, and the Border structure is optimized to improve its sealability, reduce the weight of the border, and cost savings. China as a major producer and supplier of Border, the border continuous development of industry, this article on the current status of research made a presentation, and the prospect of future trends.

## II. SOLAR PHOTOVOLTAIC MODULES FRAME CLASSIFICATION AND ANALYSIS OF THE CHARACTERISTICS.

In accordance with the use of raw materials can be divided into three categories of solar frame: Aluminum frame, Stainless steel frame, Composite material frame.

### A. Aluminum frame

Aluminum profiles existing solar PV modules used primarily for the Model 6000 series Al-Mg-Si alloys, primarily for use in general is 6061 and 6063<sup>[2]</sup>. Its surface is silver-white thin film, the main ingredient is aluminum, mixed with a small amount of magnesium, copper, iron, silicon, zinc and other metals. At present, the solar industry as a producer of solar modules aluminum frame of the main material.

Aluminum with light weight, strong corrosion resistance easy forming, high strength, easy cutting and processing, recyclable and other characteristics of the current frame in the application of solar energy is most common, accounting for more than 95%<sup>[3]</sup>.

### B. Stainless steel frame

Limited alternatives as stainless steel frame aluminum frame structure similar to aluminum alloy frame<sup>[4]</sup>. Generally use 304 stainless steel plate through a special process that can adapt to different environments, and relatively high intensity. Due to high prices, the production process is more complicated, so relatively low utilization.

### C. Composite material frame

Composite material frame mainly refers to glass, steel, namely glass fiber reinforced polymer composites. It is a glass fiber and its products (glass cloth, ribbon, felt, sand, etc.) as a reinforcing material, synthetic resin as Composite material matrix. FRP profiles currently being used in a small number of British rooftop solar cell module, but because of its plasticity is not strong and not recyclable, does not have an advantage in terms of cost, it is not widely used<sup>[5]</sup>.

In addition to the three borders, industrial plastic frame is a new product in recent years, the industry concerned. However, due to the terms of industrial plastic production time temperature, production speed, mold equipment, high demand, and environmentally sensitive polymer materials, once the temperature exceeds the critical value, the overall mechanical properties will be greatly reduced, the actual promotion of industrial plastic frame in phase there is a big uncertainty.

Table I Comparison between different materials border

	FRP	Stainless steel	Aluminum alloy
Advantage	Good corrosion resistance	Atmospheric corrosion resistance	Cheaper than stainless steel
	Good mechanical properties	Tensile strength properties	Than stainless steel surface treatment
	Good mechanical properties	Strong adaptability	No high intensity
	Good thermal performance	Intensity Hard	Good oxidation resistance
	Can design good	Strong antioxidant	Good tensile
	Excellent craft	Long life	
Disadvantage	Low elastic modulus	High prices, big weight	susceptible to lightning strike
	Poor moisture resistance	Poor plasticity	High density heavy quality
	Easy to aging	Rust easily, poor aesthetics	Poor corrosion resistance
	Low interlayer shear strength	Processing complex	

## III. SOLAR PHOTOVOLTAIC MODULE ALUMINUM FRAME

### A. The Role Of Aluminum Frame

Because solar panels need to run in many harsh conditions, to withstand wind and rain, to withstand external force, but also to ensure that the solar modules within the frame form damage, thus ensuring the normal output power performance, and the need to adapt a variety of purposes, so the role of the border is very important.

Aluminum frame has a role:

- (1) to protect the glass edge;
- (2) Aluminum alloy combine to strengthen the playing side silica gel sealing performance components;
- (3) greatly improves the mechanical strength of the overall components;
- (4) easy to install components, transportation<sup>[9]</sup>.

### B. Aluminum Frame Structure

Aluminum frame structure is divided into two categories: one is the tape of aluminum frame structure, is a silica gel aluminum frame structure;

Table II aluminum frame structure features comparative table

	tape aluminum frame structure	silica gel aluminum frame structure
Advantage	Relatively simple structure	high adhesive strength
Disadvantage	Sealing performance somewhat less	Complex structure than the former

### C. Aluminum frame fixed manner

Aluminum frame is fixed in two ways: angle aluminum riveting, taptite screws countersunk head connection.

Table III aluminum frame fixed manner Features comparative table

	Angle aluminum riveted	Self-tapping screw connections
Advantage	High installation efficiency, connecting solid structure	Itself has a strong corrosion resistance
	Because there are nail holes, Intensity weakened	Connection strength is not high

### D. Surface treatment of aluminum frame

Because Solar Photovoltaic Module to ensure that the outdoor life of 25 years or so, so the aluminum frame Solar Photovoltaic Module used to have good resistance to oxidation and corrosion-resistant properties. Borders are generally used in Solar Photovoltaic Module into anodizing, sandblasting oxidation and oxidative electrophoresis three<sup>[10]</sup>.

Table IV Comparison between the surface treatment of aluminum frame analysis table

	Anodic oxidation	Sandblasting oxidation	Electrophoresis Oxidation
Advantage	Anti-erosion ability High surface hardness Good insulation Good heat resistance Decorative fine	High hardness Dense solid	Enhanced corrosion resistance Increase the hardness Prevent abrasion Good heat resistance Good aesthetics
Cost	expensive	inexpensive	inexpensive

#### IV. SOLAR PV BORDER SITUATION ANALYSIS AND PROBLEMS

##### A. Solar PV border situation analysis

###### 1) Solar PV module frame Features of the status quo

Since solar components product specifications, production processes, there is a difference components practical application environment, and in order to reflect its intuitive product features, each solar module manufacturers border with customizable features and diversity<sup>[11]</sup>.

###### 2) Quality Solar Photovoltaic Module frame analysis of the status quo

Solar products are refined border deep processing products, strict quality requirements, including:

① Product appearance detection. If the existence of the solar frame scratches, abrasions, bumps and other issues, will lead to the border surface exposed after long-term outdoor operation of solar modules susceptible to corrosion, will affect the entire service life of components. Meanwhile, the Product appearance for the solar components grade rating an important factor, if the product does not meet the requirements of the appearance, the solar modules in the final sales will be downgraded<sup>[12]</sup>.

② Product hardness, weather ability detection. Because solar modules for outdoor installation, the use of a long, need to consider the carrying capacity of the product under the influence of the external environment of wind, snow load, etc., if insufficient solar frame stiffness, deformation and thus will lead to failure of the entire assembly<sup>[13]</sup>. Meanwhile, the need to consider the impact of natural acid, alkali, UV, heat, alternating hot and cold conditions, so the frame surface treatment, the material composition of the border, there are strict requirements, if functional failure will cause the seal and the protective effect of components failure, thereby reducing components overall performance<sup>[14]</sup>.

③ Product detection accuracy. Solar border Accuracy includes: a, section dimension of accuracy, including glass tank or cross-sectional lumen package size accuracy; precision screw holes, surface bending and twisting degree; b, precision machining dimensions: length, including machining, cutting angle, cutting off the poor, functional structure of

precision, high accuracy requirements of solar border products<sup>[15]</sup>.

##### 3.2 Solar Photovoltaic Module frame Problems

###### ① Solar frame weight, high cost

The current solar frame weight is too big, not easy to install and transport, and because the solar cells are made of aluminum alloy frame multi-material, resulting in high production cost of solar cells border<sup>[16]</sup>.

###### ② Solar module frame structure sealing performance is poor

During assembly, particularly components area is larger, since the glass itself arch-shaped or curved waveform characteristics, coupled with the product's own center of gravity is the downward direction, the product will be the central drooping, upturned ends, in the present will extrusion equipment commonly used manual or pneumatic border from the four corners of the tank where a lot of sealants, although many began to enter the amount silica gel, and also the presence of silica gel products up and down the sides of the uneven, some places do not even have the sealant sealing uniformity is difficult to control, sealing performance is difficult to guarantee, components prone to delaminating product edges, electrical insulation decline and other issues, the need to improve further<sup>[17]</sup>.

###### ③ Solar Borders low life

Existing solar frame made of aluminum alloy, the thermal expansion coefficient of aluminum is five times that of glass, so that the front plate solar panel frame with solar panels under cold conditions change, due to the expansion coefficient of the gap is too large since the loss arising from the impact of solar energy board life<sup>[18]</sup>.

###### ④ Solar border perishable

Existing solar located below the border in contact with steel solar stent, made of aluminum solar frame susceptible to galvanic corrosion<sup>[19]</sup>.

###### ⑤ Solar structural stability of the border is relatively low

Due to the current widespread use of solar energy packages will often produce long border corner border junction with short height dislocation, dislocation and around the corner joints and other defects. A lower frame structure of the conventional four border stability encapsulated solar cell module, its tensile strength is relatively low. Conventional border component's border thicker, it is more a single fixed method, and in the solar modules by external force, to produce solar modules easily cracked or broken<sup>[20]</sup>.

#### V. DEVELOPMENTS AND DOMESTIC AND INTERNATIONAL TRENDS OF SOLAR PV MODULES BORDER

##### A. The development of solar photovoltaic modules of the border

Due to Europe, Japan and other developed solar module manufacturers earlier time, in the early development of solar energy in the region borders the basic procurement, led a group of high quality, rich experience in the design of solar border suppliers, including Sweden, Sapa, Japan Sanryo Tateyama Aluminum Corporation, Germany TS-Solar, Hydro Aluminum America and so on<sup>[21]</sup>. These companies are mainly large aluminum plant, its main competitive advantages for product quality advantages, but its price is relatively high, about 30% -40% higher than the domestic

solar border products. With domestic solar border continuously improve product quality, the foreign component manufacturers to reduce costs, will gradually shift its procurement China<sup>[22]</sup>.

China's solar energy industry has gone through the border following three stages:

Prior to 2005 borders domestic solar industry has not yet formed, domestic solar module manufacturers relatively dispersed. This stage, the solar industry as a whole smaller frame, most border plant mainly solar module manufacturing companies to support the development of the enterprise, customer structure is relatively simple, the main supply peripheral components manufacturer<sup>[23]</sup>.

Since 2009, the domestic solar industry is growing rapidly border. The actual amount of new installed capacity in 2010 than 500MW. Domestic PV installed in 2011 the total reached 2.9GW, compared with 2010, an increase of 500 per cent of the total. 2013 domestic photovoltaic new capacity 11.3GW, accounting for 30.5% of global installed capacity, the 2014 domestic capacity has reached 14GW. By the end of 2014, China's total installed capacity of 30 GW, after Germany, the rapid growth of demand also contributed to the rapid development of China's solar energy industry borders. Because of China's solar industry has a strong frame price advantage, and the product quality and technical level has been significantly improved, the foreign component manufacturers gradually expand procurement from China solar frame ratio is currently China is already the world's largest supplier of solar border<sup>[24]</sup>.

#### B. The development trend of solar border

With the advancement of science and technology, the development of solar border more quickly, now with or without borders solar modules. Borders trends include fine, lightweight, high strength and integration.

- ① Fine: automated production trend component of the border to further improve product accuracy requirements.
- ② Lightweight: The product does not affect the function of the premise, from product design to reduce the weight of the material in the process, while reducing production costs, while reducing transportation costs.
- ③ High intensity: higher-strength products relatively smaller, easy to transport, and better performance.
- ④ Integration: mainly refers to the design of integrated border to facilitate post installation, including borders and architecture, engineering combined with integrated design, such as BIPV (building integrated photovoltaic); and the border with the mounting bracket integrated design.

## VI. SUMMARY AND PROSPECT

With the extensive use of aluminum alloy frame, composite frame slowly emerge, industrial escalating border. In focusing on the development of the border at the same time, the problems in the border should be resolved accordingly, such as border susceptible to corrosion, heavy, structure and poor sealing performance. Bracket border integration and building integrated photovoltaic and other advanced technology is the development trend of the future, the industry will continue to develop the border makes the PV industry progress.

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