Insulation plays a critical role in solar panel manufacturing

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The identification and selection of appropriate electrical insulation materials is a critical, and frequently overlooked, component in solar panel manufacturing. Solar panel manufacturers need to carefully select the right materials and adhesives.

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Solar panel manufacturing, whether thin film or rigid silicon, is usually discussed in terms of efficiently converting energy from the sun into electric current and delivering that current as useable power. The manufacture of more efficient, higher performance solar panels can seem to be solely focused on ways to increase the conduction of electrical energy—with scarcely a mention of electrical insulation. Understanding the insulation materials that are used between panel components is crucial for PV solar manufacturers. Insulation materials play a large role in panel performance and may not be given the proper attention during the panel's design stage. Panel failures such as arcing, overheating and component corrosion can be contributed to using the wrong insulation materials. In many cases, more than one material must be laminated together to get the desired insulation effect. Electrical insulation, electrically conductive, thermal insulation, thermally conductive and moisture barrier materials can be laminated together to block or transport current, moisture or heat.

Making a solar panel sandwich

Whether thin film or rigid silicon, a solar module is essentially a sandwich. The layers

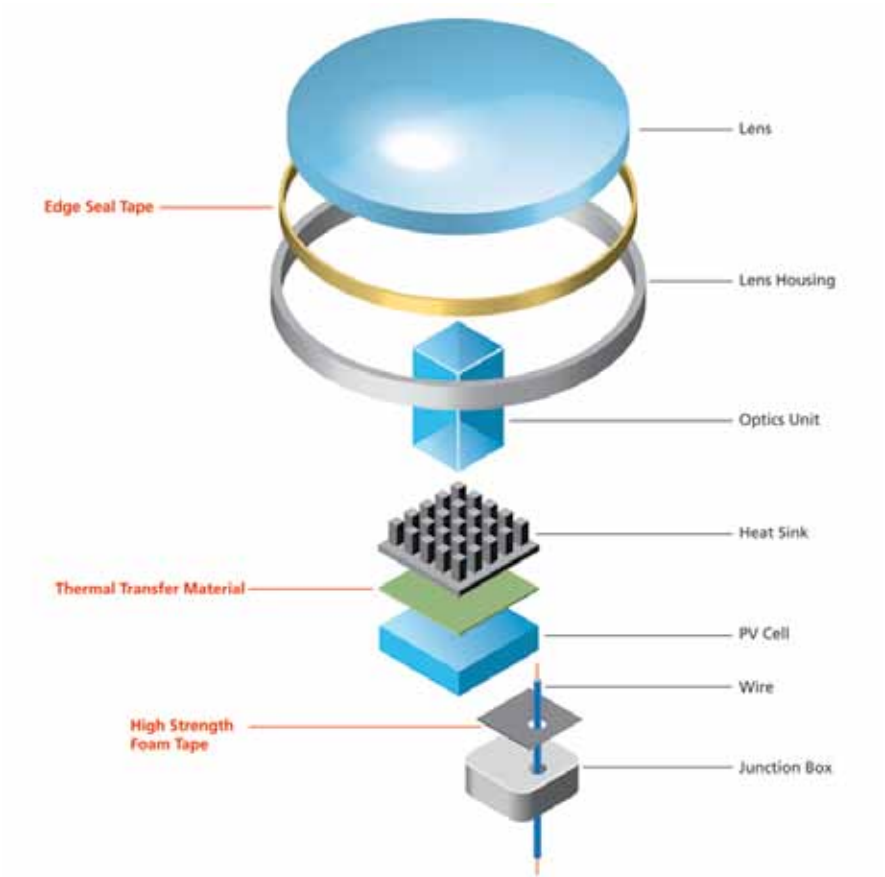

Figure 1. The components of a concentrator module. (Source: Fabrico)

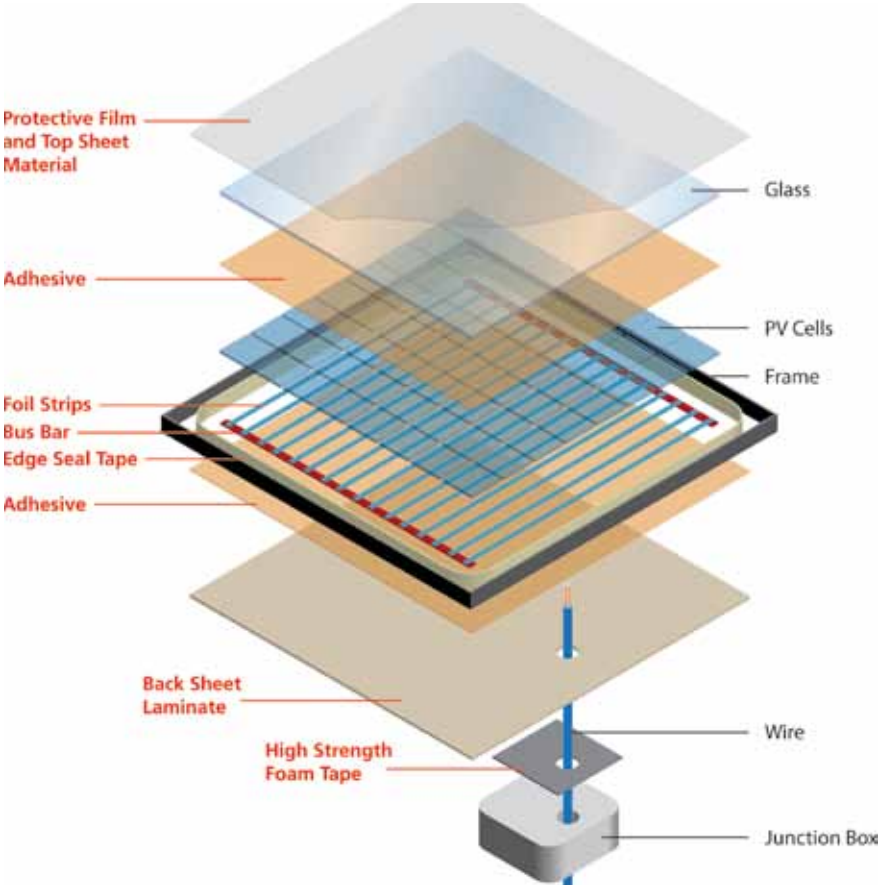

Figure 2. The components of a rigid silicon module. (Source: Fabrico)

in this sandwich can include (from the top down):

- Protective film or blackout materials—protects the glass from moisture and weather;
- Glass—a rigid outer layer that protects the PV cells and electronics while allowing light energy to pass through and be converted into electricity;
- Encapsulant layer—a transparent material that provides electrical insulation and protection against environmental corrosion;
- Photovoltaic cells—convert light energy into electricity via the photovoltaic effect;
- Bus bars—provide a path for the electric power generated by the PV cells;
- PV back sheet—acts as an electrical insulator and provides protection from moisture and weather.

Between the above layers will also be layers of adhesive—to keep the sandwich together and seal it from the environment. Adhesives can be insulating or conductive in nature and their selection depends on where and how they are to be used.

Encapsulants

Encapsulants for solar cells must have excellent adhesion to the cells, back sheet (insulation) and glass. They need to have good transmission of light over a long lifecycle and the ability to withstand weather extremes, and they must provide a good moisture barrier.

Encapsulants are typically polymers such as ethylene vinyl acetate (EVA), the most dominant material, polydimethylsiloxane (PDMS), polyvinyl butyral (PVB), polyethylene ionomers, polyolefins and thermoplastic polyurethane (TPU).

Some of the drawbacks to EVA include less than ideal mechanical and thermal properties, high diffusivity for water, production of acetic acid and poor electrical insulation. These drawbacks can translate into delamination, electric arcing and hot spots.

Often a layer of polyethylene terephthalate (PET) is placed behind the EVA to provide electrical insulation and keep moisture at bay. However, PET is not very UV or hydrolytically stable. This necessitates another layer of polyvinyl fluoride to protect the PET.

Balancing act

As the solar "sandwich" is built, there's a delicate balancing act between the thickness of materials, their weight and their dielectric properties. This is especially true for insulating components for solar panel manufacturers. The goal is to keep the layers effective, but as light and thin as possible. Solar manufacturers must find the perfect balance between the insulating material thickness, capabilities and cost. The thickness of individual components like insulation materials is important because they may not run throughout the panel. This may cause the total thickness of the material stack to vary. This thickness variable can lead to glass failure, undue stress on the internal components or panel sealant failures. In addition it can add to the overall cost and weight of the panel.

All insulating materials fail at some level of applied voltage. Dielectric strength is the most important characteristic for an electrical insulating material. It is the value a material has as an electrical insulator—the resistance it provides to the flow of electricity. It is measured as the maximum voltage required to produce a dielectric breakdown through a material and is expressed in volts per unit thickness. The higher the dielectric strength of a material (sometimes referred to as an R value), the better its quality as an insulator.

In addition to high dielectric strength, an effective backside or backsheet barrier film used for insulation demands a high integrity film. If there are pinholes or deformities in the film there is an increased chance of arcing or shorting.

An effective barrier film can typically have a fluoropolymer layer for its excellent resistance to degradation from UV, heat, and moisture. During lamination, a fluoropolymer can form strong bonds with the EVA encapsulant. This type of barrier film is typically conformable and flexible for easy, wrinkle-free lamination, has a very low moisture vapor transmission rate and provides a solvent-free process.

A variety of materials can be used for insulating barrier films, including polyesters and polyamides—as long as the material provides good dielectric strength in a thin film.

In addition to backsheet films, there are also requirements for electrical insulation along some bussing components. Dielectric insulation tapes can provide reliable electrical insulation with rapid application. The tapes are easy to apply either manually or as part of an automated process.

Selecting the right adhesives

Throughout solar panel manufacturing, selecting the right adhesive is a critical task. The adhesive thickness of a pressure sensitive adhesive (PSA) can be taken into consideration when calculating the dielectric strength of a material, but normally the carrier's material dielectric strength is the most important factor. In the case of panel manufacturing, adhesive thickness is often the first thing sacrificed.

Purity of the adhesive is crucial for any application that involves the inside of a solar panel. Some adhesives contain corrosive impurities in their make up. Normally these corrosive components are found in a lower cost PSAs. Solar panels run at a high internal temperature, causing these PSAs to outgas corrosive impurities into the panel. Outgassing can lead to component corrosion throughout the panel.

Selecting the right materials

The right materials can play a key role in the manufacture of solar panels, so manufacturers need to carefully select those appropriate to their application. What foil tapes meet the manufacturer's specification for bus bars? Which thermal conductors, insulators, and electrical insulators will work best in a particular panel design? What foam or foam tape materials might be suitable for edge seal applications? Solar panel manufacturers may need to get help from experts in order to come up with interleaf materials for flex panels or to specify foam tapes—some exceedingly thin. These foam tapes adhere well under changing environments with factors such as moisture, temperature, and vibration, while providing the desired dielectric performance. In using these materials, solar panel manufacturers will need to consult experts on topics such as contamination—and not just environmental contamination.

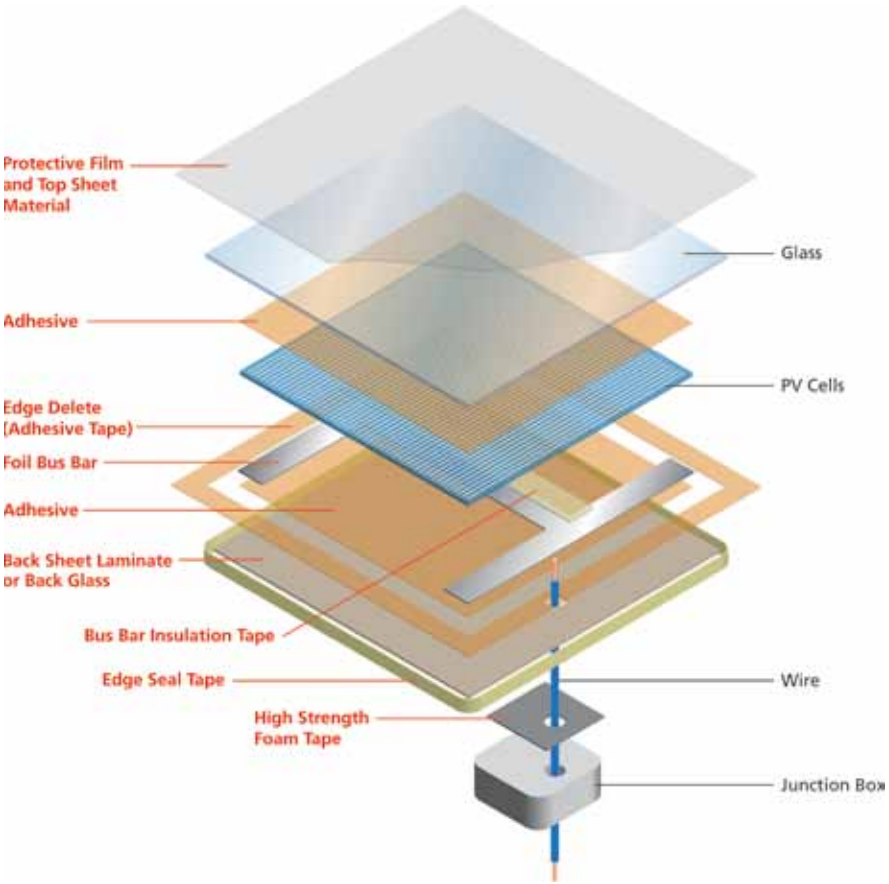

Figure 3. The components of a thin film module. (Source: Fabrico)

As new generations of solar modules become an increasing challenge for manufacturers, design, development and testing of materials becomes more important. This will ensure compliance with governing standards as well as provide expertise and support to optimize costs, minimize rejects and meet manufacturing schedules.