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ADVANCES IN PRESSURE-SENSITIVE ADHESIVE TAPES IMPROVE BUS BAR TECHNOLOGY

POWERING A SUSTAINABLE FUTURE

ADVANCED WIRE SAWING TECHNOLOGY FOR SOLAR PHOTOVOLTAIC CELLS

Mitch Schoch
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Advances in pressure-sensitive adhesive tapes improve bus bar technology for solar manufacturers

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Bus bars provide the key interconnection between the energy a solar panel collects and the current it produces. Advances in conductive and non-conductive pressure-sensitive adhesive tape for bus bar fabrication enable solar panel manufacturers to increase production, decrease costs, and improve the efficiency and durability of the finished solar panel.

Keywords: Bus Bars, Bus Bar Tape, Converters, PSAs/Pressure-Sensitive Adhesives

For solar panel manufacturers, even the smallest electrical improvements translate into increased module efficiency and reduced manufacturing costs. Key areas for improvement include capturing more light, converting more of that light to electrons and providing better conductive pathways for those electrons.

Conductive and non-conductive pressure-sensitive adhesives (PSAs) have been used in solar manufacturing since its inception. As an alternative approach to soldering, they offer a faster, easier to apply and less risky method for joining materials. Solar cell substrates are delicate. The manual soldering process used by many manufacturers can apply stress to the material and create micro-cracks. This occurs because the soldered copper and silicon elements have different thermal expansion rates. The resulting micro-cracks are virtually undetectable during manufacturing but can significantly shorten a panel's lifespan.

In addition to soldering, conductive epoxies and mechanical fasteners are also used to bond materials in a solar panel. However, sensitive, more complex components, plus thinner profiles and smaller product footprint, have increased interest in the advantages of conductive and non-conductive PSAs.

PSAs have been used successfully in automotive, medical, packaging and electronics applications. They form strong bonds with slight pressure and require no heat to activate or cure the adhesive. For solar manufacturers this translates into a number of benefits:

- Flexible formulations—the ability to design the adhesive to fit a specific need;
- Versatility in bonding a wide range of substrates, including those that are dissimilar;
- Instant bonding to speed up the manufacturing process;
- Consistent and easy application;
- Minimal waste and clean-up;
- A thin precise bond whose thickness can be controlled;
- The ability to "build-in" additional functions.

Bus bar tape characteristics

Bus bars not only provide the "route" for transferring a charge from internal cells to the external junction box, they also form interconnects within the module. To keep these connections strong, they must withstand extreme temperatures, continual thermal cycling, humidity and other environmental pressures.

Bus bar tapes consist of foil (copper, tin plated copper, or aluminum), adhesive (acrylic, silicone, conductive, or non-conductive) and a liner. The foil provides x-y conductivity and carries current to the junction box. Sometimes the foil is protected by a polyester overlay tape. The adhesive fixes the foil to the panel. In addition, conductive adhesive provides a current path from the cells to the foil. PSA bus bar tapes provide strong adherence for a long product life under harsh environmental conditions and improve the connectivity of the bus bar.

Advances in bus bar tapes center on creating specific formulations for conductive and non-conductive PSA tapes to enhance:

- Electrical and thermal conductivity;
- Dielectric properties;

- Environmental stability.

By using new formulations of adhesive, conductive and non-conductive PSA bus bar tapes can provide enhanced electrical connection in addition to a strong physical bond between the cell surface and the main foil carrier. In addition, there is the potential for higher z-axis conductivity for advanced panel geometries/currents.

Electrical conductivity in harsh conditions

Improved bus bar tapes must provide good conductivity through a wide range of operating temperatures, humidity and voltage. Key electrical characteristics for advanced PSA bus bar tapes include:

- Electrical conductivity, especially in the z-axis;
- Good conductivity throughout exposure to heat and humidity—for example, 85˚C/85% RH, 1000h;
- Good conductivity throughout temperature extremes, from -40˚C to 80˚C for 200 cycles
- Low outgassing at high temperature (110˚C)—outgassing can cause a loss of electrical contact as well as arcing;
- Good conductivity at very high voltage and high temperatures.

With the latest PSA bus bar tapes, these electrical enhancements are combined with easy application, delivering the following advantages:

- Strong, flexible electrical interconnects formed by laminated overlap joints instead of rigid solder;
- Stable performance under environmental extremes;
- Reduced/eliminated hot spot problems due to conductivity problems or defects;
- Good resistance to corrosion due to conditions inside and outside the panel;
- Efficient heat dissipation with a high surface area to cross-sectional area ratio.

The role of the converter

As new generations of solar panels increase challenges for manufacturers, the design, development and testing of materials becomes more important. Testing ensures compliance with regulatory standards as well as providing the expertise and support to optimize costs, minimize rejects and meet manufacturing schedules.

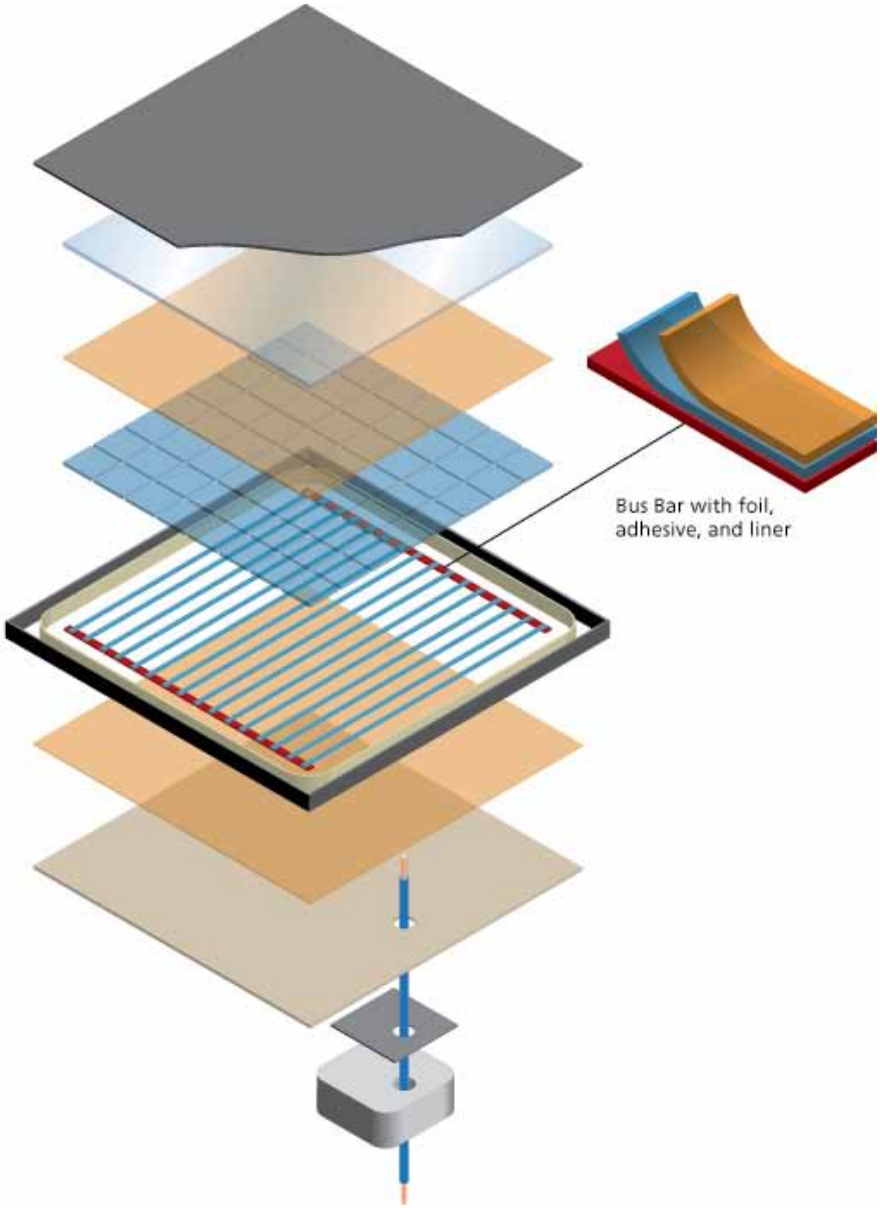
Bus bars can provide several challenges to solar panel manufacturers. The selection of the proper adhesive is often critical. Inconsistent adhesion can cause hot spots that lead to arcing and affect panel performance. An experienced converter can recommend adhesives with the appropriate crosslink capabilities. With a strong understanding of adhesives, a converter helps the panel manufacturer overcome issues that occur during vacuum lamination or other manufacturing steps.

A converter provides assistance in materials and adhesive selection by participating at the very beginning of the design process. In addition, the converter also engages in ongoing research and development of new materials and processes. Materials and adhesives can be qualified based on:

- Temperature resistance, including performance at upper temperature limits;
- Shear, tensile and peel strength;
- Outgassing;
- Contact resistance;
- Electrical and thermal conductivity;
- Slitting widths and tolerance.

A full laboratory facility will allow testing to American Society for Testing and Materials (ASTM) standards for:

- Part dimension verification;
- Adhesive testing/release liner testing;



Bus bar illustration.

- Material strength;
- Static shear test;
- Material weight;
- Microscopic imaging;
- Electrical testing.

Once materials and adhesives have been selected, the converter can provide:

- Precision die-cutting using rotary, laser or water jet technology;
- Accurate and precise slitting and rewinding;
- Laminating, from one step to multiple laminations, narrow and wide web, single to double-coated PSAs;
- Label printing, including certification to print UL labels;
- Packaging and kitting.

A converter can also help a manufacturer process unique materials by customizing processes and materials. The converter's materials processing knowledge helps a manufacturer gain a competitive advantage and handle unique materials in a cost-effective manner. This is especially important in slitting and laminating bus bar tapes where precision is key to optimum bus bar functionality and fail-safe performance.

Summary

New materials and new adhesive formulations are increasing the effectiveness of pressure-sensitive adhesive bus bar tapes in solar panel manufacturing. New tapes offer solar panel manufacturers an easy-to-apply bus bar that can enhance process efficiency, electrical conductivity, and durability of the panel.

Brent Ekiss is the solar market technical Specialist for Fabrico. In this position, Mr. Ekiss has worked closely with solar customers to develop new materials that have solved complicated cost/performance materials issues. With more than 18 years of experience in the flexible materials converting industry, coupled with his understanding of the solar industry, Mr. Ekiss has helped Fabrico's solar customer increase product performance, stream-line manufacturing, and reduce development time. Mr. Ekiss is well versed in the materials and manufacturing requirements of the thin film, rigid/flexible CIGS, crystalline silicon and concentrator applications.