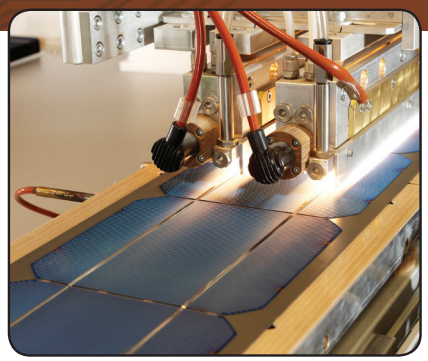
Solar Ribbon Stringing with Epoxies



What is solar ribbon attachment?

Solar cells are converted into solar modules (or panels) by conductive interconnects known as "solar ribbons". Solar ribbons form the electrical bridge of the transparent conductive oxide (TCO)/PV layer into the circuitry of the solar substrate through the use of various joining methods. As the process is repeated, solar cells "use ribbon stringing methods" to produce arrays, modules and panels.

What are the methods for electrically joining/attaching solar ribbons?

Solar ribbons can be attached with Silver-filled epoxy, often referred to as Electrically Conductive Adhesives (ECAs), as well as other conductive joining materials including, solder and Pressure Sensitive Adhesives (PSA)tapes. Solder joining ribbons to TCO/ PV layers is the mainstream process used with crystalline Si wafer cells. However, as some solder alloys aren't compatible with TCO layers in Thin Film Solar cell technologies; ECA tapes and adhesives are used.

Although ECA tapes are convenient, they aren't the most robust and reliable interconnect method. Therefore, ***Silver-filled epoxy*** enjoys significant success, not only in Thin Film Solar, but also in emerging PV technologies such as Organic Solar (OPV), and Dye Sensitized Solar (DSC/OPV). Ag based epoxy (ECAs) are widely known with thin film solar cells including amorphous Silicon (aSi, uSi) and CIS (Copper Indium Selenide)/ CIGS (Copper Indium Gallium Selenide) based PV layers.

What are some unique epoxy based ECA challenges and solutions?

Challenge: ***High volume manufacturing***

Solution: The ideal product would "snap cure" the ribbons in seconds, and have a very long pot-life for easy syringe dispensing operations, therefore minimizing the curing and cleaning cycle processes. The result would be a lower cost per watt ($/watt) of ownership.

Product	PV Technology	Curing Process	PV Comments
H20E	aSi/uSi or tandem	140°C/70 sec	Historical choice, IEC & UL certified uSi panels, industry standard
H20E-SLR	aSi/uSi or tandem	140°C/40 sec	Added snap cure and improved syringe rheology. Suitable for turnkey solar equipment lines
H20E-SLR-HV	aSi/uSi or tandem	140°C/40 sec	Increased "green" strength to hold ribbons in place prior to cure
H20E-SLR-HVMX	aSi/uSi or tandem	140°C/40 sec	"Green strength" and meter mixing compatible
H20E-SLR-MX	aSi/uSi or tandem	140°C/40 sec	Maximum pot life during syringe dispensing, meter mixed on the dispenser, avoids -40°C shipping and storage
H20E-FC	aSi/uSi/CIGS/OPV/ DSC	140°C/10 sec	Seconds cure, or "zero seconds cure", using EVA film lamination at 150°C/15 minutes as the post-cure, suitable for turnkey automation

Challenge: ***Ribbon misalignment***

Solution: Some epoxies have a high level of adhesion during the wet un-cured ***"green strength"*** stage. This stage is prior to the curing oven for ribbon attachment and alignment to the PV substrate, and good green strength can prevent slipping and curling. Due to good green strength, the epoxy curing step is removed from the manufacturing line, instead curing of the ribbons occurs down-stream during the introduction of EVA film lamination and encapsulation (ie. 150°C/15 min press). ECAs can accept Sn, Ag and Cu plated ribbons.

Product	PV Technology	Curing Process	PV Comments
H20E-SLR-HV	aSi/uSi or tandem	140°C/40 sec	Increased "green" strength to hold in place prior to cure
H20E-SLR-HVMX	aSi/uSi or tandem	140°C/40 sec	"Green strength" and meter mixing compatible

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What are some unique epoxy based ECA challenges and solutions? *(continued)*

Challenge: ***Low temperature curing***

Solution: Curing temperatures of <110-120°C are required with Mo based substrates intended for CIS/CIGS solar cells. Even lower curing temperatures are employed with OPV/DSC solar cells, ≤80°C or less. Many ECAs can accept this level of cure temperatures without any problem.

Product	PV Technology	Curing Process	PV Comments
EJ2189-LV	OPV/DSV	23°C – 80°C cure	Ambient, or low temperature oven cured for textile & plastic based organic solar

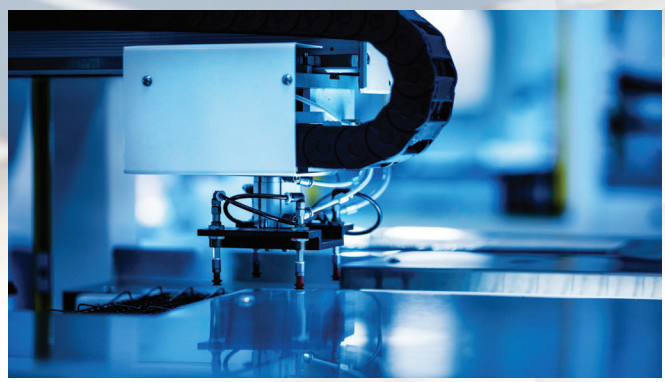
Challenge: ***The need for flexible ECAs***

Solution: Flexible ECAs can be used on "roll-up" style solar cells, whether CIS/CIGS format or OPV/DSC solar cells. Flexible PV applications exist in portable power, sport, leisure and military markets.

Product	PV Technology	Curing Process	PV Comments
EV2002	CIS/CIGS, OPV/DSV	120°C/15 min	Screen printable and flexible ECA for "rollup", and reel-to-reel format

How Do The EPO-TEK Properties Compare?

EPO-TEK®	VISCOSITY @ 23°C	GLASS TRANSITION TEMPERATURE (Tg)	DIE SHEAR STRENGTH @ RT (80mil x 80mil)	POT LIFE (@ room temp.)	SHELF LIFE (@ room temp. unless noted)
EJ2189-LV	25,000 - 45,000 cPs @ 1 rpm	≥40°C	≥10 kg/3,400 psi	4 hours	1 year
EV2002	24,000 - 46,000 cPs @ 5 rpm	≥50°C	≥5 kg/1,700 psi	4 hours	1 year
H20E-FC	2,361 cPs @ 50 rpm	85°C	≥10 kg/3,400 psi	20 hours	1 year
H20E	2,200 - 3,2000 cPs @ 100 rpm	≥80°C	>10 kg/3,400 psi	2.5 days	1 year
H20E-SLR	4,424 cPs @ 50 rpm	81°C	≥10 kg/3,400 psi	20 hours	1 year
H20E-SLR-HV	7,025 cPs @ 50 rpm	84°C	≥10 kg/3,400 psi	19 hours	1 year
H20E-SLR-HVMX	7,174 cPs @ 50 rpm	88°C	≥10 kg/3,400 psi	19 hours	1 year
H20E-SLR-MX	4,341 cPs @ 50 rpm	78°C	≥10 kg/3,400 psi	20 hours	1 year



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