



Sunwire ranks first among leading PV ribbons

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The performance and reliability of PV ribbon play crucial roles in determining the corresponding overall PV module performance and reliability during its service life. While the cost of addressing issues increases roughly 10 times as a module manufacturer moves through the progressive stages of product development, the accelerated testing on full size modules to understand the reliability of new components can also be expensive and time consuming.

Having a robust PV ribbon evaluation process can help to mitigate some of these costs and give some peace of mind to PV modules manufacturers as they look to change their choice of PV ribbon or add busbars to their bill of materials. Whether your concern is efficiency, microcracks, hot spots or manufacturability, manufacturers can be more agile and reduce the risk of failures by having intimate knowledge of its PV ribbon's characteristics.

Jabil Study – Jabil conducts a ribbon evaluation study of commercially available PV ribbons every six months. The results of the study conducted in the second half of 2016 are included on the back page.

And we've done much of the work for you. In a recent PV ribbon evaluation study conducted by Jabil Solar and Environmental Test Center in St. Petersburg, Florida, Sunwire received the highest overall score among five leading PV ribbons.

Learn more about how Sunwire by Luvata compares in terms of reliability, performance and overall rankings compared with other leading PV ribbons.

Jabil Study

Jabil conducts a ribbon evaluation study of commercially available PV ribbons every 6 months. The results presented here are for the study conducted in the second half of 2016. In the Jabil study, all five PV ribbons had a copper core with tin-lead coating and they are supposed to be used with 4-busbar solar cells. The nominal cross section dimensions were 1.2 mm x 0.2 mm including that for Sunwire. However, ribbon 3 had somewhat thicker copper core while ribbon 1 was slightly narrower than the ribbons with nominal cross sections.

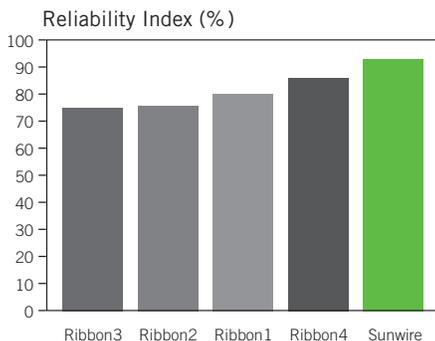
The testing and analysis conducted by Jabil is used to rank PV ribbons in terms of reliability and performance, in addition to a combined overall index score. In addition to the highest overall score, Sunwire PV ribbon secured first place in reliability mainly due to its lowest in class yield strength, superior tensile and solder adhesion properties. Sunwire's low yield strength ensures that it will exert less stresses on the solar cells and would mitigate the cell cracking issues in module manufacturing.

Reliability Index Calculation

The reliability index of the tested PV ribbons takes into account the contributions of each parameter, namely yield strength, elongation at break, elastic modulus, busbar-ribbon solder peel strength, cell-ribbon solder peel strength and cell strip deflection.

Each parameter has equal importance in determining the overall reliability of the ribbon. Sunwire is ranked as having the highest reliability index.

Sunwire ranks first on Reliability Index



Reliability Conclusions

Sunwire has the lowest yield strength and second lowest elastic modulus among all ribbons tested. This indicates Sunwire is significantly 'softer', which means it will exert lower stresses on solar cells, thus leading to reduced cell breakage.

Sunwire also demonstrates the highest values of cell-ribbon and busbar-ribbon solder peel strength. This means that PV modules made with Sunwire are less likely to suffer from interconnect issues in the field. Further, Sunwire displays the second highest elongation at break among all ribbons tested, meaning it can endure high strain values before breaking.

As the thickness of solar cells used in the industry reduces, cell cracking is expected to become a bigger issue in manufacturing. For this situation, Sunwire is strongly recommended as it will alleviate the cell cracking problem by imposing less stresses on solar cells.

How well do you know your PV ribbon?

Performance Index Calculation

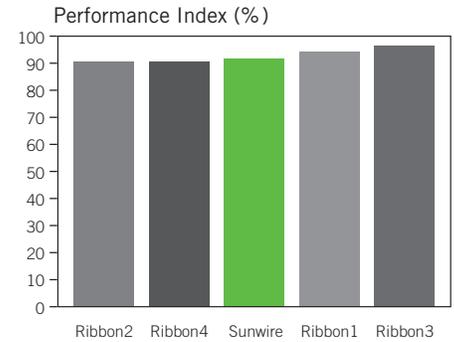
Certain properties of PV ribbon can directly influence the amount of power generated by the PV module. For example, the width of the ribbon determines the total area of the cell covered by the ribbon and hence blocked from receiving sunlight. At the same time, conductance of ribbon helps reduce the series resistance losses in a PV module. Since these two parameters directly impact the module power performance, they are considerations in the performance index calculation.

As the two parameters (specific resistance and shading reduction) can be opposing to each other, manufacturers have to find the right compromise between the two.

Performance Conclusions

It should be noted that ribbon types (like 1 and 3) that show a higher performance index than Sunwire, have employed non-standard cross sectional areas. These ribbons also show poor reliability as compared to ribbons with standard cross

Sunwire shows comparable Performance Index

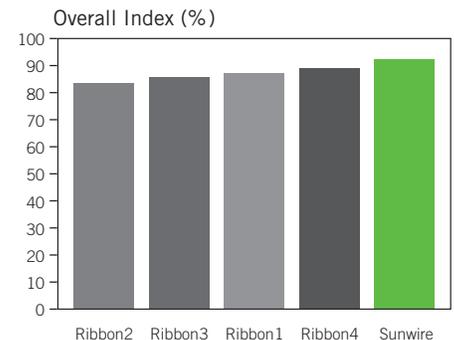


sectional areas such as Sunwire and Ribbon 4. While Sunwire ranked slightly lower than the ribbons that employ non-standard cross sectional areas, it actually performed slightly better than other ribbons with the same standard cross sectional areas due to better conductivity.

Overall Index Calculation

In calculating the Overall Index Calculation, the Jabil study assumes that reliability and performance carry equal weight and is the average of these two indices.

Sunwire ranks first on Overall Index



Due to having the highest reliability index and acceptable performance index, Sunwire ranks first for the overall ribbon index. An interesting and unique property of Sunwire as demonstrated in the Jabil study, is that despite having the lowest yield strength, it shows the second highest tensile strength.

We know you have a choice in PV ribbon, and as demonstrated by the Jabil Study your choice of PV ribbon matters. How well do you know your PV ribbon characteristics and how do they compare?

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