3M™ Solar Light Redirecting Film (LRF) T80

Procedure to accurately measure the power gain of PV modules manufactured with LRF T80 Film
Introduction

Tabbing ribbon width is selected for both minimizing optical shadowing loss and optimizing electrical gain. For most commercialized PV modules, the surface area occupied by tabbing ribbons is approximately 3%. 3M Light Redirecting Film (LRF) T80 is designed to recapture light reflection loss by tabbing ribbons. As much as a 2% power gain is demonstrated by many current customers. This white paper explains the procedure to measure power gain from LRF T80 modules reliably and accurately.

Module configuration and expected power gain

We recommend that customers use the same tabbing ribbons (width and thickness) as regular modules, and simply add LRF T80 over the ribbons. This avoids the complication of module manufacturing with different ribbons (process and logistics). The following are typical configurations of baseline and LRF T80 modules:

- **Baseline modules:**
  - 4BB, 1.2mm/0.25mm ribbons, 400 gm2 front EVA
- **LRF T80 modules:**
  - 4BB, 1.2mm/0.25mm ribbons, 560 g/m2 front EVA, 1.5 mm wide LRF T80

Expected power gain: ~2.0%

Module sample preparation

CELL BINNING AND SELECTION

It is very important to have a narrow power distribution of both baseline and LRF modules in order to reliably measure the power gain. It is recommended that cells are sorted based on efficiency (<0.1%) as well as Isc (0.05 – 0.1A).

NUMBER OF MODULES:
- Baseline modules: a minimum of 10 modules
- LRF T80 modules: a minimum of 10 modules

LRF T80 APPLICATION PROCEDURE

- Manual process: hot plate temperature setting of 90 degree C (may need to set higher due to surface temperature drop, such as 110 degree C). Caution: wear appropriate gloves to avoid excessive heat to the operator’s hands.
- Automation: Autowell or LEAD applicators

INSPECTION OF MODULES AFTER LAMINATION

- Visual inspection should show good alignment of the LRF on tabbing ribbons. There should not be any exposed tabbing ribbons below the LRF film.
- EL Images: no cell cracking before or after lamination.
Solar simulators

<table>
<thead>
<tr>
<th>Classification</th>
<th>Spectral Match (each interval)</th>
<th>Irradiance Spatial Non-Uniformity</th>
<th>Temporal Instability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>0.75–1.25</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Class B</td>
<td>0.6–1.4</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Class C</td>
<td>0.4–2.0</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

For example, a class AAA simulator would have performance in the top row for all three specifications.

Good solar simulators are assessed by the following:

- Good match to sun spectra
- Good spatial uniformity
- Good temporal uniformity

We recommend the use of class AAA simulators, such as Pasan from Meyer Burger, which uses physical distance between the solar lamp source and the test modules to get spatial uniformity. Some box type simulators (e.g. Spire) use frosted glass to get spatial uniformity without distance. These box type simulators break the angle of incidence from the sun, which is not suitable for accurate measurement of module power.

Measurement example

The following data is from a set of 100 full size 60-cell PV modules from a current customer.

Example: Measured Results are in good agreement with modeled results
Modeled: 1.7%, measured 1.5%
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