High PID resistant cross-linked encapsulant based on polyolefin  SOLAR  ASCE™

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Motivation

✓ In PV modules, cross-linked EVA encapsulant is commonly used because it has its transparency, thermal creep resistance, proven long term reliability on the field exposure over 20 years

✓ To address PID issue, high insulation encapsulant is one of the solutions

✓ Thermoplastic polyolefin encapsulant show better insulation property than EVA, but there are some concern about thermal creep resistance

✓ We have developed new polyolefin encapsulant “SOLAR ASCE™”, which is based on high electrical resistivity polyolefin resin and is cross-linked during lamination like EVA encapsulant
Scheme of designing New PO encapsulant

1) Raw material

2) Developing material design
   - Adhesive property
   - Long term reliability
   - Thermal property
   - Electrical property
   - Chemical property
   - Mechanical property

3) Sheeting

4) Checking material property

5) Electrical evaluation

Feed-back

- Voltage (V)
- Current (A)
Volume Resistivity %

![Graph showing volume resistivity vs temperature for different materials (EVA, SOLAR ASCETM, New PO).]
PID acceleration tests method

Damp heat chamber

Test conditions
Cell: single cell or full module
Exposure time: 96h - 240hr
Voltage: -600V or -1000V
Temp.: 60°C/85% or 85°C/85%
Cell selection by PID test with conventional EVA

EVA with **PID-prone cell**
(60°C 85%RH, -600V)

Power loss: 40%

EVA with **PID-durable cell**
(60°C 85%RH, -600V)

Power loss: 2%

We have chose PID prone cells to evaluate SOLAR ASCE™
PID durability of New PO %

PID test condition
- Module
  1 Cell, 6 inch multi-crystalline
  (PID sensitive sell)

- 85°C 85% -1000V
  Measurement of Pmax
  Irradiance: 1000W/m²
## PID durability of New PO %

### 60 cells full module PID test with various encapsulant %

<table>
<thead>
<tr>
<th>PID condition</th>
<th>SOLAR ASCE™ New PO</th>
<th>EVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>60°C85%</td>
<td>-1%</td>
<td>-75%</td>
</tr>
<tr>
<td>-1000V 96hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85°C85%</td>
<td>-1%</td>
<td>-80%</td>
</tr>
<tr>
<td>-1000V 48hr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PID test module %

60Cells (6x10cells) %

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SOLAR ASCE™ REAL PID FREE
Cell quality effect on PID %

Electroluminescence image of PID occurred module

Reflective Index of AR-coating affects PID degradation

The data above was published at SOLON SE
Damp heat durability of New PO %

DH test of 36cells full module &

![Graph showing output power (%) vs DH exposed time (hrs) for SOLAR ASCE™, New PO, and EVA.]

- **SOLAR ASCE™**
- **New PO**
- **EVA**

2000 hr: % generally recognized as the equivalent to 20 years in the field

* Mono-Crystalline module (36Cell, 1200mm × 527mm)
Thermal creep stability %

Elongation of encapsulant at 120°C

<table>
<thead>
<tr>
<th>Encapsulant Type</th>
<th>Condition</th>
<th>3000Pa</th>
<th>100Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLAR ASCE™ New PO</td>
<td>Cured</td>
<td>13%</td>
<td>0%</td>
</tr>
<tr>
<td>EVA</td>
<td>Cured</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>Thermoplastic PO encapsulant</td>
<td>Non-Cure</td>
<td>217%</td>
<td>12%</td>
</tr>
</tbody>
</table>

\[
\text{Elongation} = \frac{\text{Distance C after 120°C x 1hr}}{\text{Original distance C}}
\]

3000 or 100 Pa x 120°C x 1hr %

Thermal Creep property is improved by curing
Summary

- PID failure occurs on high temperature, high humidity and high negative voltage on modules
- PID failure depends on Cell quality, especially reflective index of AR-coating
- Our New PO encapsulant, SOLAR ASCE™, shows prominent PID improvement effect and expanding diversity of cell choices
- Cross-linking of New PO improve thermal creep stability just as good as cross-linked EVA encapsulant