Indoor measurement of angle resolved light absorption by antireflective glass in solar panels

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**Introduction**

The effect of the angle of incidence (AOI) on the optical properties of the cell is considerable for AOI larger than 45° and needs to be taken into account when assessing performance of solar cells, including the antireflective (AR) glass.

In this work, we normalize the relative short circuit current to a cosine response thereby isolating the optical effect of the glass-air interface. This form of data presentation is frequently described as the “incidence angle modifier” (IAM) and is used in PV modelling programs such as PVsyst.

**Results**

After $I_{sc}$ - AOI measured:
- Area correction for angles >±75°
- Normalized to AOI = 0°

Since we used a collimated light source, we neglected the diffuse component.

**Experimental Method**

A laser driven light source (LDLS):
- Off-axis parabolic mirror for collimation
- Angular divergence of about 0.1°

**Set up View Schematic**

- Sample holder stepper motor
- Short circuit current ($I_{sc}$) measuring transducer.

**Samples**

<table>
<thead>
<tr>
<th>Bare Cell</th>
<th>Smooth Glass</th>
<th>Diffuse Glass</th>
<th>Smallest AR structure</th>
<th>Intermediate AR structure</th>
<th>Biggest AR structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Structured Glass 1</td>
<td>Structured Glass 2</td>
<td>Structured Glass 3</td>
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<td>Structured Glass 4</td>
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<td>Structured Glass 4</td>
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</tbody>
</table>

**Simulations**

- IAM data were used to create unique PV module files in PVsyst.
- Energy production of a 10 kWpeak grid-tied system.
- The locations selected so as to span a variety of latitudes.
- PV balance of system (BOS) was also kept constant in all simulations.
- A fixed-tilt rack relative to a horizontal plane was equivalent to the location’s latitude.

**Summary of monthly DC energy production estimates when the seven glass types are used across four locations.**

- Copenhagen (55.7°N)
- Rome (41.8°N)
- Miami (25.8°N)
- Nairobi (1.3°S)

**Conclusions**

- The results indicated that the different AR glasses present diverse optical effects from angles intervals between 0 – 45° and 60 – 90°.
- PVsyst simulations showed that Diffuse Glass sample can improve monthly yields by as much as 2% relative to Structured Glass 2 sample.
- Based on the PVsyst simulations, we consider the setup presented a valuable tool for indoor measurements of the IAM i.e. the angular performance on solar cells and mini modules.

**Outlook**

- Round Robin between other laboratories with AOI cell testing indoors and outdoors, for a comprehensive setup validation.
- Modelling of different glass types on BIPV systems, where the installed tilt angle does not allow for receiving the optimal amount of solar irradiance.

**References**