LIGHT TRANSMITTANCE ENHANCEMENT OVER LIFETIME PERFORMANCE OF ANTI-REFLECTIVE PV MODULE COVER GLASS

Geert Aben[2]; Tessa Kockelkoren[1]; Yi Li[1]; Kornelia Matloka[1]; Marc Plaum[1]; Ron de Rijk[1]; Hugo Schoot[2]; Nicoletta Voicu[1].
[1]DSM Ahead; Functional Coatings and Materials; Urmonderbaan 22; 6167 RD Geleen; The Netherlands
[2]DSM Advanced Surfaces; Mauritslaan 49; 6129 EL Urmond; The Netherlands

Work motivation

In the view of strong market drive to maximize power output of photovoltaic modules while maintaining low production costs, a single layer anti-reflective coating KhepriCoat® was developed to increase the transmittance of PV cover glass, and therefore increase power output of the module.

Transmittance measurements of a single-side KhepriCoat® coated low-iron solar glass have shown transmittance improvement of ~3% at normal angle in a wide range of wavelengths. In this work, the effect of the coating on the power output of a single cell module is determined.

As diffuse light has a significant contribution to irradiation of PV modules, in this presentation we will discuss improvement of power output in relation to angle of incidence. Befits in power output of single and double site coated anti-reflective glass will be compared to performance of uncoated glass.

KhepriCoat®: anti-reflective coating for glass

KhepriCoat® is a thin interference coating (~100nm) with a low refractive index of 1.3. Such low index of refraction is obtained via use of hollow silica nanoparticles synthesized from a charged latex polymer template and a binder material. Resulting formulation is deposited and processed as a thin film on a glass surface.

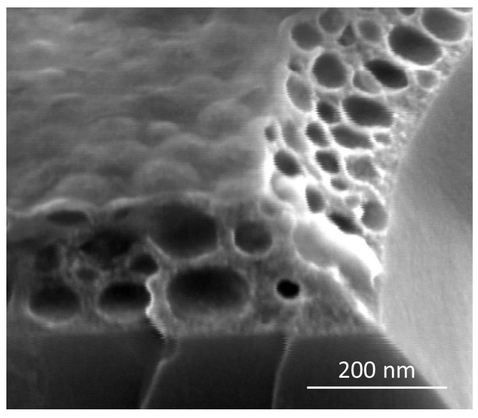
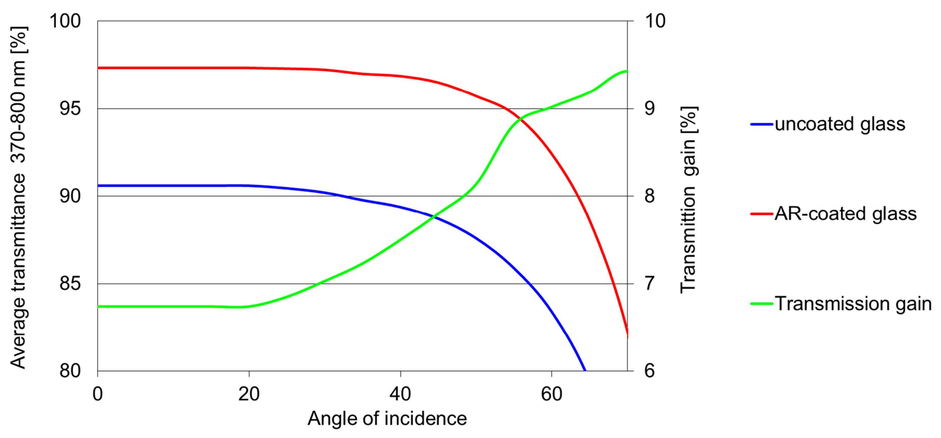


Figure 1. 3D crosssection SEM image of KhepriCoat® coating on silicon wafer (400ºC).



Graph 1. Angle dependent transmittance measurements of double–side Khepricoat® coated and uncoated 4mm low-iron float glass.

Test method

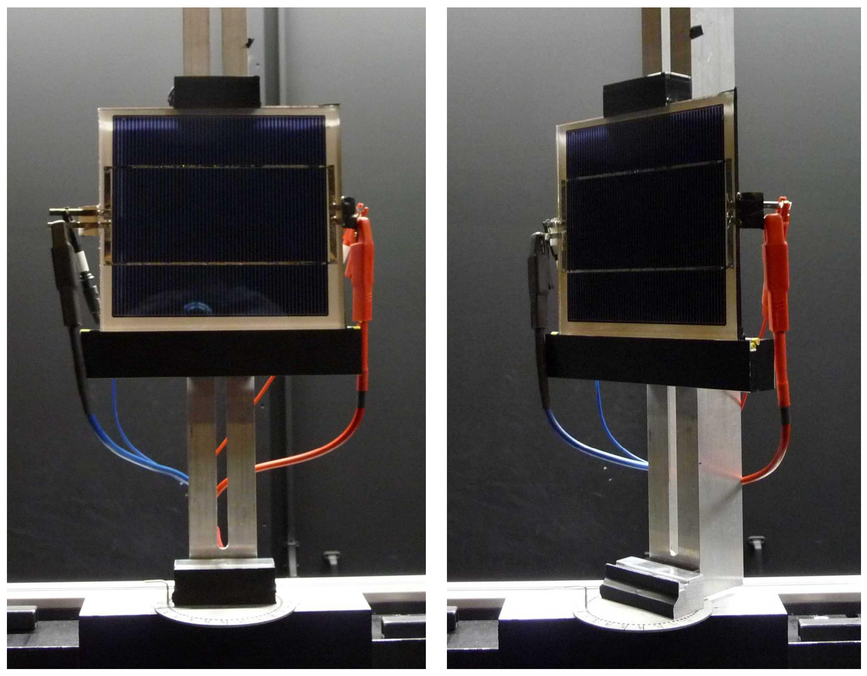
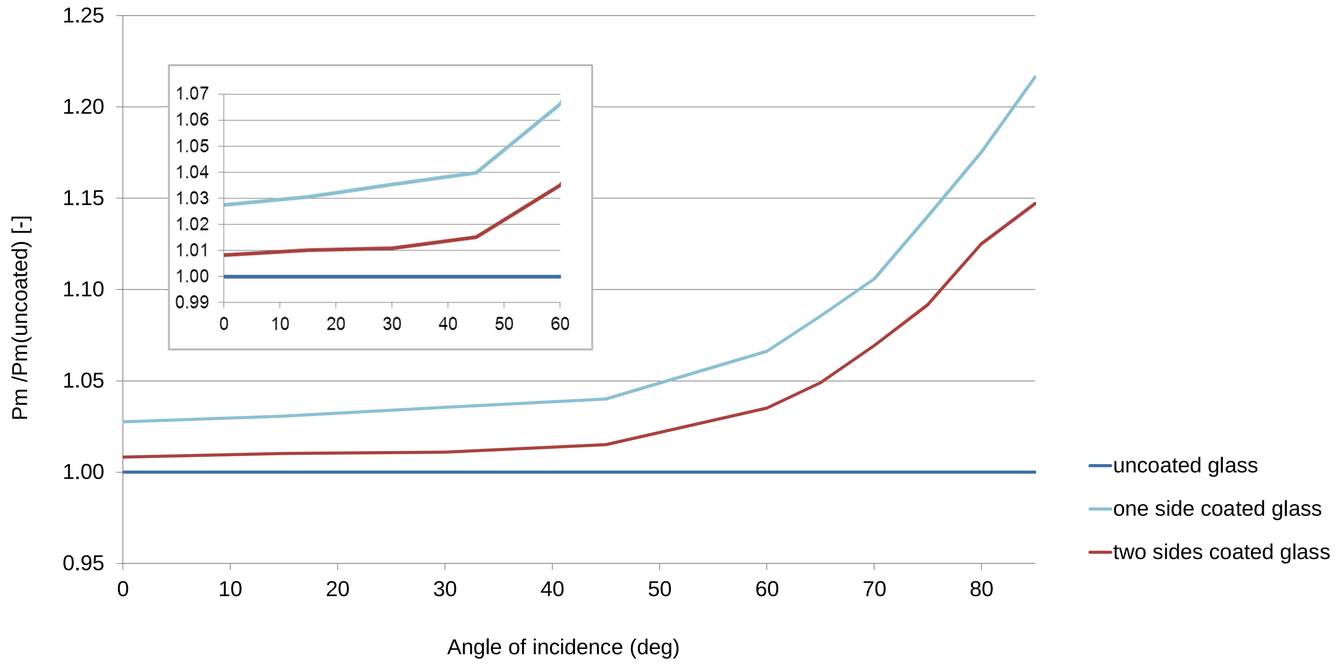


Figure 2. Pictures of sample in the Pasan 3b flash-tester. The holder for the sample can be rotated to change the angle to the incident light. The left picture shows the sample perpendicular to the light source. The right picture shows the sample at 45°. The cell is characterized by measuring the IV curve.

Flash test measurements



Graph 2. Plot showing the gain in absolute power output of the coated over the uncoated glass.

A set of modules were manufactured with single and double side coated as well as uncoated glass. The modules were limited to single cell modules The cells were selected to have a performance as close as possible to each other. The results were normalized to the cell with the highest current. The cells were standard H-pattern cells. Tabs were soldered to the cells. The tabs were passed through the back-sheet foil to allow the cell to be contacted for IV measurement. The cells were laminated with standard cure EVA from STR (A9918P/UF) with a white TPT back-sheet (Icosolar 3374). Five modules were made for each glass type (3 measured). The modules were characterized with a Pasan 3b flash tester developed by ECN. The holder in the flash tester was adapted to allow measurement at different angles of incident light. The holder was designed to allow a high level of reproducibility of the angle to allow direct comparison between the different modules at different angles.

Table 1. Configuration of modules manufactured.

Series of modules	Glass type (float)	Number of modules measured
1	Uncoated	3 out of 5
2	Single side coated	3 out of 5
3	Double side coated	3 out of 5

Table 2. Average P_{mp} of cells per series and calculated cell factor for compensation of power in modules.

Series of modules	Measured average P_{mp} of cells	Cell factor corrected to P_{mp} of series 1 cells
1	3.888	1.0000
2	3.881	1.0018
3	3.874	1.0038

Summary

- KhepriCoat® clearly shows a positive contribution to the power output of the module. With the modules perpendicular to the light source, an increase of almost 3% is measure in power output for a single side coating relative to uncoated flat glass. The double side coated modules show a smaller increase of performance of 0.8%. This is due to the mismatch of the refractive indices on the glass/coating/EVA interfaces.
- The relative increase in power output rises with increasing angle of incidence. The single coated glass modules show an improvement of over 20% in power output relative to uncoated flat glass at an angle of 85°. The double side coated glass modules shows an improvement in power output of 14% at 85°.

Acknowledgements

We would like to thank Ian Bennett from ECN (Energy research Center of the Netherlands) for modules manufacturing, flash test measurements, and overall fruitful collaboration, and Joachim Loos from DSM Resolve for SEM work.

HEALTH · NUTRITION · MATERIALS

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.