Technical University of Denmark

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Introduction • This project aims to develop and demonstrate a PV-panel which will both work as a balcony fence and at the same time produce energy to the electricity grid. The PV-panel will be building integrated, be constructed with a uniform color to the extend its possible, and have a mechanical strength complying with safety norms and rules in Denmark. The product will have a marginal installation price of 1 €/Wp, and it must be an attractive product for architects, which can esthetically be integrated in balcony's by means of a simple installation. The solar cells on the balcony fence have in general a suboptimal position and orientation, where it is to be expected that the solar panels not will be illuminated homogenously for extended time periods and furthermore the direct sunlight will hit the panels in fairly large angles. This publication focus on investigation of optimal light coupling into the solar cell and a qualified choice of front glass containing microstructures.

Experimental • In this work, 3 experimental setups has been realized to fuel a mathematical tool to calculate the annual yield of a given PV panel buildup for a balcony.

- Transmission measurements on glass
- Transmission measurements on single cell panels
- Field test of single cell panels

An optical model of the balcony has been build, based on the measurements to calculate the annual yield of the balcony with a given build up for the best choise (see

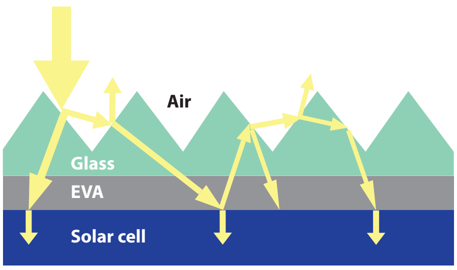

Figure 1 - Optical model of PV panel for balcony use.

Figure 1). The different setups are shown. In Figure 2 the setup used for measuring transmission on the raw glass in different angles of incidence is shown. A directional fiber coupled light source is mounted on a rotating stage with the center of rotation being at the front surface of the glass. Behind the glass is an integrating sphere with a fiber coupled spectrometer which acts as a detector. For reference a normal incidence measurement without a sample is used, and subsequently a sample is mounted and the transmission is measured from 0 to 70o. The light source used is a deuterium tungsten halogen lamp (Ocean Optics DH-2000) providing light in the spectral range from 200-2500 nm. and the spectrometer used is a Ocean Optics QE65000 with the ability to measure from 200-1100 nm. However, despite the good spectral ranges only signals in the wavelength range 500 nm - 830 nm had a sufficient large signal to noise ratio. This is most likely due to the limited lamp power of 45 W in combination with the optical losses in the fibers the spectrometer signal was very low. In figure 4 the angular dependent transmission is shown for 9 glass samples. Figure 3 shows an illustration and a picture of the setup used for measuring angular response on mini modules. wo tubes are directed towards the sun, letting only the direct sunlight onto the sample, which is located in a box at the end of the tube. In the box the sample is placed on a rotating sample holder, and in the other box a reference sample is placed with an orientation normal to the rays. The short circuit current is measured for the reference sample and the sample under test simultaneous together with a time stamp. The time stamp enabling data afterwards can be correlated with a tracked pyrheliometer located on campus. The tube-lightbox assembly is mounted on a platform where the tilt is adjusted manually with the help of a shaft that is rotated with a worm gear. The Field test is the next to be installed to complete the experimental setups in the project.

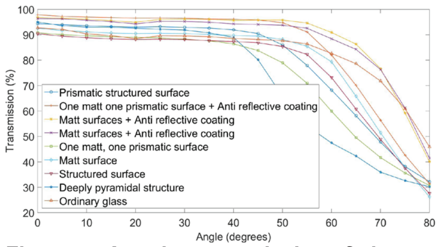

Figure 4 - Angular transmission of glasses

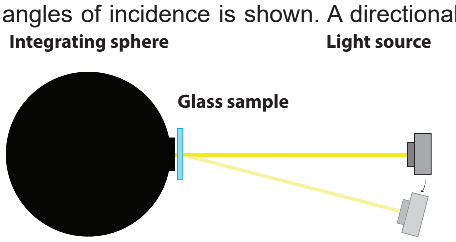

Figure 2 - setup for measuring transmission on the raw glass

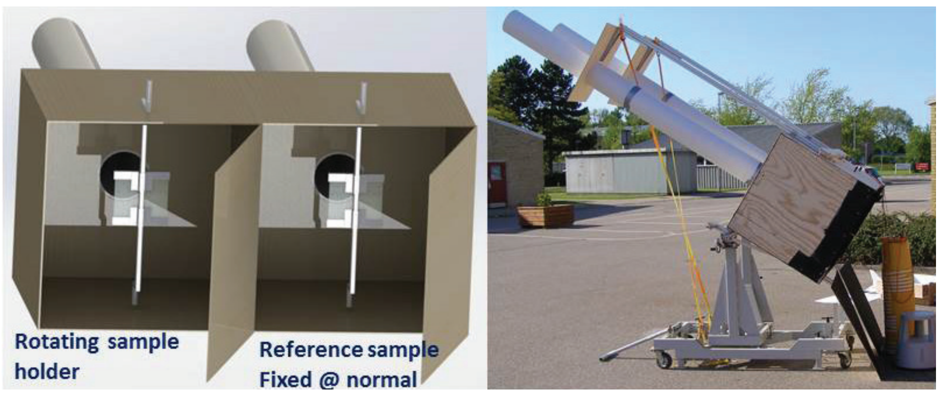

Figure 3 - illustration and picture of the Solar Canon - setup for measuring angular response on the mini modules.