Zukunft Bau
SUMMARY REPORT
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Heading

Technology development of light and flexible photovoltaic elements for architecture, based on ETFE and CIGS thin-film solar cells

Occasion

For developing new fields of application for the photovoltaic technology, PV thin-film elements, on the basis of extremely lightweight, highly flexible foil-based solar cells (CIGS) and ETFE films, were developed and tested for the integration into membranes for flexible and filigree roof and façade constructions.

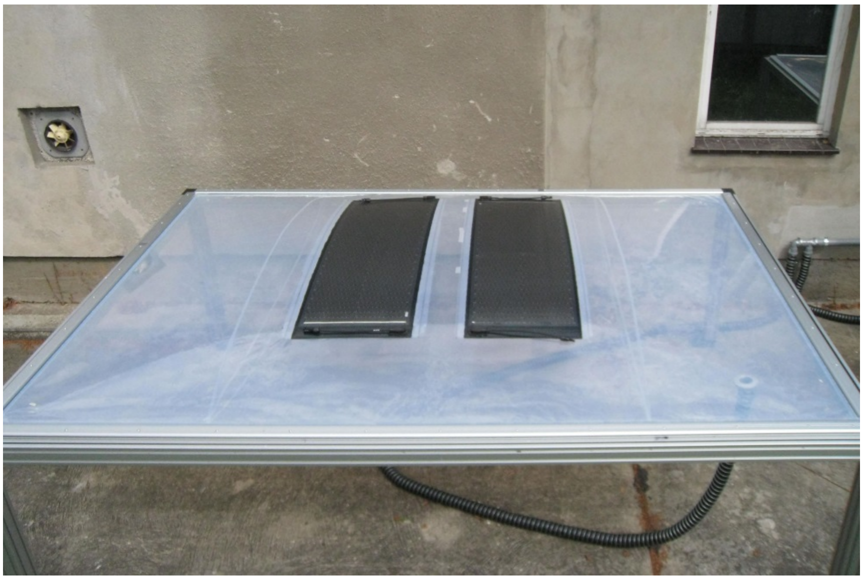

Fig. 1: Outdoor exposure stand of the ETFE cushions prototype with exterior PV modules

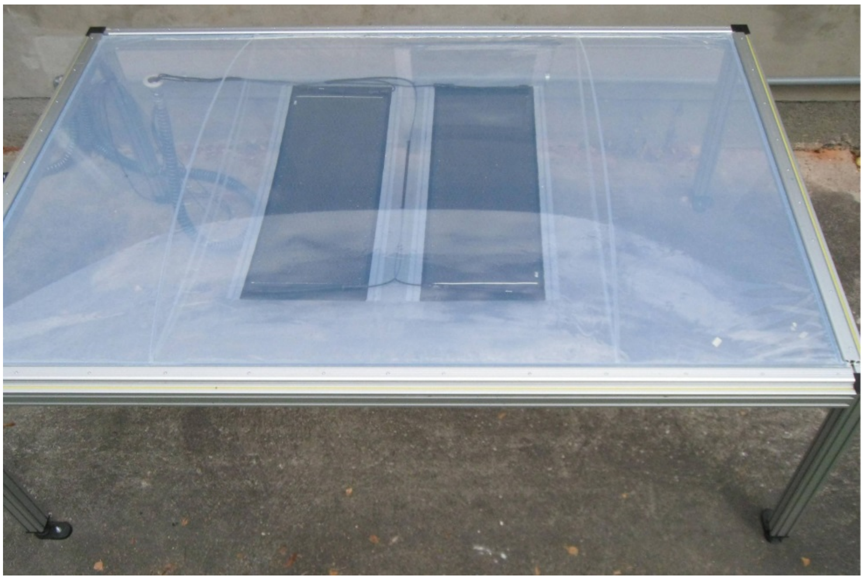

Fig. 2: Outdoor exposure stand of the ETFE cushions prototype with interior PV modules

Subject of the Research Project

Membrane structures allow the establishment of very economical and aesthetic building shells in various contours, which bring plenty of air and daylight into the interior. They fascinate with their transparency or translucency, lightness and dynamism. The often large surfaces, facing the sun without interfering and shadowing buildups and internals, are not yet applicable for generating solar energy, since no utilizable photovoltaic system solutions are available. Using a direct integration of CIGS thin-film solar cells in the membrane material, a new field of application for the PV technology can be developed. However, the foil-based CIGS solar cells are very sensitive to moisture and therefore require a vapor-tight cover. Currently, the required lifetimes in the building industry can only be achieved with glass as a vapor diffusion tight front cover. As a material for membrane constructions, ETFE foil has proved its worth in the construction industry worldwide for decades, due to its excellent mechanical properties and very good resistance. As a building material, it is characterized by a self-cleaning surface, a good fire behavior and a nearly complete recyclability. However, ETFE film is not vapor-proof; hence it cannot serve as an alternative barrier layer and cover for CIGS thin-film solar cells without further ado. Thus the research approach of the completed research project consisted in the modification or optimization of ETFE films in terms of an effective moisture barrier and the development of a PV laminate made of foil-based solar cells and ETFE.

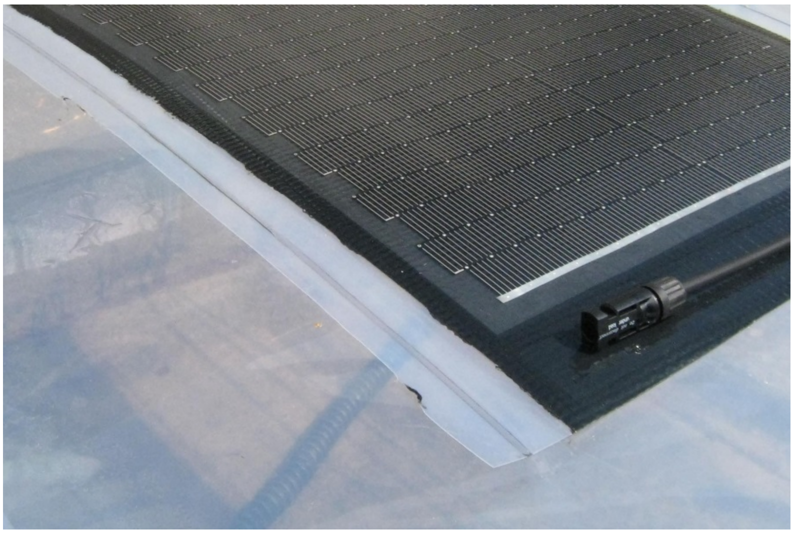

Fig. 3: Outdoor exposure stand of the ETFE cushions prototype with exterior PV modules (detail)

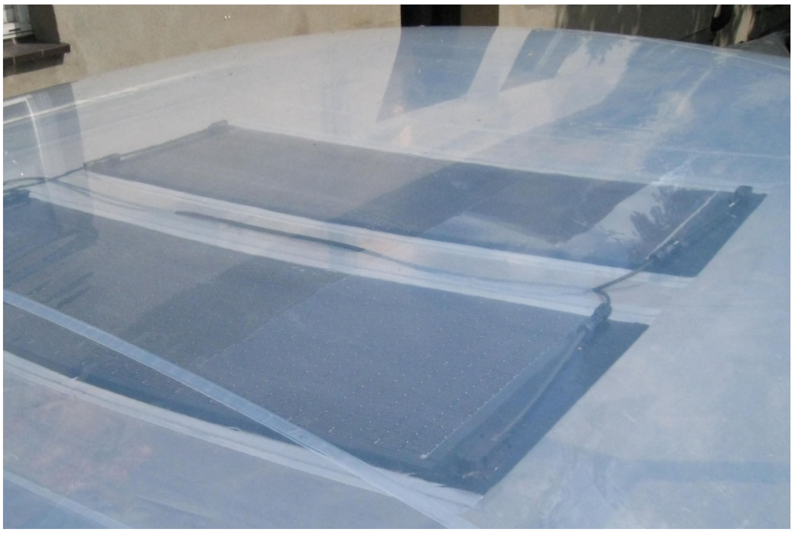

Fig. 4: Outdoor exposure stand of the ETFE cushions prototype with interior PV modules (detail)

To investigate the durability and serviceability of composites made of ETFE and PV modules in practical use, an outdoor exposure stand was developed. The occurring loads were measured through experimentation on two model structures of foil cushions, in particular with regard to temperature and humidity development. Furthermore, a water-vapor-barrier was to be applied to the ETFE foil. Here, the substrate presented a particular challenge. ETFE has a very low surface tension and thus can be wetted very poorly. To improve the wettability, two different pre-treatment processes were tested. Besides the application of corona plasma, a primer was used. In the next step, an adhesive layer was developed, which formed a permanent joint with the pretreated ETFE films. Then a barrier layer was to be applied to the adhesive layer. There were several barrier layers used so that various ETFE film patterns were obtained using different combinations of pre-treatment, adhesive layer and barrier layer. With these film samples, PV test modules were fabricated and tested in the damp heat test. A suitable joining technique had to be developed also for the application of real PV modules onto ETFE cushions because of the poor adhesion of ETFE films. With the help of a thermo-mechanically stable embedding material (Geniomer®), it was possible to laminate ETFE stripes onto the PV modules and, in a further step of manufacturing the ETFE cushion, to secure the PV modules by welding them to the ETFE cushion layers. Two different prototypes were constructed from respectively three-layer ETFE cushions. For one cushion, the PV modules were on top of the cushion, for the other on the middle layer and thus within the ETFE cushion. Thus prepared the prototypes were placed in the outdoor exposure stand. Using an I-V curve tracer with irradiance and temperature sensors, solar radiation, temperature and power were measured on the prototype.

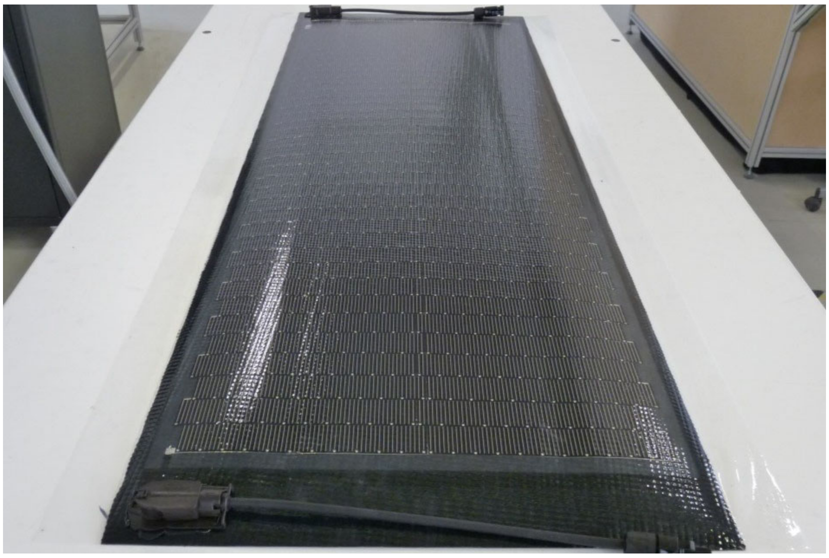

Fig. 5:PV module with ETFE stripes at the module edges for application onto the ETFE cushions prototypes

Conclusion

Within the project a joining process was developed, which enabled a permanent attachment of PV modules on ETFE cushions despite the poor adhesive properties of ETFE. Two different three-layer ETFE cushions were prepared with the PV modules on the top layer of the one model and on the middle layer of the other model. The solar technical studies showed that the power output of the internal PV modules was slightly higher in comparison. To reduce the water vapor permeability of the ETFE film to protect the sensitive cells, various barrier coatings have been developed, but none of the layers turned out to be suitable.

Key Data
Short title: ETFE-PV
Research / Project Coordination: Prof. Dr.-Ing Bernhard Weller, TU Dresden, Faculty of Civil Engineering, Institute of Building Construction, 01062 Dresden
Total costs: approx. 227.000 €
Percentage of federal subsidies: 69,27%
Project term: 05/21/2012 till 04/30/2014