Project 12: Project Progress Summary – Fall 2009 to Fall 2015

The project studied the performance of full-scale STPV windows, through testing and simulation. The optical and thermal properties of the STPV window, and the presence of low emissivity coatings or suspended films have a direct impact on operating temperatures, window electrical performance and durability. Issues such as heat management, visual and thermal performance as well as cost and durability are as important as STPV electricity production. E.g. the selection of STPV optical properties has a direct impact on STPV electrical performance, solar heat gains and daylight availability within the building. A deeper understanding of these interactions and the ability to measure and predict key properties such as the solar heat gain coefficient (SHGC) and thermal conductance (U-value) allow PV researchers and the window industry to provide the necessary PV materials and designs for high performance STPV window. Focus was given to two promising STPV cell technologies: transparent a-Si/nc-Si PV films and low cost organic PV films with tunable optical properties. The project developed, refined and fabricated processes, materials and STPV devices (TRL1 to TRL4) to enhance the performance of STPV technologies, suited for window and skylight applications. The project outputs are summarized below. For more technical information, please download Project Scientific Progress.

- An integrated simulation model (thermal, electrical and daylighting) of STPV windows was developed and verified with experimental data. The model was used to study the potential benefits of STPV windows on the building energy, daylighting and thermal performance, for various STPV technologies (namely crystalline Si, a-Si/µc-Si, a-Si/nc-Si and organic PV);
- Several full-scale STPV prototype windows were assembled, characterized and studied, utilizing opaque crystalline Si PV cells arranged in such a way as to allow light to pass through the resulting space between the cells or a-Si/µc-Si "see-through" thin film;
- An experimental methodology, utilizing an indoor solar simulator and solar calorimeter, was developed to determine the solar heat gain coefficient (SHGC) of STPV windows; a key property for the impact of STPV windows on the building energy performance and comfort;
- Transparent amorphous Si and nanocrystalline Si thin films were developed to function as active parts of a STPV thin film;
- A process was developed to create highly conductive and transparent oxide films (TCO) on glass. The purpose was to completely eliminate the metal grid in the cell structure. In order to further enhance the performance of the device, an advanced light trapping transparent conductive layer was designed and fabricated;
- Prototype a-Si/nc-Si solar cells were fabricated achieving electrical efficiencies of up to 6.53%;
- Several grams of PCDTBT were synthesized. This material is among the most efficient polymer studied in polymeric solar cells reaching power conversion efficiency of up to 7.2% and expected lifetime up to 7 years;
- Following a cheap, green and efficient polymerization procedure, two promising TPD-based polymers were synthesized demonstrating power conversion of up to 7.1%;
- Several FPD and SePD copolymers were synthesized and evaluated, reaching power conversion up to 6.1% in single layer BHJ solar cells (optimized devices).