# White Solar Modules: from Prototypes to Industrial Products

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*CSEM has developed white solar PV modules with conversion efficiencies above 10%. This innovative PV technology is particularly attractive for the BIPV market. In 2015 a company, Solaxess SA, has been founded to exploit this technology, and together with CSEM is now working on the industrialization of the technology.*

Henry Ford's famous, "Any customer can have a car painted any color that he wants so long as it is black," is almost valid for solar panels as most of the actual installed PV modules are made from crystalline silicon solar cells interconnected by metallic ribbons and therefore present the same blue-black visual aspect with highly reflecting metallic ribbons.

In October 2014, CSEM has unveiled to the public its white or colored module technology. This technology is well suited for the BIPV market as Architects constantly demand new solutions to customize the color of PV elements to make them blend into the building skin.


*Figure 1: White PV modules fabricated at CSEM.*

As shown in Figure 2, in order to make true white solar modules, the technology developed by CSEM combines various elements: (1) a solar cell technology able to convert solar infrared light into electricity; (2) a selective scattering filter which scatters the visible spectrum while transmitting infrared light.

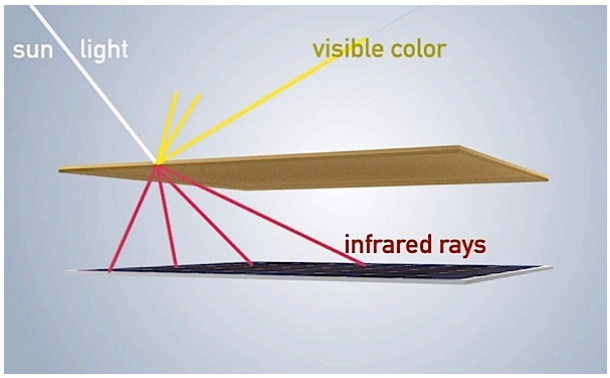


*Figure 2: Schematic principle of the white PV module.*

Crystalline solar cells are well suited for this application as more than 50% of the current generated under standard solar illumination comes from the infrared. The selective scattering filter has gone through a detailed optimization process, aiming at improving the efficiency, the visual aspect, the manufacturability, while performing all relevant reliability testing. Other colors than white can be produced by including colored pigments during the processing of the film.

As shown in Table 1, a performance of 11.4% has been achieved for a white solar module. The size of the module is 55 cm x 60 cm and it consists of 9 heterojunction solar cells interconnected in series. The loss in efficiency, i.e. comparing the same cell technology having usual or white appearances, is 40%. It is entirely due to losses in current as most of the visible light is reflected and therefore lost for current generation. The module presents a true white aspect. Neither the cells nor the connections are visible anymore.

*Table 1: Summary of the performance parameters extracted for the reference and white modules.*

| Sample | Voc [V] | FF [%] | Jsc [mA/cm²] | Efficiency [%] |
|---|---|---|---|---|
| **Reference** | 0.727 | 71.8 | 36.56 | 19.1 |
| **White** | 0.714 | 74.7 | 21.38 | 11.4 |
| **Δ [%]** | -1.8 | 4.0 | -41.5 | -40.2 |

At the beginning of 2015, a startup company Solaxess SA has been founded in Neuchâtel with the goal to manufacture and commercialize the white or colored PV technology developed by CSEM. Together with Solaxess, CSEM is now involved in the transfer from laboratory prototype fabrication to large scale industrial production. The two main technical objectives for the industrialization are the demonstration of the reliability of this new technology and the upscaling of the selective scattering filter fabrication at an acceptable production cost for the BIPV market. These two points are the subject of the CTI project NanoWhite which has been lunched in autumn 2015. The targeted product is a specialty foil which, whose color can be easily adapted and which can be implemented by any module maker worldwide.