# Study of the efficiency of a photovoltaic encapsulated cell according to the radiative properties of its backsheet

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**ABSTRACT**:
It is a well known fact that the efficiency of solar photovoltaic (PV) cells decreases with increasing operating temperatures, giving an electrical output that can drop by 0.65% for every 1°C raise [1]. Excessive temperatures also accelerate the degradation of the PV modules, as higher temperatures lead to thermal stresses within a PV module. Therefore, to improve the performance of solar cells, it is necessary to have knowledge of their operating temperature and to maintain it at its lowest possible setting as well.
Most solar modules are composed of solar cells, with a glass layer on the front and a protective backsheet on the rear side. The latter, usually made from a type of polymer, is both a barrier against moisture and ultraviolet (UV) radiation and acts as an electrical insulator. At the same time, the use of a reflective foil as a backsheet, improves the efficiency of a PV module by reflecting, diffusely or not, the incident light. The most typical backsheet color is white, the black ones being employed for aesthetic purposes [2].
In this study, the modeling of the radiative exchanges between the semi-transparent strata of an encapsulated photovoltaic silicon cell was performed. The case considered here is a PV cell placed under the lamp of a solar simulator with a controlled temperature. A 2D geometry with a grid mesh was created with shrinkage across the subdomain of the encapsulated PV cell (Fig. 1). Dirichlet boundary conditions were applied to the upper and lower parts, enforcing constant temperatures in order to obtain a 1000 W/m² incident irradiance on the upper surface of the PV cells and a 25°C temperature for the PV cell (STC conditions), assuming an emissivity of 1 (blackbody) for the upper surface of the backsheet. A convective flux condition was taken for both the sides considering them as fully reflective. Numerical calculations were carried out using the finite volume method to solve the energy equation and the solutions of the radiative transfer equation (RTE) were found using the Monte-Carlo ray-tracing approach accounting for the spectral properties in the wavelength range 0.1 µm -100 µm. Calculations are handled with the CFD-Ace code, utilizing the Algebraic Multi Grid solver for faster convergence. Parametric simulations were performed, decreasing the backsheet emissivity from 1 down to 0 (fully reflective surface) with a 0.1 step while keeping the same boundary conditions for the other surfaces. Results show that the thermal emissivity of the backsheet has a significant impact on the temperature of the solar cell. The temperature of the silicon cells drops from 46.2°C to 25.0°C when the emissivity is changed from 0 to 1, as the absorptivity of the backsheet is gradually stepped up (Fig. 2). This reduction would lead to a 13% variation of the efficiency. The sensitivity of the cell temperature to the IR properties of the backsheet is ascertained here by the present modeling. A backsheet that is fully reflective in the wavelength range corresponding to the spectral response of the PV cell and that is strongly absorbent in the IR range would be the ideal setting and this spectral property will be considered in our next calculations.

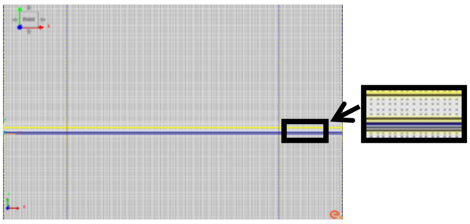

***Fig 1***. Tight mesh at the glass and the backsheet of the encapsulated PV cell.

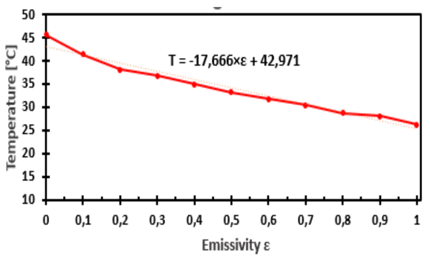


***Fig.2.*** Mean temperature of the Si-wafer versus emissivity.

**Keywords**: photovoltaic cell; backsheet; radiative heat transfer; Monte-Carlo ray-tracing method; efficiency.

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