EXTENDED DETAILED BALANCE MODELING TOWARD SOLAR CELLS WITH CEMENT-BASED RADIATIVE COOLERS

Radiative cooling is an attractive route to increase efficiency and lifetime of solar cells by reducing their operating temperature. Within the project MIRACLE, we have recently proposed cement-based materials as cheap, scalable and stable radiative coolers [Cagnoni et al. (2022), Cementitious Materials as Promising Radiative Coolers for Solar Cells, iScience 25, 105320]; these could be a valid alternative to the much more expensive metamaterials or UV-unstable polymers proposed in the literature. In particular, we have shown that they could provide a temperature reduction of about 19 K in single-junction c-Si solar cells, with a 0.7% efficiency increase and a four-fold lifetime extension. Yet, the model used to reach these conclusions describes the solar cell in the radiative limit and with perfect thermal coupling to the cooler. In our most recent publication [**Cagnoni et al. (2023), Extended Detailed Balance Modeling Toward Solar Cells with Cement-Based Radiative Coolers, Prog. Photovolt, doi:10.1002/pip.3758**] we have lifted these two approximations to obtain a model of the cell/cooler stack closer to reality and obtained a better assessment of the potential of radiative cooling for the thermal management of solar cells, with emphasis on cement-based materials. In particular, we have incorporated Auger and Shockley-Read-Hall recombination in the solar cell model, and introduced a thermal contact resistance at the cell/cooler interface, which is expected to be non-negligible for cement-based radiative coolers because of the poor adhesiveness of these materials. Remarkably, we have demonstrated that the temperature reduction and associated efficiency gain provided by the cooler in c-Si solar cells is higher than estimated with the previous model because of the non-radiative recombination channels, which modify solar cell self-heating and temperature coefficients. In particular, the temperature reduction could reach 21 K, with efficiency gains up to 1.4%. Furthermore, we have found that a significant cooling can be achieved also when a thermal barrier between cell and cooler is present, as long as the corresponding heat transfer coefficient is large enough. We have quantified this effect and defined design guidelines for the cell/cooler interface.

For more information, please contact Dr. Matteo Cagnoni (matteo.cagnoni@polito.it) or visit our web page http://miracle-concrete.eu .

MIRACLE Photonic Concrete

This research has been carried out within the MIRACLE project and has received funding from the European Union's Horizon 2020 research and innovate under grant agreement No 964450