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research highlights

PHOTOVOLTAICS

Cool designs

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Solar modules warm up under the sun. The excess heat leads to lower photoconversion efficiency and shorter lifetimes for the solar panels, so strategies to cool the modules at the lowest possible cost are needed. Devices to control the convective and conductive heat transfers and to manage inward and outward radiation towards the sky and the ground are therefore being developed. Now, Xingshu Sun and colleagues from Purdue University and NREL in the USA analyse the self-heating mechanisms in Si, CdTe, GaAs and $CuIn_xGa_{(1-x)}Se_2$ (CIGS) photovoltaic (PV) modules and quantify the efficiency of various photonics-based cooling designs to reduce the modules' temperature.

In PVs, photons absorbed below the semiconductor bandgap contribute to heating but do not generate electricity. All the modules studied, except for GaAs, suffer from this sort of non-convertible energy input. Reversely, when the cell heats up, it radiates and loses heat. The researchers show that thermal radiation from isolated cells is inefficient, but full modules are good thermal emitters already thanks to the cover glass and backsheet. Consequently, selective-spectral cooling, which removes non-convertible photons before they even reach the absorber, is more effective than optimizing the module thermal emission (except for GaAs modules). Selective-spectral cooling can be achieved by different photonic devices depending on the PV technology and application, for example with wavelength-selective filters. Importantly, the researchers' model quantifies how local and variable environmental factors such as wind speed, ambient temperature, illumination intensity and the composition of the atmosphere dictate the actual effectiveness of these strategies. Photonics-based cooling strategies are most efficient for low wind speeds and could reduce the temperature of Si modules by up to 6 °C, leading to an important 0.5% absolute efficiency increase and 85% delay in module failure.

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