RadCool: a Web-enabled Simulation Tool for Radiative Cooling

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ABSTRACT

Thermophotovoltaic (TPV) systems can generate electricity from high-temperature heat sources via thermal radiation. However, the intense heating of a photovoltaic (PV) cell can greatly reduce the overall efficiency of the system. Therefore, it is critical to develop techniques to keep the PV cells close to ambient temperature without consuming energy. Radiative cooling is a passive technique that dissipates heat into remote space via thermal radiation. A simulation tool to predict the performance of radiative cooling systems would be particularly helpful in designing new experiments. The current TPV model simulation tool, TPVexpt, can calculate the theoretical performance of the TPV system. However, it does not consider the thermal management of the PV cell. A new tool, Radcool, is created to complement TPVexpt as well as to predict the performance of a radiative cooling system in general. The main design considerations of Radcool include: (1) the area ratio between the PV cell and the cooling emitter, and (2) the cooling emitter materials. The cooling performance is evaluated by equilibrium heat transfer analysis. Radcool has been validated with the existing experiment, but more experiments need to be done to confirm the generality of the system and modeling approach. In the future, this radiative cooling model can be connected directly with the existing TPV model, so that TPV systems will become more efficient for real world applications. The radiative cooling technique is not limited to TPV systems; other potential applications include solar cell cooling, infrared detectors, and sensitive electronic devices that are used outdoors.

KEYWORDS

Radiative cooling, thermal radiation, thermophotovoltaics, radiative heat transfer