Si Based Thermophotovoltaic Cell with Integrated Air-Bridge Back Surface Reflector

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OVERVIEW

A Silicon (Si)-based thermophotovoltaic (TPV) cell with high out-of-band (OOB) reflectivity

- Utilizes the advantages of Silicon including wide availability and low cost
- Leads to improved efficiency through minimization of energy loss

BACKGROUND

Thermophotovoltaic cells (TPVs) can scavenge excess heat energy from high temperature source such as furnaces, engines or turbines, through conversion from the hot emitter into electricity. These devices utilize the principle of blackbody radiation, converting radiated photons from the hot emitter into electricity. TPV cells are designed with specialized materials that can efficiently absorb and convert those photons into electron-hole pairs, generating an electric current. Unlike photovoltaic (PV) devices, emitter temperature depends on the heat source, and the distance between the cell and the heat source can be within close proximity. Therefore, engineering the reflectivity of the cell can help improve the power conversion efficiency by minimizing the energy loss from unabsorbed out of band (OOB) photons. A need exists to maximize the ability of TVCs to scavenge and convert excess heat energy that would otherwise go unused, offering a potential solution for improving energy efficiency and reducing the environmental impact of these industrial applications.

INNOVATION

Researchers have created a Silicon (Si)-based thermophotovoltaic (TPV) cell with high out-of-band (OOB) reflectivity facilitated by an air-bridge back surface reflector. The advantage of using Si as the absorber material is that it is widely available and cost-effective. As such, the use of Si can overcome the potential limits of scalability and expensive manufacturing costs associated with conventional TPC materials such as Indium Gallium arsenide (InGaAs) or Indium antimonide (InSb). The design incorporates a structured air gap between the silicon absorber and the reflector, optimizing the reflection of OOB photons while allowing efficient transmission of in-band photons for absorption. The air-bridge structure enables precise control over the reflectivity spectrum, enhancing the overall performance of the TPV cell. Previously, an InGaAs TPV cell with air-bridge back surface reflector was reported, with PCE improvement from 24% to 32% compared to the same cell with gold back reflector. The available data suggests that with high OOB reflectivity, even higher bandgap materials such as Si can achieve reasonably high efficiency by reflecting back the OOB photons and thus minimizing the major energy loss.

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Category

Hardware

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