The Summer Undergraduate Research Fellowship (SURF) Symposium
4 August 2016
Purdue University, West Lafayette, Indiana, USA

Designing an Experimentally Feasible Selective Emitter For a Thermophotovoltaic System

Namrata Raghavan[1], Enas Sakr[1], Haejun Chung[1,2], Peter Bermel[1,2]
[1]School of Electrical and Computer Engineering, Purdue University
[2]Birck Nanotechnology Center, Purdue University

ABSTRACT

More than 60% of the raw energy used in the US is dissipated as waste heat. Thermophotovoltaics (TPV) provide a means to capture this waste heat into electricity. Inefficiencies in TPV systems are due to various loss mechanisms, particularly a lack of spectral matching between the emission spectrum of the emitter and the absorption spectrum of the photovoltaic cell. This study aims to design a simple structure emitting thermal photons mostly at high energies, which could allow for efficient generation of electricity through a photovoltaic cell. Optical data for the different materials obtained using ellipsometry and previous research is incorporated into a nanoHUB tool, known as the Thermophotonic Selective Emitter Simulator (TPXsim), to compute the expected enhancement of the TPV system efficiency. Changes have been made to the TPXsim tool to incorporate customized top dielectric mirror layers, samarium doped glass cavity and bottom metallic back reflectors. It is seen that a TPV system consisting of a rare-earth wafer emitter at 1573 K plus a cold-side rugate filter at 300 K shows an overall efficiency of around 18%. Previous research on emitter designs with top and bottom layers of dielectric mirror is seen to increase this efficiency at a large number of layers while degrading the performance for a small number of layers. Our research shows that using aperiodic customized multilayer structures and metallic back reflectors improves the efficiency over a bare wafer while maintaining the ease of fabrication of the selective emitter.

KEYWORDS

Thermophotovoltaics, selective emitter, spectral matching, metallic back reflectors, aperiodic multilayer structures, emission spectrum, efficiency.