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Theoretical investigation of vacuum thermionic energy conversion devices for efficient conversion of solar to electrical energy JOSHUA SMITH, ROBERT NEMANICH, GRIFF BILBRO, North Carolina State University — A vacuum thermionic energy conversion device (TEC) would offer the potential of efficiently converting solar energy directly to electrical work. These devices consist of a heated emitter electrode and a collector electrode separated by an evacuated interelectrode space. Models for such conceptual devices are developed, and efficiency is calculated by considering electron transport across the device as well as Stefan Boltzmann radiation. A device operating with an emitter and collector temperature of $775K$ and $375K$, respectively is considered. The conceptual TEC features diamond materials having low emission barrier heights as electrodes. Hydrogen terminated diamond is known to have a negative electron affinity (NEA) and nitrogen or phosphorus doping introduces donor levels at $1.7eV$ and $0.6eV$, respectively, below the conduction band minimum. For the devices considered, the barrier heights are $1.1eV$ and $0.5eV$ for the emitter and collector, respectively. The Richardson constant is $10A/cm^2K^2$, consistant with experimental results. Assuming an emissivity of 0.5, the device has a Carnot efficiency of 0.52, and a calculated absolute efficiency of 0.17 at a maximum power of $0.25W/cm^2$. The theory is extended to include the negative space charge effect, and the NEA properties of the materials are shown to mitigate the space charge effect and increase output power.

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