Development of InSb Thermo-Radiative Cell for Space Waste Heat Recovery

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Plutonium-238 has been identified as one of the most suitable radioisotope fuels for General Purpose Heat Source (GPHS) modules since the 1960s. The current stock of Pu-238 is quite limited, and its production process is very expensive. Therefore, efficiently using the heat generated by the GPHS is very important and critical for NASA space applications. However, the efficiency of the most widely used radioisotope thermoelectric generators is only about 6-8%, which means that a significant amount of the radioactive fuel energy is dissipated as waste heat via radiators to deep space. Past theoretical modeling has showed that a thermo-radiative cell made from a narrow-bandgap semiconductor p-n junction could potentially serve as a promising waste heat recovery technology for radioisotope power systems (RPS). In this presentation, we develop a InSb thermo-radiative cell with an area orders of magnitude larger than commercial narrow-gap semiconductor p-n junctions, and demonstrate its thermo-radiative performance using mild heat as an energy source and a liquid-nitrogen cooled chamber as a heat sink. This is the first experimental effort of fabricating a thermo-radiative cell device with areas orders of magnitude larger than commercially available narrow-gap semiconductor p-n junctions. Integrating thermo-radiative cells with a radioisotope heating unit (high-grade heat) or spacecraft radiator (low-grade waste heat) could provide a new way to significantly increase the energy efficiency of Pu-238 or other radioisotope fuels.