Thermophotovoltaic Generation of Electricity in MicroFuel Converters

Personnel

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Sponsorship

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Based on a suspended tube microchemical reactor developed at MIT, this project aims at converting heat released from the reactor by radiation, into electrical power by the use of low-bandgap photovoltaic cells. The devices are likely to be operated at around 1000ºC, at which temperature the radiation is mostly in the infrared regime, calling for low-bandgap converter materials such as GaSb or GaInAsSb. The cells are obtained commercially or from other research programs, while the emitter structure, photon recycling scheme, thermal management, and packaging (including vacuum) are developed within the project.

Among the photons emitted, only those that have energies above the photovoltaic cell bandgap, can be converted into electricity. This combined problem of emitter characteristics and photon recycling will be approached in different ways. Since radiation is a surface property, the reactor (emitter) surface can be tailored to yield more desirable radiation spectra. Material coatings such as rare-earth oxides or refractory metals can be used to enhance emission in certain energy bands, and 2-D patterns or 3-D photonic crystals can have similar desirable effects. These will all be considered although fabrication complexity must always be weighed heavily in making choices. Photon recycling schemes include filters and back-side reflectors on the photovoltaic cells. Most likely a combination of these different approaches will be pursued.

Other tasks will include optimizing the existing reactor structure for thermophotovoltaic purposes and packaging the entire structure, including the photovoltaic cells. Vacuum packaging will be essential, and it is currently being worked. The ultimate goal is to demonstrate a device that can convert chemical energy to electricity with an overall efficiency in the 10-15% range. Power density goals are on the order of $\frac{1}{2}$ W/cm^2. The work is targeted at developing a replacement technology for batteries in certain applications, based on higher energy conversion efficiencies and energy densities.