A Research Program Nuclear Energy Conversion

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Direct conversion of nuclear energy to electricity has been a challenging problem since the inception of the generation of electricity from nuclear reactions. The development of wide band-gap, p-n junctions in materials such as diamond, gallium nitride, aluminum nitride, and silicon carbide is at the heart of this research. A p-n junction in materials with band-gaps greater than 3 eV can be used in nuclear energy conversion in multiple ways. For example, for direct conversion of the kinetic energy of particles from the decay of radioisotopes, a diamond p-n junction has some unique advantages. It is less susceptible to radiation damage than SiC, GaN, and AlN because, at high temperatures, it can self-anneal point defects caused by radiation damage. A method which eliminates the radiation damage problem is a Two-Step Photon Intermediate Direct Energy Conversion (PIDEC) method that uses the efficient generation of photons from the interaction of particulate radiation with fluorescer media. The photons are then transported to wide band-gap photovoltaic cells where electrical current is generated. PIDEC holds the promise of 40% energy conversion efficiency in a single cycle. PIDEC can be applied both to large power generation systems and to small scale nuclear batteries based on radioisotopes (Radioisotope Energy Conversion System-RECS). Students and faculty have built a test stand for the PIDEC and RECS concepts which tests the physics of fluorescence production from the interaction of radiation with various fluorescer media, the transport of photons, radiation shielding methods, photovoltaic conversion with wide band-gap photovoltaic cells, and conversion efficiencies. The technology is licensed to a Missouri company (US Semiconductor, Independence MO) and is helping to facilitate economic development in the State of Missouri.