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Smart material-based radiation sources[1]

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From sensors to power harvesters, the unique properties of smart materials have been exploited in numerous ways to enable new applications and reduce the size of many useful devices. Smart materials are defined as materials whose properties can be changed in a controlled and often reversible fashion by use of external stimuli, such as electric and magnetic fields, temperature, or humidity. Smart materials have been used to make acceleration sensors that are ubiquitous in mobile phones, to make highly accurate frequency standards, to make unprecedentedly small actuators and motors, to seal and reduce friction of rotating shafts, and to generate power by conversion of either kinetic or thermal energy to electrical energy. The number of useful devices enabled by smart materials is large and continues to grow. Smart materials can also be used to generate plasmas and accelerate particles at small scales. The materials discussed in this talk are from non-centrosymmetric crystalline classes including piezoelectric, pyroelectric, and ferroelectric materials, which produce large electric fields in response to external stimuli such as applied electric fields or thermal energy. First, the use of ferroelectric, pyroelectric and piezoelectric materials for plasma generation and particle acceleration will be reviewed. The talk will then focus on the use of piezoelectric materials at the University of Missouri to construct plasma sources and electrostatic accelerators for applications including space propulsion, x-ray imaging, and neutron production. The basic concepts of piezoelectric transformers, which are analogous to conventional magnetic transformers, will be discussed, along with results from experiments over the last decade to produce micro-thrusters for space propulsion and particle accelerators for x-ray and neutron production.

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