

Near-perpetual Power Sources for Microsystems and Pathways to Large Area Nanofabrication

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This talk will present MEMS based power sources that utilize radioisotopes, solar energy, and potentially nuclear energy through advancements in integration of new structures and materials within MEMS. Micro power harvesters can harness power from vibration, radioisotopes, light, sound, and biology may provide pathways to minimize or even eliminate batteries in sensors. Work on radioisotope thin films for MEMS will include the self-reciprocating cantilever, betavoltaic cells, and high DC voltages. The self-reciprocating cantilever energy harvester allows small commercially viable amounts of radioisotopes to generate mW to Watts of power so that very reliable power sources that last 100s of years are possible. In addition to providing electrical power, our work with radioisotope thin films has led to self-powered vacuum pumps, vacuum gauges, counting clocks, light sources, and surface acoustic wave transponders.

In addition to providing energy, we have shown that radioisotopes can be used for self-powered electron lithography (SPEL). The electrons emitted from radioisotope thin films can also be used to radiate electron beam resists for less than 5nm structures, while we have demonstrated structures as small as 30nm. This approach to electron lithography eliminates the use of electron beams, vacuum, and may enable nanolithography over extremely large and curved surfaces. We have used this lithography to create nano-wire arrays that can be themselves used to harvest energy and enable new sensors and actuators based on thermo-optical actuation. For example, we have used self-powered electron lithography for fabricating nanowire solar cell fabrication which yield high efficiency and large solar collection angles. We have also used these devices for femtomolar DNA and protein concentration sensing.

Amit Lal is a Professor in the School of Electrical and Computer Engineering at Cornell University, Ithaca, NY. He received his B.S. degree (1990) in Electrical Engineering from the California Institute of Technology, and his Ph.D. degree (1996) in Electrical Engineering from the University of California, Berkeley. His technical interests and activities are in the areas of MEMS, ultrasonics, optics, micromachining, piezoelectric systems, design and analysis of integrated circuits, and applications of radioactivity in microsystems. From 2005-2009, Prof. Lal served as a Program Manager in the Microsystems Technology Office of the Defense Advanced Research Projects Agency (DARPA), where he developed and managed programs in the areas of navigation, low-energy computation, bio-robotics, and atomic microsystems. He holds 18 patents and has published more than 145 research papers in the area of microsystem engineering. He is the recipient of the NSF CAREER award and, with his students, several best paper awards at the IEEE Ultrasonics and Frequency Control Symposium. He is also a recipient of the Department of Defense Exceptional Service Award, and a Best Program Manager Award for his work at DARPA.