Radioistopes to Solar to High Energy Accelerators - Chip-Scale Energy Sources

Amit Lal [1]
SonicMEMS Laboratory, School of Electrical and Computer Engineering, Cornell University

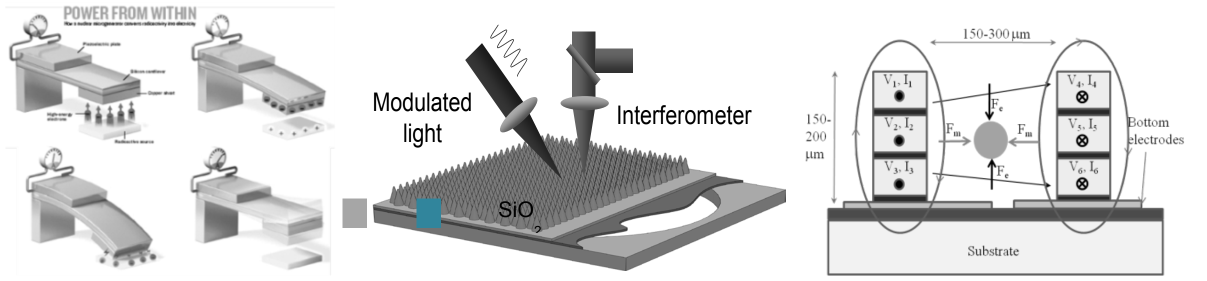
E-mail: amit.lal@cornell.edu

Abstract. 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 sensor nodes. In this talk work on radioisotope thin films for MEMS will be 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. The tradeoffs between reliability and potential stigma with radioisotopes allow one to span a useful design space with reliability as a key parameter. These power sources provide pulsed power at three different time scales using mechanical, RF, and static extraction of energy from collected charge. Multi-use capability, both harvesting radioisotope power and local vibration energy extends the reliability of micro-power sources further.

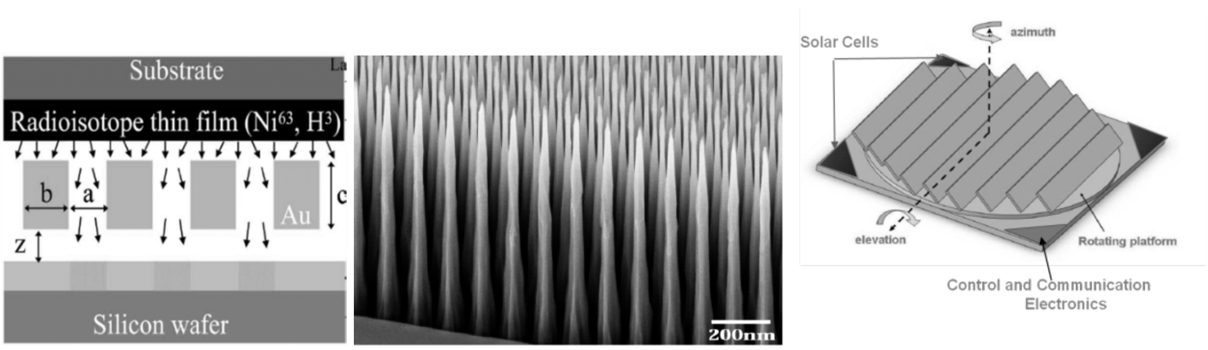
1. Introduction

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 femto-molar DNA and protein concentration sensing. With SPEL one can also envision the development of massively parallel micro-mirror arrays for concentrating solar power for applications such as planar heliostats. The development of planar heliostats will be described not only at the microscale, but also at the mesoscale for energy harvesting applications.

Lastly the talk will present recent development of chip and wafer scale electrostatic guidance of charged particles (electrons and ions) that could lead to very high energy beams for active methods for energy generation, and reduction of energy usage in applications such as medical imaging.



(a) **(b)** **(c)**



(d) **(e)** **(f)**

Figure 1. Chip scale power source

2. About The Speaker

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.