

STATEMENT OF GRANT PURPOSE

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Microenergy Harvesting using Next Generation MEMS Devices

1. Background

From enabling doctors to diagnose diseases quickly by simplifying and consolidating lab equipment to enhancing weather models and forecasting through inexpensive, wireless environmental sensors, micro-electro-mechanical systems (MEMS) is, as stated on IMTEK's website, a "science which opens new horizons and lets visions become reality." Originally driven by the automobile industry's search for cheap and reliable pressure, speed, and collision sensors, MEMS not only shrinks existing solutions, such as motors, cogs, sensors, and electronic systems, down to the micron scale, but also reduces costs and shortens development and production time. With energy resources becoming increasingly depleted, MEMS promises yet another solution which utilizes the technology's potential for harvesting ambient sound sources. In Germany, the world-famous, high-tech automobile industry has collaborated with MEMS powerhouses like Bosch, which gives its name to the popular silicon 'Bosch' etching technique, triggering immense growth and interest in MEMS. Because of Germany's historic lack of natural resources and its cultural emphasis on sustainability and green living, the environmental technology sector has flourished. This combined with Germany's high-tech scientific institutes, community of scientists and engineers, and governmental and public support create the ideal environment for pursuing the potential of harvesting unutilized sound and vibrational energy.

2. Proposal

Drawing from my master's level experience over the next year at the University of Louisville's J.B. Speed School of Engineering and built on the strong foundation of my undergraduate education there, I plan to begin a project at University of Freiburg's Institute of Microsystems Technology (IMTEK) to develop next generation, cost-effective MEMS devices to efficiently reclaim this wasted energy. Working in the lab of Dr. Ulrike Wallrabe, Chair of the Microactuator research group, I will design, fabricate and characterize MEMS devices which utilize the established principle of electromagnetic induction to convert the mechanical energy of sound and vibrations, from sources such as factory equipment, trains, and automobiles, into useable electrical energy through designs that include a small magnet that oscillates between two coils. Arrays of these devices in a flexible, elastic membrane could then be easily applied en masse to vibrating surfaces, such as the walls of tunnels or the bridges of the Autobahn. Through these large-scale installations, potentially significant levels of power could be harvested. Though research to capture this energy exists, the technology has yet to develop to the stage where a scalable, affordable solution could be widely adopted. After researching which design parameters result in the greatest efficiencies extracting power and determining what source frequency bands result in the greatest energy output, the design can be optimized for production by utilizing cheaper, synthetic material and fine-tuning for the location's specific vibrations.

3. Environment and Affiliation

The University of Freiburg, as one of the oldest universities in Germany, pulls from its strong

academic heritage to encourage and foster modern innovation. The Institute of Microsystems Technology, a testament to the university's dedication to advancements, has eighteen professors heading various research groups addressing every major aspect of MEMS from microoptics to sensors to actuators to biomicrotechnology to design of microsystems, including a unique PhD program dedicated to microenergy harvesting. Perhaps influenced by being in the self-proclaimed solar capital of Germany, IMTEK's recently established Microenergy Harvesting program takes the green energy movement a step further, affording the unique opportunity for very specialized study, ideal for this project. Dr. Wallrabe, with great interest in electromagnetic harvesters, will supply the necessary research environment as stated in the letter of affiliation. Being the largest research institute in Germany dedicated to MEMS, IMTEK offers unparalleled resources, including a fully-equipped cleanroom as well as electronics, optics and chemistry labs.

4. Timeline

After graduating with my Masters of Engineering specializing in Electrical Engineering in May 2010, I will arrive at the University of Freiburg's Institute of Microsystems Technology. Ideally, I will have the opportunity to do the seven week supplementary period of German language study which requires arrival in August in order to boost my German ability. After being introduced to the resources available and being trained on all major cleanroom and lab equipment procedures required for my research, I will begin to optimize the energy harvesting designs, reaching conclusions based on the laboratory results and on-site tests. Supplementing my research, I will take classes to increase my knowledge specific to MEMS energy harvesting. I plan on taking Electromagnetic Microsystems and High Frequency Engineering during the Winter 2010/2011 semester and then Signal Processing and Advanced Silicon Technology during Summer 2011. These specialized courses will serve the double purpose of aiding my research and helping to further immerse me into the Freiburg Engineering student community, allowing deeper intellectual and cultural exchange.

5. Personal Qualification and Future Goals

Starting with my capstone project during my undergraduate education, I was introduced to MEMS technology involving thermal actuators and bistable switches, working in the lab of my faculty advisor, Dr. Cindy Harnett. Using a LabVIEW program that my group designed, we were able to simulate coordinated leg actuation as well as provide a tool to aid in further MEMS testing. This project involved an introduction to cleanroom processes and MEMS technology which led me to pursue a related independent study the next semester. I then designed a template for actuators and developed a pass-through for the scanning electron microscope for testing of the MEMS devices. Those experiences and the coursework I will complete in graduate school, specifically Microfluidics and Advanced MEMS, will give me the requisite academic background and lab training for further studies in the field. Following this program, I plan to enroll in a Microenergy Harvesting Ph.D. program, such as the one offered by the University of Freiburg, with the motivation to optimize the design for potential industrial applications.