Title
Manufacturing of Thermal Based Energy Scavengers for Wireless Sensor Networks

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Manufacturing of Thermal Based Energy Scavengers for Wireless Sensor Networks

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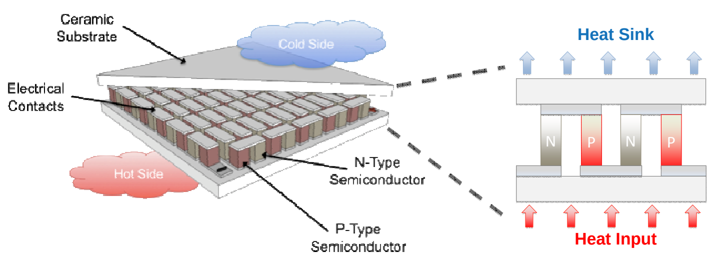
Vision

Field deployable autonomous wireless sensors require that each device must have enough power for sensing and communication over the entire lifetime of the node (>10 years). To meet these challenges, we consider the use of energy harvesting techniques from low-grade waste heat to continuously power the nodes. Small temperature gradients are sufficient for thermal energy harvesting using thermoelectric devices. These devices are silent, require no moving parts, have proven reliability through extended use, and are scalable.



Schematic of a Thermoelectric Device

Fabrication of these devices requires hundreds of long, thin doped semi-conductor elements (50-200 μm in diameter by 200 μm long) placed electrically in series and thermally in parallel. This is due to the non-negligible thermal contact resistance of the hot and cold heat sinks. As the height decreases, the effective temperature drop across the active elements becomes small in relation to the total temperature drop of the system. This presents problems for standard microfabrication techniques due to limitations of evaporation techniques. As a result, we are investigating a promising printing technique, specifically developed to additively create microscale thermoelectric generators.

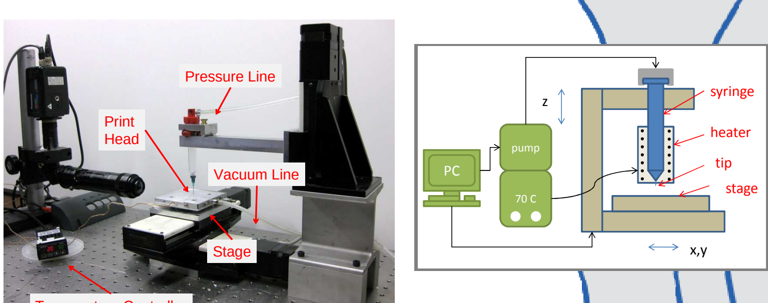
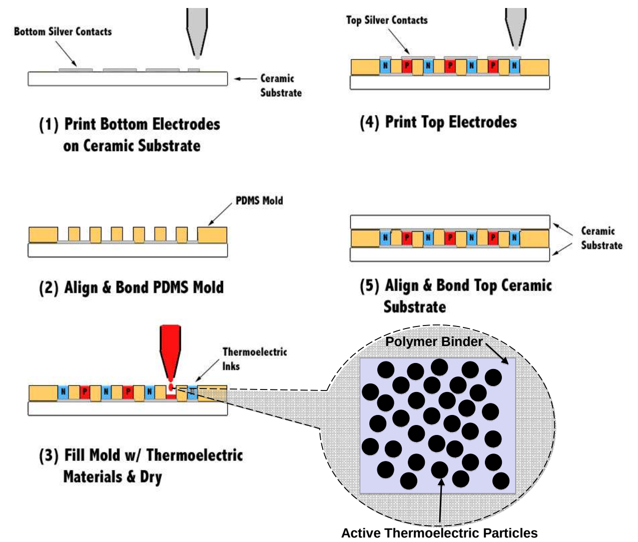


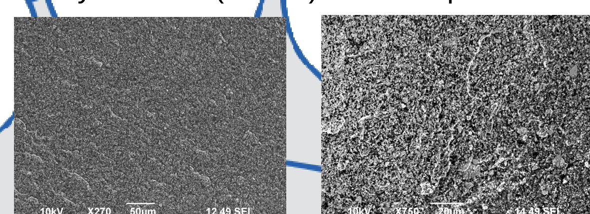
Image & schematic of Direct-Write Dispenser Printer



Manufacturing Process Steps of Printed Thermoelectric Modules

Methods

A contact dispenser printer is used to print thermoelectric inks containing suspensions of active thermoelectric materials in polymer binders. The active thermoelectric materials include bismuth-telluride and bismuth-antimony-telluride powders mechanically alloyed using high-energy ball-milling techniques. The polymer binder consists of an epoxy resin (bisphenol F)/ hardener (MHHPA) mixture. The thermoelectric inks are then filled in prefabricated polydimethylsiloxane (PDMS) mold templates.



SEM Images of bismuth telluride/ epoxy composite films

Findings

- Initial composite materials have approximately 1/10 performance of bulk materials. The power factor and figure of merit of Bismuth Telluride epoxy composites are 1.87×10^{-4} W/mK^2 and 4.01×10^{-4} K^{-1} respectively. Electrical conductivity is thirteen times lower than bulk values hence degrading figure of merit. We are exploring various dopants and sintering parameters to improve conductivity
- Dispenser printing is a viable and cost-effective method for fabricating optimally designed thermoelectric micro-generators.

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