Thermal energy including waste heat and thermal radiation from the sun are important renewable energy sources. Thermal energy can be converted to electricity by thermoelectric phenomena, which when operated in a reverse modus by providing electricity will create cooling effect to a heat source. Thermoelectric devices are scalable, renewable, and cost effective devices that offer capabilities to harness waste heat or environmental heat and convert the captured heat into usable electricity. The operating principle of a thermoelectric device requires that a temperature difference be present which induces the flow of electrons from the hot side of the device to the cold side. Thermoelectric devices are currently hampered by the low conversion efficiencies and strict operating temperatures for certain materials. This study investigates the main factors affecting efficiencies of thermoelectric devices as energy harvester and aims to optimize devices for maximum efficiency at lower costs, based on integration of microfabrication and self-assembled materials for complete thermoelectric modules (TEMs). By first establishing operating conditions and desired mode of operation, optimization equations have been established to determine device dimensions and performance parameters. Compacted integration realized by microfabrication technologies that allows multiple output voltages from a single chip were also investigated. Additionally cost savings were found by reducing the number of fabrication processing steps and eliminating the need for precious metals during fabrication. The optimized design proposed in this study utilizes copper electrodes and requires fewer applications of photoresist than previous proposed designs. In fabrication of microscale devices the film quality and the composition are essential elements for producing TEMs with desired efficiencies. Although Bi2Te3 has been investigated as thermoelectric material, this study created both N-type and P-Type Bi2Te3 from a single electrolyte solution. This study found that by precisely controlling average current densities during electrochemical deposition the composition of Bi2Te3, a flexible and durable thermoelectric film can be varied in composition and therefore the operation. Films were produced with both AC and DC signals and varied composition of Te at.% of Bi2Te3 was achieved. A linear relationship was established between the average current density and the resultant Te content. Rapid film growth during deposition was found at high peak current densities by using an AC signal with a 2% duty cycle. SEM and EDS were used to characterize the morphology and the composition. With the fabricated thermoelectric materials, high energy harvesting efficiency with a temperature difference as low as 10K can be developed. The analytical results obtained by the developed optimization equations agree well with the FEA models produced by using COMSOL, multiphysics software with powerful solving algorithms. Further improvements to device performance can be achieved by designing a segmented thermoelectric device with multiple layers of thermoelectric material.

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The public is welcome to attend.