# Evaluation of Internal Resistance and Power Loss in Micro Thermoelectric Generators (μTEGs)

S. Seif[1], K. Cadien[1]

[1]Department of Chemical & Materials Engineering, University of Alberta, Edmonton, AB, Canada

## Abstract

Introduction: One of the major challenges in designing μTEGs is to minimize power loss associated with internal resistance (r) of Thermoelectric (TE) materials. To solve this problem we have performed simulation analysis of voltages and currents passing through the TE materials. The TE materials used in this simulation analysis to evaluate currents and voltages were n-type SiGe [1], p-type SiGe [2], PbTe, PbSe, PbS [3], n-type PbTe-PbI [4], p-type PbTe-CdTe [5], and PbTe-SrTe-Na [6]. The obtained voltages and currents from this analysis were then used to calculate the internal resistances of each TE material. The calculated internal resistances of eight TE materials were then compared to the power generated across the copper electrode. These results showed that as the internal resistances across the TE materials increased, the power analyzed on the copper electrode decreased significantly.

Use of Comsol Multiphysics®: PDE in Comsol Multiphysics® was used to compute voltages as a function of temperatures. This program incorporated the Seebeck coefficients (α), electrical conductivities (σ) and thermal conductivities (λ). Since the current density (J) and the areas (A = 2.5×10 ^(-9) m^2) of all TE materials are known, the currents passing through the TE materials were calculated using (E = αΔT- ρJ), where J = I/A, I is the current, E is the generated voltage due to TE effects, and ρ is electrical resistivity of TE materials.

Results: The simulation results showing voltages and currents passing through the TE materials are depicted in Figures 1 and 2. These results were then used to calculate the internal resistance of TE materials (Figure 3). Note that, as the internal resistances (r) of TE materials increased, the power analyzed across copper electrode decreased significantly (Figure 4).

Conclusions: This paper reports on the relationship between the internal resistances of TE materials and powers analyzed across the copper electrode. This analysis shows that as internal resistances of TE materials increase, the powers analyzed across the copper electrode decreased significantly. The analyzed powers across the copper electrode when using materials with high internal resistances such as PbS, PbTe, and PbSe, are less as compared to TE powers analyzed on copper electrode using other TE materials. These results proved that, due to losses associated with internal resistances of TE materials and the diffusion barrier, the TE power generated across the TE materials will not always get extracted fully on the copper electrode. Both n-type and p-type SiGe alloys were found to be the best TE materials for the fabrication of

μTEGs, because they have low internal resistances and lose less power across the diffusion barrier.

## Reference


[1]. X. W. Wang, H. Lee, Y. C. Lan, G. H. Zhu, G. Josh. Enhanced Thermoelectric Figure of Merit in Nanostructured n-Type Silicon Germanium Bulk Alloy. Applied Physics Letters 93, 19 (2008) P. 193121.
[2]. G. Josh, H. Lee, Y. Lan, X. Wang, G. Zhu, D. Wang, R. W. Gould, D. C. Cuff, M. W. Tang, M. S. Dresselhaus, G. Chen, and Z. Ren. Enhanced Thermoelectric Figure-of-Merit in Nanostructured p-type Silicon Germanium Bulk Alloys. Nano letters 8, 12 (2008) p. 4670-4674.
[3]. Y. Ling Pei, Y. Liu. Electrical and Thermal Transport Properties of Pb-based Chalcogenides: PbTe, PbSe, and PbS. Journal of Alloys and Compounds 514 (2012) p. 40– 44.
[4]. C. Long, X. Hou, Y. Gelbstein, J. Zhang, B. Ren, and Z. Wang. Preparation and Thermoelectric Properties of N-type PbTe Doped within and PbI2. International Conference on Thermoelectrics (2006) p. 382-385.
[5]. Y. Pei, A. D. LaLonde, N. A. Heinz, and G. J. Snyder . High Thermoelectric Figure of Merit in PbTe Alloys Demonstrated in PbTe–CdTe. Advanced Energy Material 2, 6 (2012) p. 670-675.
[6]. K. Biswas, J. He, I. D. Blum, C. IWu, T. P. Hogan, D. N. Seidman, V. P. Dravid, and M. G. Kanatzidis. High-performance Bulk Thermoelectric with All-scale Hierarchical Architectures. Nature Materials 489 (2012) p. 414–418.


## Figures used in the abstract

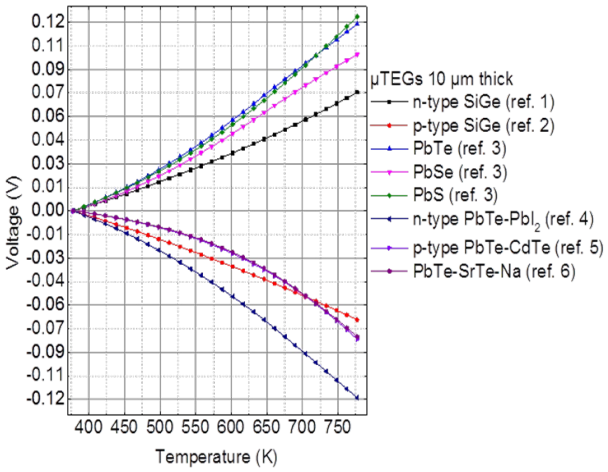


**Figure 1**: The curve which shows the variations of voltages as a function of temperatures in different TE materials with either positive or negative Seeback coefficients, when the applied ΔT was 405 K.

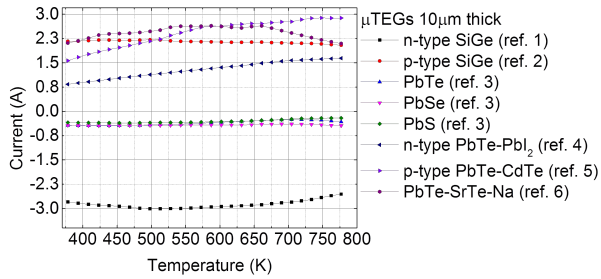


**Figure 2**: The curve which shows the variations of currents as a function of temperatures in different TE materials with either positive or negative Seeback coefficients, when the applied ΔT was 405 K.

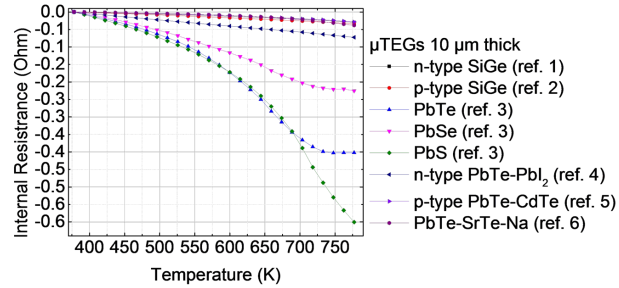


**Figure 3**: The curve which shows the variations of internal resistances as a function of temperatures in different TE materials with either positive or negative Seeback coefficients, when the applied ΔT was 405 K.

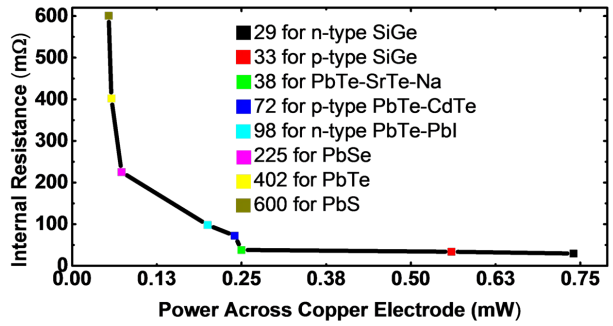


**Figure 4**: The curve which shows the variations of internal resistances as a function of analyzed powers on copper electrode when different TE materials were interfaced with copper electrode.