Thickness Designs for Micro-Thermoelectric Generators using Three Dimensional PDE Coefficient-COMSOL Multiphysics 4.2a Analysis

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Introduction:

Predicting the optimum thickness and gap size between n-type and p-type legs of micro thermoelectric devices shown in Figure 1, are the major challenges in designing micro thermo electric generators. In this presentation we have reported the gap size and optimal thickness (see Figure 2) for optimal output power. We found that the tgap should be 0.1 microns; but, depending on fabrication capability, the gap size can be varied from 0.1 to 6 microns, by doing that, the power crossing the tgap will degrade from 0.0008 to 0.00055 Watts respectively. We expect that, to obtain 1.0 Watt for the device fabricated using SiGe, we will need to fabricate 625 pairs of micro thermoelectric generators having both n-type and p-type, same as having 1250 thermo legs on a wafer.

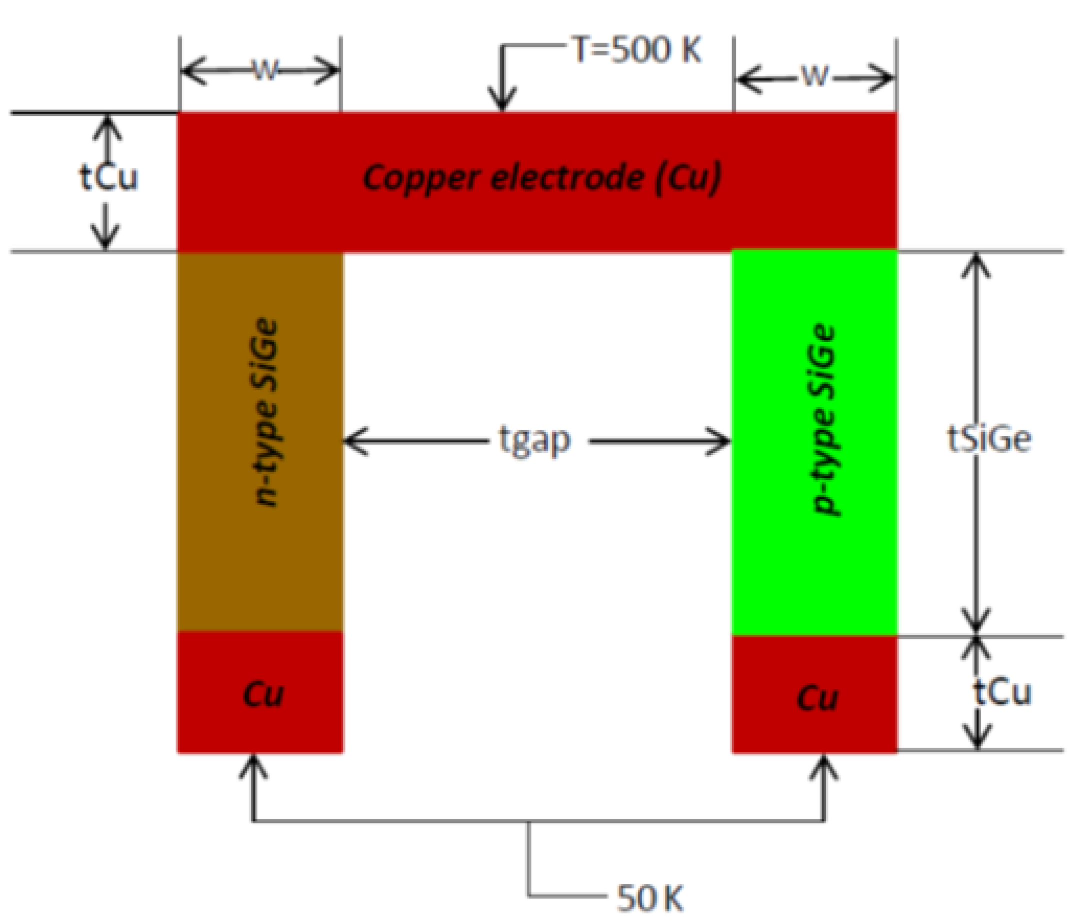

Figure 1. Schematic diagram showing 1-dimension geometrical configuration of the designed micro thermoelectric generator.

Computational Methods:

$$e_a \frac{\partial^2 u}{\partial t^2} + d_a \frac{du}{dt} + \nabla.(-c\nabla u - \alpha u + \gamma) + \beta.\nabla u + au = f; \text{ on } \Omega$$

$$n.(c\nabla u + \alpha u - \gamma) + qu = g - h^T \mu; \quad \text{on } \partial\Omega$$

$$u = r; \quad \text{on } \partial\Omega$$

Final equation used in PDE is $\nabla.(-c\nabla u) = f$

$$\mu = \begin{pmatrix} T \\ V \end{pmatrix}$$

$$c = \begin{pmatrix} \lambda + \sigma\alpha^2 & \sigma\alpha T \\ \sigma\alpha & \sigma \end{pmatrix}$$

$$f = \begin{pmatrix} \sigma((\nabla V)^2 + \alpha \nabla T \nabla V) \\ 0 \end{pmatrix}$$

$$E = \alpha \nabla T - \rho J$$

$$[\sigma_n(\alpha_n \nabla T - E) + \sigma_p(\alpha_p \nabla T - E)] * A * V = P$$

Results:

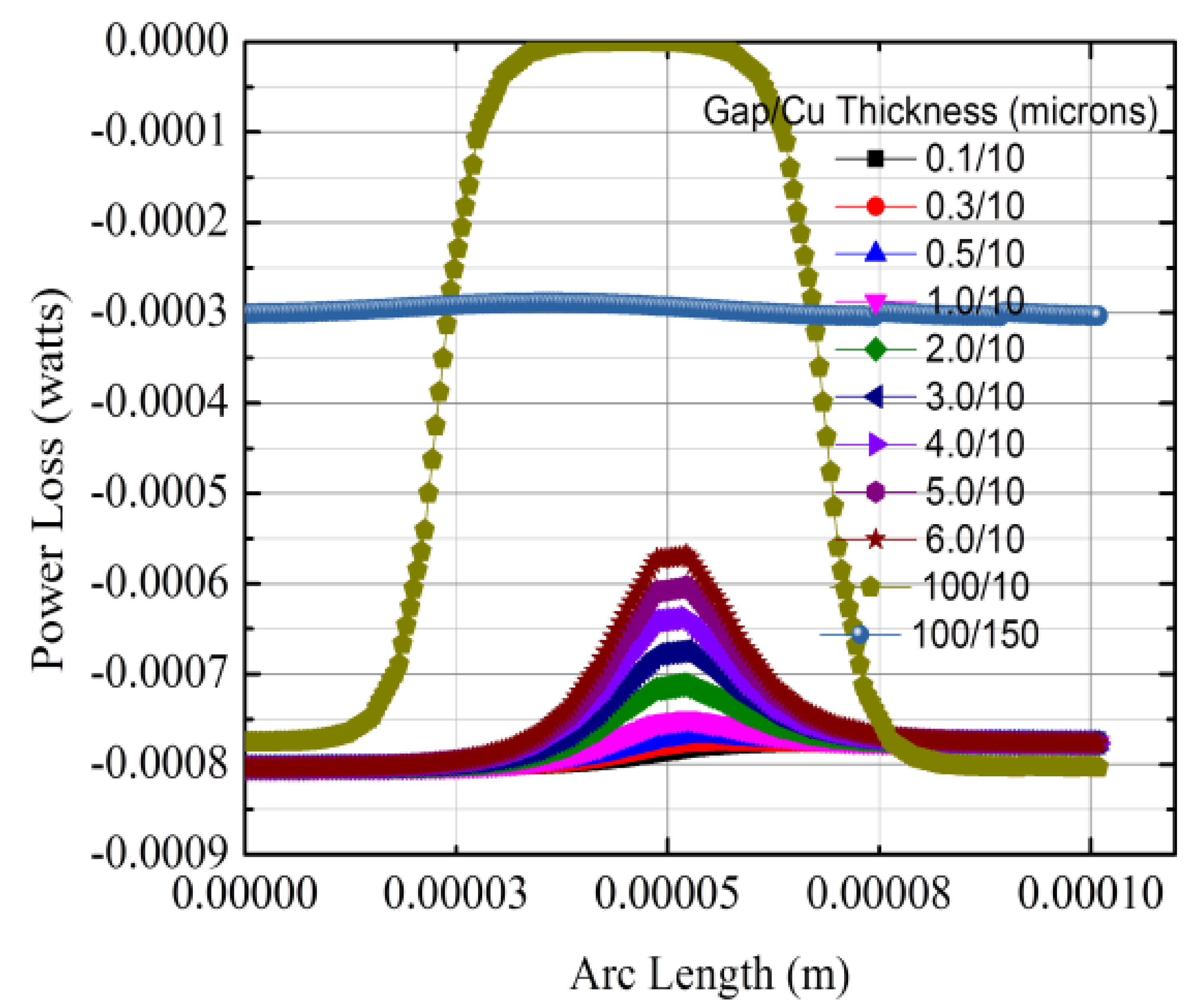

Figure 2. Curve showing variation of power versus arc length of tCu as the tgap of copper electrode is varied from 100 to 0.1µm.

Conclusions:

Table 1. Parameters of the designed micro thermoelectric generator.

Parameters	Value (µm)
W	50
L	50
tgap	0.1
tSiGe	10
tCu	10
tCu (tgap)	150

References:

1.Wang et al. Enhanced Thermoelectric Figure of Merit in Nanostructured n-Type Silicon Germanium Bulk Alloy. Applied Physics Letters, **93,** 193121, p. (2008).

2.Josh, G. Enhanced Thermoelectric Figure-of-Merit in Nanostructured p-type Silicon Germanium Bulk Alloys. Nano letters, **8, 12,** p. 4670-4674, (2008).

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