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

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Introduction: One of the major challenges in designing Micro Thermoelectric Generators (μTEGs) is to minimize power loss associated with internal resistance of Thermoelectric (TE) materials. This paper reports on simulation analysis of internal resistances of TE materials as a function of TE powers analyzed on copper electrode.

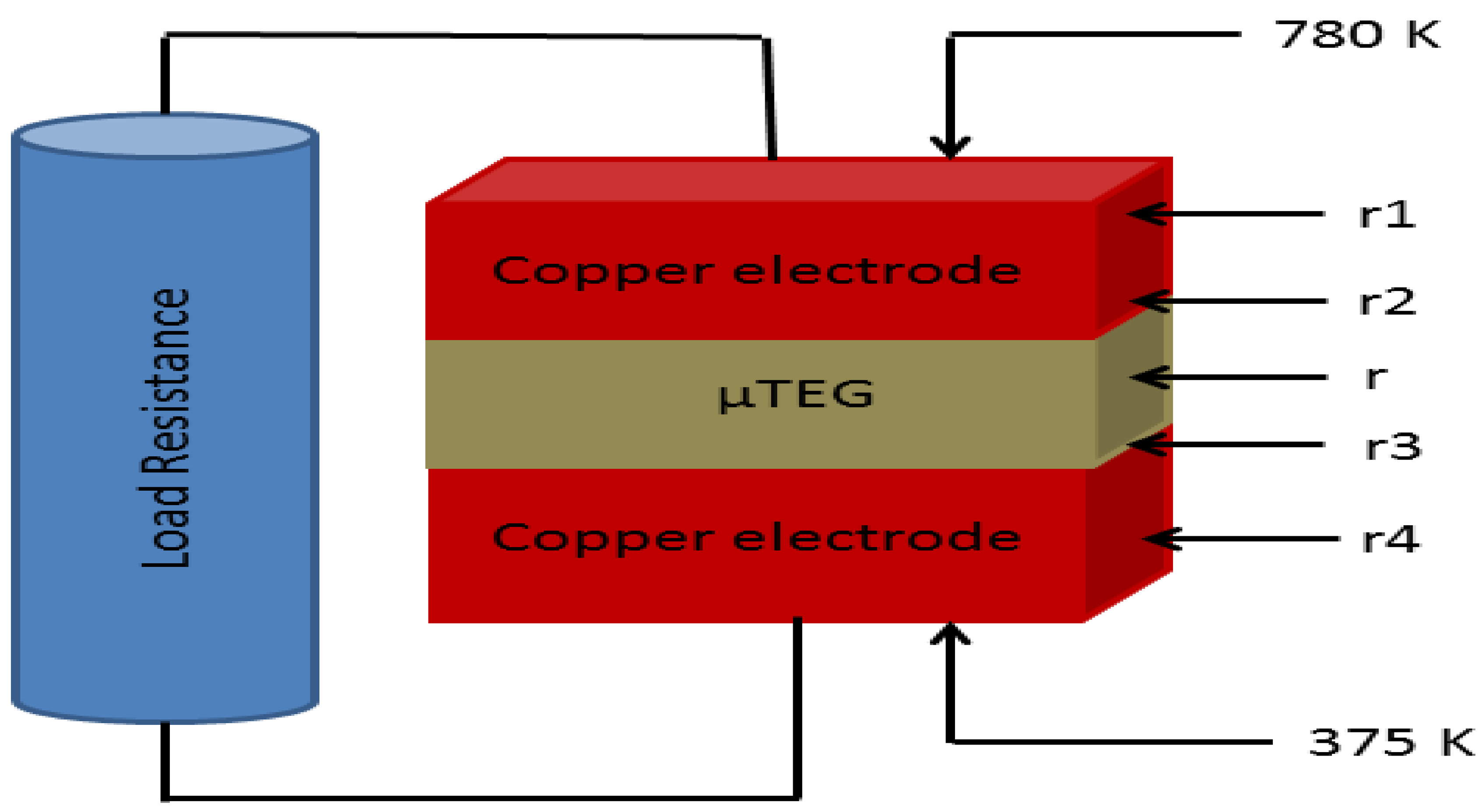

Figure 1. Simulation design of μTEGs having top and bottom copper electrodes.

Computational Methods: The following equations were used to compute thermoelectric effects of different materials using comsol multiphysics.

$$P = VI = \frac{V^2}{4r} = \frac{m^2\alpha^2}{4r}(\Delta T)^2 \qquad (1)$$

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

$$f = \begin{pmatrix} \sigma\left((\nabla V)^2 + \alpha\nabla T\nabla V\right) \\ 0 \end{pmatrix} \qquad (3)$$

$$E = \alpha\nabla T - \rho J \qquad (4)$$

$$A\sigma(E - \alpha\Delta T) = -I \qquad (5)$$

TE Materials	Dimensions (μm)			ΔT (K)
	l	w	t	
$PbTe\text{-}PbI_2$	50	50	10	405
PbTe-CdTe	50	50	10	405
n-type SiGe	50	50	10	405
p-type SiGe	50	50	10	405
PbS	50	50	10	405
PbSe	50	50	10	405
PbTe	50	50	10	405
PbTe-SrTe	50	50	10	405
Copper electrode	50	50	10	405

Table 1. Parameters of TE materials used in the simulation design.

Results:

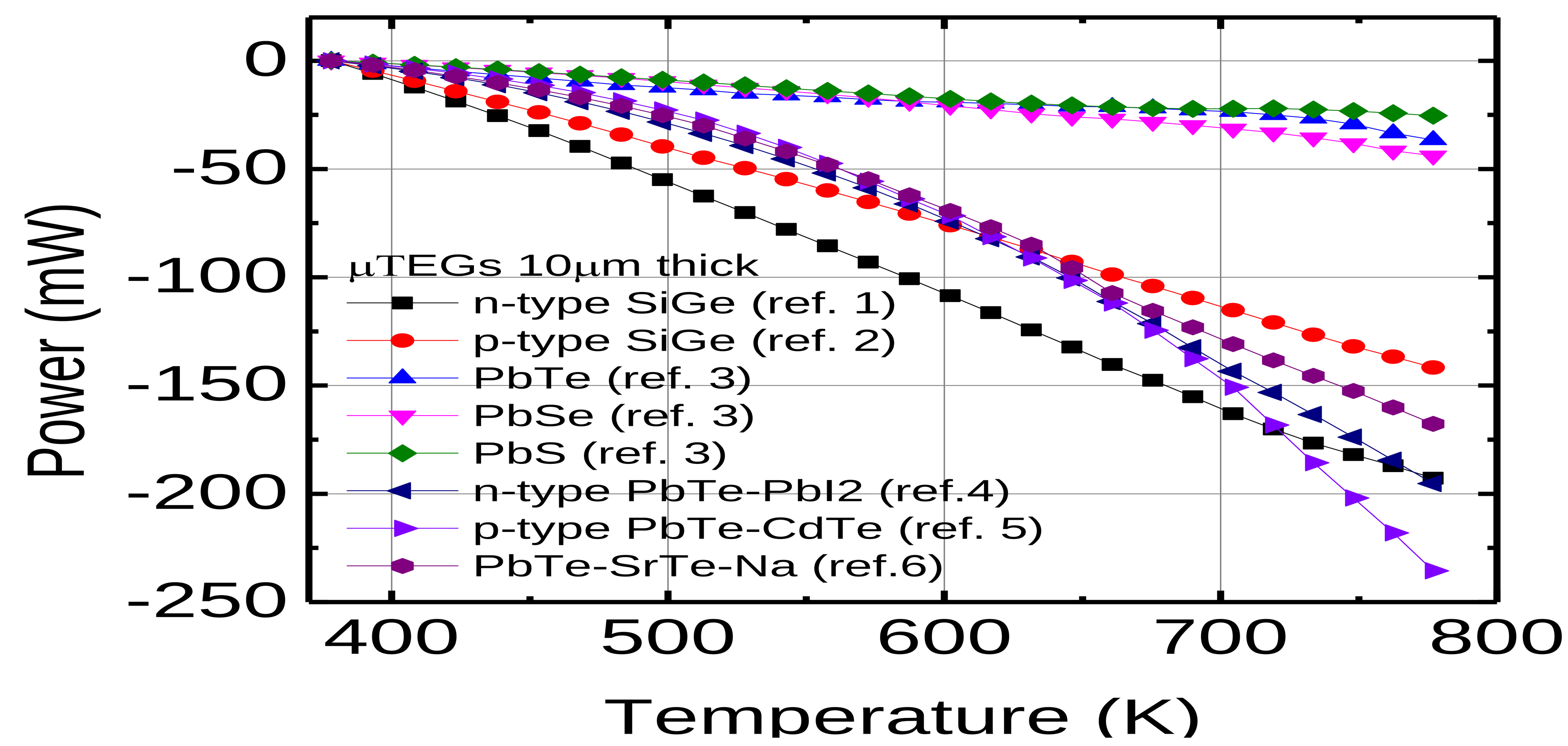

Figure 2. Power across TE layers versus temperatures.

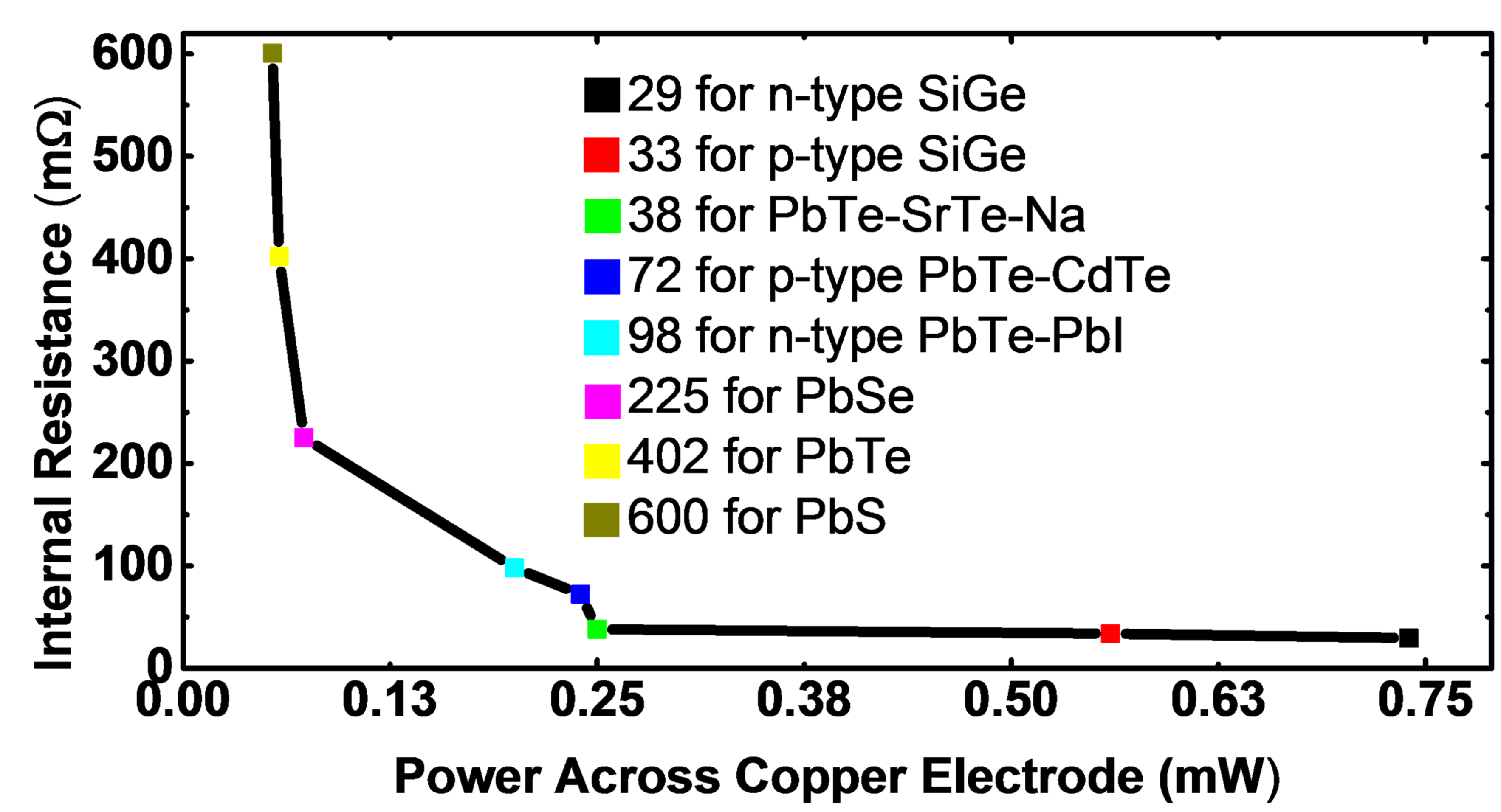

Figure 3. Internal resistance versus power across copper electrode when the temperature is 780 K.

Conclusions: These results showed that, due to losses associated with internal resistances of TE materials, and diffusion barrier, the TE power generated across the TE materials will not always get extracted fully on copper electrode. It is clear to conclude that, PbTe-SrTe-Na, n-type and p-type SiGe alloys are better TE material for the fabrication of μTEGs; because, they have low internal resistances and lose less power across the diffusion barrier.

Reference

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