Asymmetry Induced Terminal Voltage Improvement in Mg2Si-based Thermoelectric Unicouple

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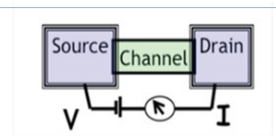
Introduction:

- Device to convert heat energy in to electrical energy.
- Thermoelectric generator- Seebeck Effect
- Output electrical power-
  - Factors:- Material
    Shape & Size of the leg



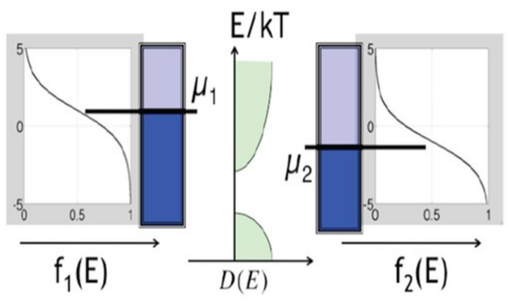


Figure 1. Current flow due to potential difference

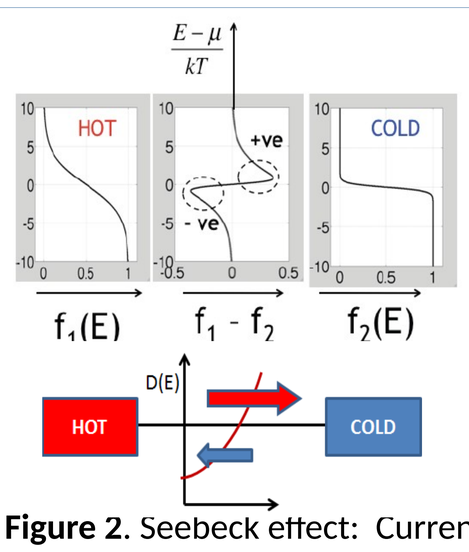
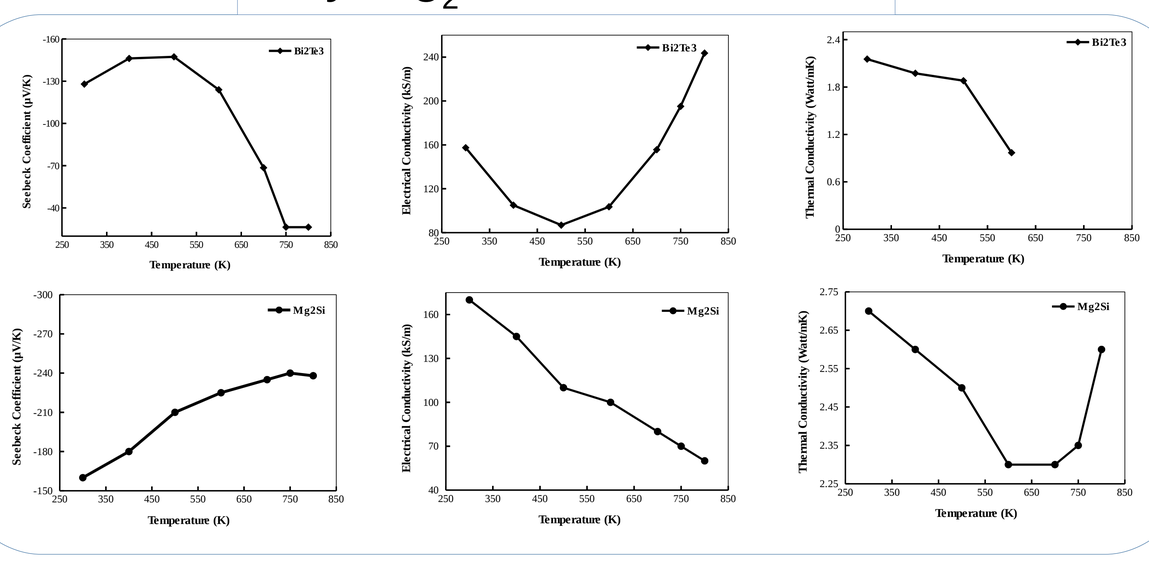


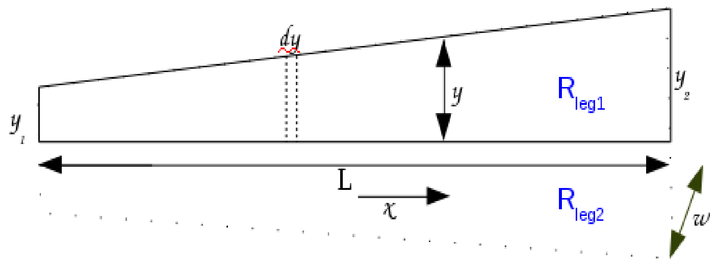
Figure 2. Seebeck effect: Current flow due to temperature difference

Computational Methods: Equation solved in COMSOL Multiphysics for the theoretical analysis :

$$\rho C_p \frac{\partial T}{\partial t} + \nabla\left(-\kappa \nabla T + PJ\right) = Q$$
$$J = -\sigma\left(\nabla V + \alpha \nabla T\right)$$

Why Mg_2Si-based Material:





$$R = \int dR = \frac{1}{\sigma}\int \frac{dx}{wy}$$
$$K = \int dK = \kappa_{avg}\int \frac{wy}{dx}$$

$$V_{out} = V_{oc}\frac{R_{Load}}{R_{inte} + R_{Load}}$$

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Results:

- Terminal electrical voltage increases
- Efficiency of tapered leg increases

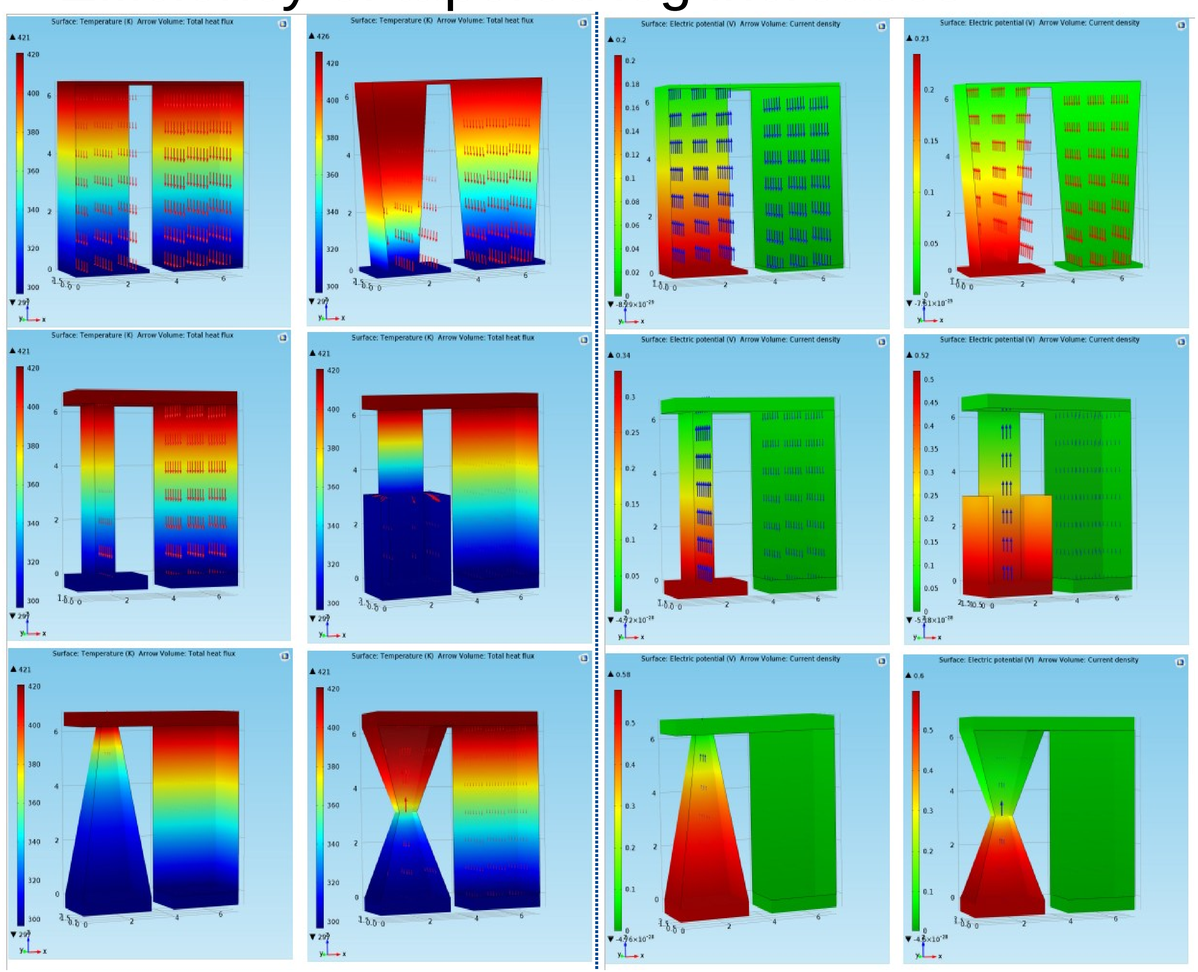

Figure 2. Structure details and simulation process of various unicouple

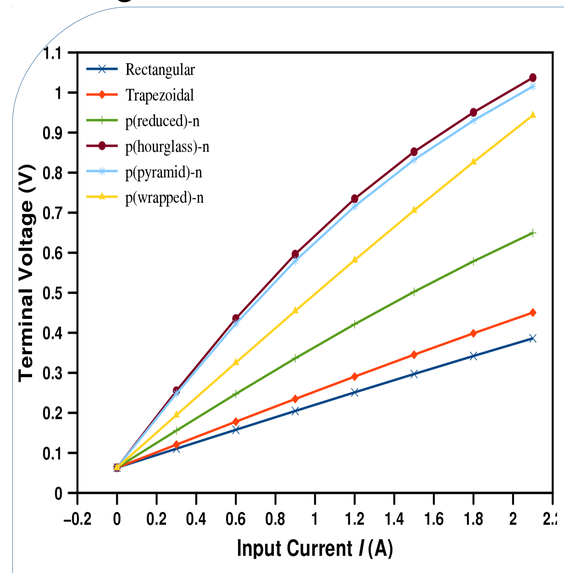

Figure 3. Terminal voltage of different shaped pn unicouple as a function of input current.

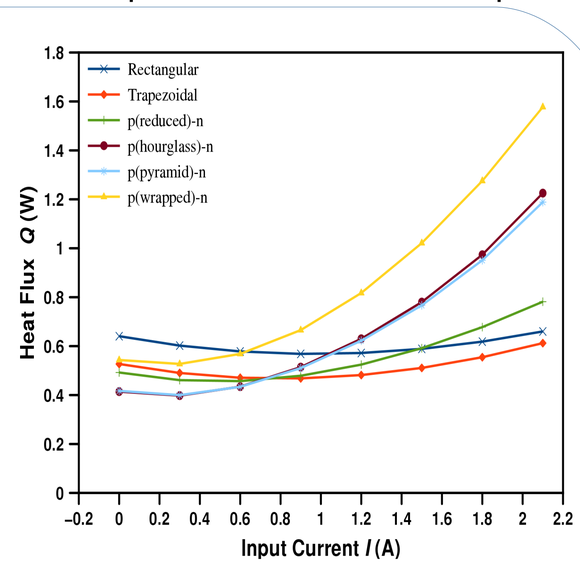

Figure 4. Conductive heat flux at cold end of different shaped pn unicouple as a function of input current.

Conclusions: The measured terminal voltage of a unicouple is observed to increase on introducing the various asymmetries in the leg geometry. It is observed that, the geometry with hourglass shaped p-leg and rectangular n-leg shows the higher voltage across the ends. The inclusion of asymmetry in p-legs can act as a potential way to enhance the efficiency of the thermoelectric unicouple.

[1] Ahmet Z. Sahin and Bekir S. Yilbas, The Thermoelectric as Thermoelectric Power Generator: Effect of Leg Geometry on the Efficiency and Power Generation, Energy Conversion and Management, 65 (2013) 26-32

[2] Yu Mu et. al., Effect of Geometric Dimensions on Thermoelectric and Mechanical Performance for Mg_2Si-based Thermoelectric Unicouple, Materials Science in Semiconductor Processing, 17 (2014) 21-26

[3] COMSOL Multiphysics 5.1, Heat Transfer Module User's Guide