UNIVERSITI TEKNOLOGI MARA | College of Built Environment

Poster Book

IIIDBEX 2023

20 JANUARY 2023

International Invention, Innovation & Design Exposition for Built Environment and Engineering 2023

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OPTIMIZATION OF THERMOELECTRIC PERFORMANCE BY VARYING THERMOELECTRIC HEIGHT

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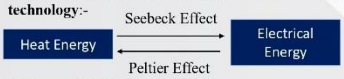
INTRODUCTION

Thermoelectric (TE)

- Global population growth and rapid pace of industrialization is increasing, therefore people are facing **energy supply depletion and environmental pollution.**
- TE has been widely investigated as **clean energy conversion technology**:-



Coefficient of Performance (COP)

- TE has problem of **low efficiency/zT values.**
- **Oxide perovskite material** is becoming more critical as it has been found to have **high-temperature durability, non-toxic and environmentally benign nature.**

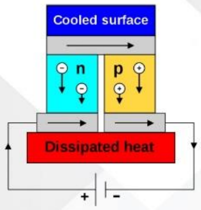


Figure 1 shows Peltier effect describes how a temperature gradient is induced by the application of an electric current, where the force flow of charged carriers creates a temperature difference.

ISSUES/ PROBLEM STATEMENT

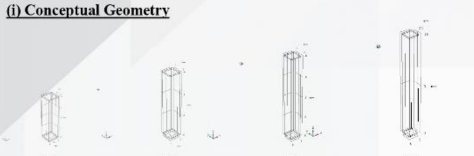
- Current thermoelectric materials, Bi_2Te_3 is not resistant to high temperature and high toxicity.
- Efficiency TE materials is low.

OBJECTIVES

To investigate electrical performance for optimize thermoelectric Peltier effect in COMSOL Multiphysics by:-
(i) Using two oxide perovskite materials, $SrTiO_3$ and Ca_2FeMoO_6
(ii) Varying the height of thermoelectric leg, n = 4mm, 6mm, 8mm, 10mm.

METHODOLOGY

(i) Conceptual Geometry



(a) (b) (c) (d)

Figure 2 A geometry model of thermoelectric was built in COMSOL Multiphysics software which are a single leg TE. This model is simulated to by varying the height of the geometry (a) 4 mm (b) 6 mm (c) 8 mm (d) 10 mm. The set of measurement was from a previous paper which also based of the application library example in COMSOL Multiphysics.

Table I : Dimension of Each Geometry Parts in Thermoelectric Peltier Effect which is based on previous simulation geometry.

Part	Length (mm)	Width (mm)	Height (mm)
Thermoelectric Leg	1	1	n = 4,6,8,10
Top Copper	1	1	0.1
Bottom Copper	1	1	0.1

(ii) Simulation Condition

- Mesh is determined using sweep mesh approach.
- Carried out in a steady-state environment.
- Materials are in linear-elastic.

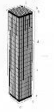


Figure 3 Meshing pattern of the geometry was manually specified to increase accuracy and save calculation time.

NOVELTY

- The novelty of this project are the optimization of thermoelectric height for oxide perovskite materials, Ca_2FeMoO_6 and $SrTiO_3$ by varying the thermoelectric height to get the best COP values.
- Therefore can produce and predict a better efficiency for the Thermoelectric Cooling or Heating in the near future.

CONCLUSION

- It can be observed that temperature and electrical distribution both have increment in both materials as height was increased.
- Further observation, as height increase, resistance of the thermoelectric also increase.
- Numerical calculation of COP was calculated based on previous researcher method.
- COP decrease as height increase due to the greater temperature gradient that was built up.
- 4 to 6 mm are ideal to use as optimize height considered that $SrTiO_3$ and Ca_2FeMoO_6 having COP closes to 1.

COMMERCIALIZATION

The potential that sufficiently advanced thermoelectric materials and device construction could one day be **recognize as a potentially ideal thermoelectric cooling or heating technology** due to their ability to convert electricity directly into heat and to develop cost-effective, pollution-free forms of energy conversion.

RECOGNITIONS

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Universiti Teknologi Mara (UiTM). This research was financially supported by Fundamental Research Grant Scheme.

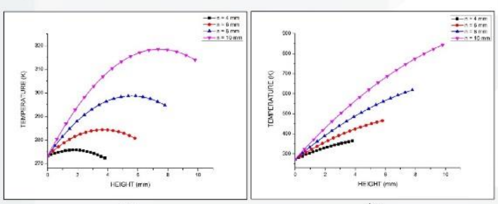
CONFERENCES & PUBLICATION

(i) **NANOSYMS 2021:** S. F. N. S. Omar, N. Burham, and A. A. Aziz, "**Simulation of Heat Transfer Response on Single Leg Thermoelectric Materials Behaviour**," *Trans. Tech. Pubs., Ltd,* vol. 1055, pp. 69-75, 2022.

(i) **ICSE 2022:** S. F. N. S. Omar, N. Burham, A. A. Aziz, and M. Muhamad, "**Electrical Performance of Single Thermocouple with Different Types of Materials Using Multiphysics Simulations,**" in *2022 IEEE International Conference on Semiconductor Electronics (ICSE)*, *IEEE*, pp. 33-36, 2022.

FINDINGS

(i) Temperature Distribution



(a) (b)

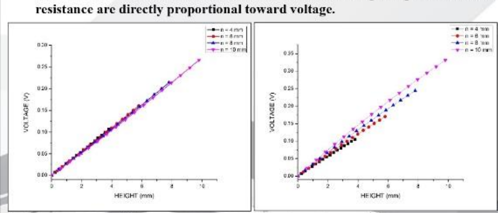
Figure 4 Temperature distribution for (a) $SrTiO_3$ (b) Ca_2FeMoO_6. It can be observed that the temperature difference of the **thermoelectric for both materials increase with increasing TE height.** As can be seen, that the temperature of Ca_2FeMoO_6 produce is higher than $SrTiO_3$ due to difference of thermal conductivity and internal resistance of each material

(i) Electrical Distribution

Table II : Effect Of Resistance Against Height Variation

Height (mm)	Resistance (Ω)	
	$SrTiO_3$	Ca_2FeMoO_6
4	0.16	0.13
6	0.24	0.20
8	0.32	0.27
10	0.40	0.33

- **The resistance of the leg increase as height of the TE legs increases.**
- **Based on Ohm's law, when resistance increase, the voltage output increase as resistance are directly proportional toward voltage.**



(a) (b)

Figure 5 (a) and (b) shows the electrical distribution for varying height 4 mm, 6 mm, 8 mm and 10 mm for $SrTiO_3$ and Ca_2FeMoO_6. From the graph we can see that both have a linear increment and as the height of the TE leg increase, the voltage output also increase.

Table III : Voltage of Top Electrode

Height (mm)	Voltage (V)	
	$SrTiO_3$	Ca_2FeMoO_6
4	0.10659	0.10508
6	0.16084	0.16983
8	0.21392	0.24393
10	0.26585	0.33107

- **It can be seen that the highest voltage was 0.26V for $SrTiO_3$ and 0.33V for Ca_2FeMoO_6.**
- **However, having high voltage and high temperature different does not mean it will very good efficiency for thermoelectric.**

(i) Coefficient of Performance (COP)

Table IV : Coefficient Of Performances Of Oxide Perovskite

Height (mm)	Coefficient of Performances (COP)	
	$SrTiO_3$	Ca_2FeMoO_6
4	17.11204	0.078507
6	2.084558	0.047008
8	0.760708	0.034063
10	0.424298	0.027301

- **The COP decrease as the height of the thermoelectric increase.**
- **Having high output in voltage and temperature different does not guarantee a good COP output**
- **4 to 6 mm height is considered the best in this simulation as COP value is more than 2 which is the value of the COP was 2.084558 for $SrTiO_3$ and 0.047008 for Ca_2FeMoO_6.**

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