# Investigation on Pyroelectric Ceramic Temperature Sensors for Energy System Applications

Sarker, R.,[1] Karim, H.,[1] Sandoval, S.,[1] Love, N.,[1] Lin, Y.[1,†]
[1] Department of Mechanical Engineering, The University of Texas at El Paso

## Introduction

### Objective:

- To design, fabricate, and test wireless temperature sensors using the principle of pyroelectricity[1]


Figure 1: Motivation behind this project

## Methodology & Materials

### Rationale:

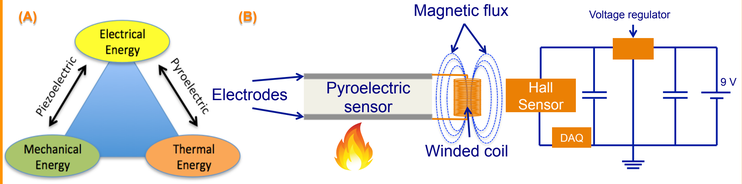


Figure 3: (A) Principle of the proposed sensor, (B) Schematic and working mechanism of the sensor components

### Sensor fabrication:

**Materials:**

- Pyroelectric ceramic: Lithium niobate ($LiNbO_3$)
- Binder: Polyvinyl alcohol (PVA)

**Process:**

- Ceramic compressed at 3 metric tons
- Cured at 150°C for 120 minutes

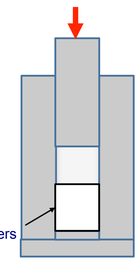


Figure 5: Schematic for compression

### Testing:

**Tests performed:**

- Hall effect sensor demonstration
- Signal interference testing
- Pyroelectric ceramic testing

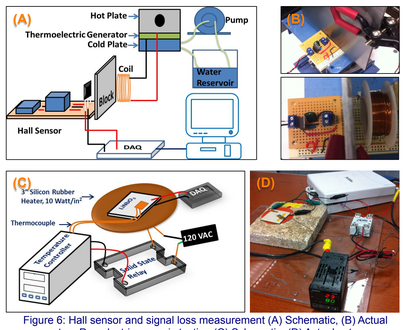


Figure 6: Hall sensor and signal loss measurement (A) Schematic, (B) Actual setup. Pyroelectric ceramic testing (C) Schematic, (D) Actual setup

## Results

### Sensor fabrication:

- Different geometries were achieved
- Cracked surfaces observed on certain samples
- Silver painting of the commercial sample

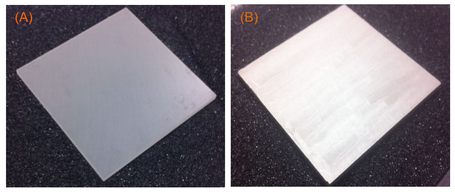


Figure 7: (A) Commercial pyroelectric ceramic (B) After silver paint coating

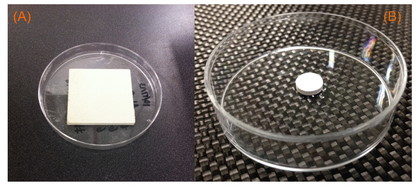


Figure 8: (A) Square sample (B) Cylindrical sample of $LiNbO_3$

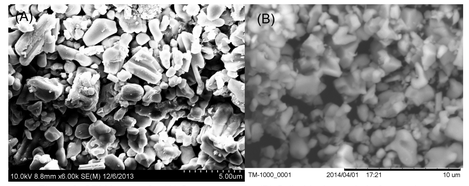


Figure 9: SEM images for (A) Square sample, (B) Cylindrical sample before curing

### Testing results:

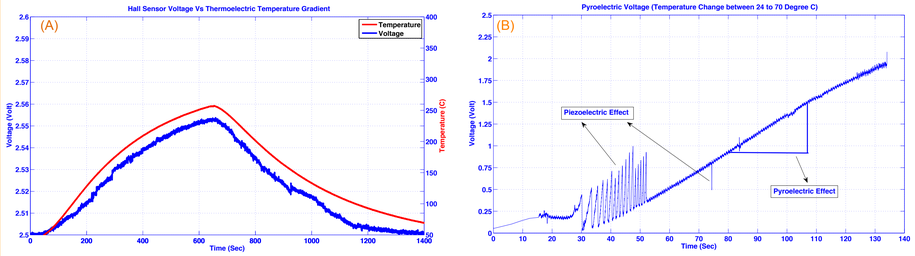


Figure 10: Testing results for (A) Thermoelectric/Hall sensor demonstration, (B) Commercial pyroelectric ceramic

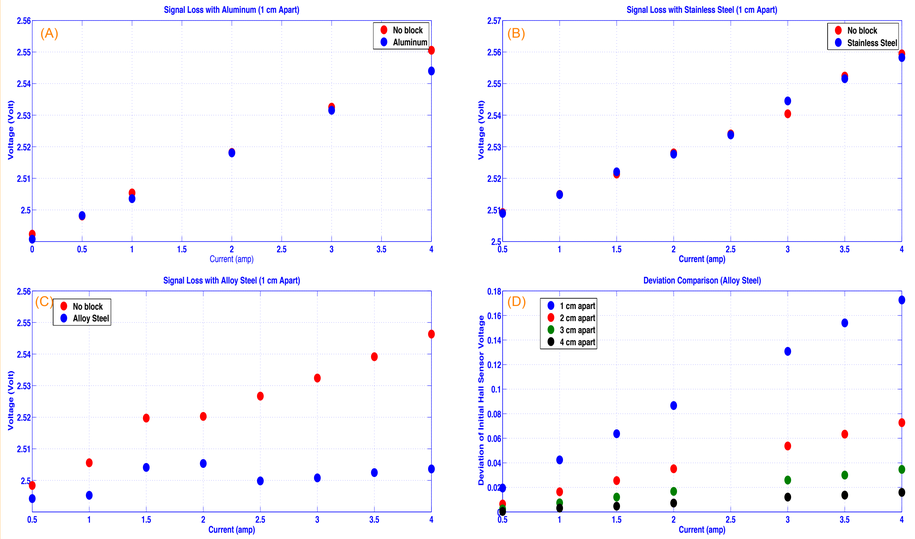


Figure 11: Signal loss testing results for (A) Aluminum, (B) Stainless steel, (C) Steel alloy and (D) Deviation comparison

## Conclusion

- The first stage of the sensor fabrication was carried over successfully
- The Hall effect sensor concept was demonstrated using a thermoelectric sensor
- Voltage change in the Hall effect sensor can be used for temperature sensing
- Signal loss was found when using steel alloys

## Future Work

| | 2013 - 2014 | | | | 2014 - 2015 | | | | 2015 - 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| **Objective 1** | | | | | | | | | | | | |
| Task 1.1: *Materials determination* | | | | | | | | | | | | |
| Task 1.2: *Sensor Fabrication* | | | | | | | | | | | | |
| Task 1.3: *Material Evaluation* | | | | | | | | | | | | |
| **Objective 2** | | | | | | | | | | | | |
| Task 2.1: *System Development* | | | | | | | | | | | | |
| Task 2.2: *Sensor Calibration* | | | | | | | | | | | | |
| Task 2.3: *Performance Evaluation* | | | | | | | | | | | | |
| **Objective 3** | | | | | | | | | | | | |
| Task 3.1: *Torch Testing* | | | | | | | | | | | | |
| Task 3.2: *Gas Turbine Testing* | | | | | | | | | | | | |
| Task 3.3: *Energy System Evaluation* | | | | | | | | | | | | |

## Student Involvement

## Acknowledgements

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## References

1. Whatmore, R.W., “Pyroelectric Devices and Materials”, Reports on Progress in Physics, 1986, 49(12): P. 1335