भारतीय प्रौद्योगिकी संस्थान गुवाहाटी

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

MINI PROJECT

PH 312

HIGH ENERGY OXIDES IN ENERGY GENERATION

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Content

ABSTRACT:

The project comprehensibly deals with the study of various High Entropy Oxides HEOs, which includes energy extraction techniques and maximum output generation out of the various sample. So, we can utilize this sample for sustainable and efficient energy generation techniques, which will be of great importance in global energy-related places.

1. INTRODUCTION:

Our era is demanding an all-time high output sustainable energy resource. Hence, to revolutionization the energy generation, a quest for innovative material has gained its significance. One of such material is HEOs *i.e.*, High Entropy Oxides []. HEOs remarkable properties categorized it as fascinating class of material which promises its vast potential in the field of next generation energy systems. They have immense use in energy conversion and storage because of their high stability, complex structure and diverse elemental composition.

HEOs consist multiple cations of different element, which ultimately introduce disorder at the atomic level. Due to this, they attain high configuration entropy when solidifies, which turns them into energy-harnessing compounds. These compounds can be easily engineered accordingly to one desired property, such as catalytic process, mechanical strength, electronic conductivity, ionic conductivity, etc. Therefore, this type of unique combination leads many researchers to research on these compounds and unlocking its potential for energy related fields.

This report consists of overviewing HEOs as means for energy generation. Here, we study the geometry and area-dependent energy generation, analyzing their energy extraction techniques, maximize the energy output and the feasibility part for future implantation at various applications. Hoping HEOs acme energy harvesting part and lead us to have a sustainable and efficient energy technologies. So, addressing all the global needs related to energy.

2. Experimental Work:

Total experimental work is compiled with 3 steps.

- Electrode preparations
- Mechanical Module
- Electronic Module

3. Electrode Preparation:

The key aspect of the sample preparation part is to maximize the energy generation and fulfill criteria shown below at same time. In order to have the desired output series of high entropy oxides were prepared in different concentrations and tested with utmost accuracy.

- Maximum energy output generation.
- Non-volatility
- Economical
- Environmental criteria (Pollutant free, waste disposable, etc.)
- Inert to the atmosphere
- Sustainability
- Durability
- Reliability
- Reusability, *etc.*

With the above objective, we have chosen our electrode materials.
The electrodes are divided in two types.

1. Base Electrode
2. Striking Electrode

3.1. Base Electrode:

- Take a copper plate and cut it into square shape size 10 cm x 10 cm.
- Solder a thin wire at one of the corners of the plate. This is the wire through which outputs form this plate are channelized to the corresponding place.
- Clean the copper surface with the acetone.
- Carefully applying the Polyimide take on the cleaned surface. Make sure there is no gap left over the plate.

NOTE: Ensure that there is no area exposed of the copper plate. Area must be covered with the polyimide tape.

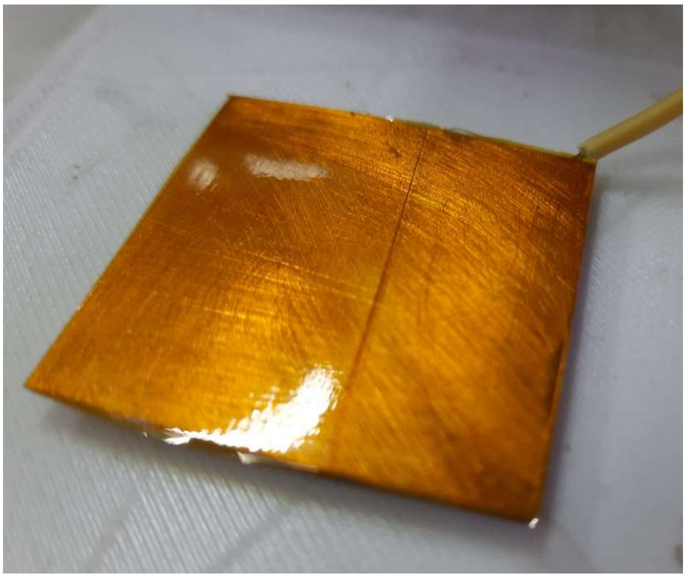

Fig 1. Base Electrode

3.2. Striking Electrode:

This section of experimentation ensures about the output generation waveform confirmation. Then same experimental setup is used for different types of electrodes such as square and circular electrodes. Helping us to study the electrode's geometrical impact on the output-generated waveform. Henceforth determining the area optimization part for the whole setup. So, the result will help us determine the geometry and area of the electrode going to use for further experimentation with the test aluminium electrode.

Striking Electrode: (Referencing output electrode)

Here we decided to test three different types of electrodes sample.

1. 2 cm radius circular electrode
2. 2.5 cm radius circular electrode
3. 3.5 cm length square electrode

- Take the copper electrode and cut-out the required shapes and sized as mentioned above.
- Then solder a wire for output energy information channelization.
- Clean the copper surface with sandpaper and clean it with acetone.
- Paste the aluminium tape on the copper plates. Hence the electrode is ready for referencing the output generation.

Note: The assembly process should be performed in a controlled environment, such as a cleanroom, to minimize any contamination that could affect the performance of the sample.

. a) b) c)

Fig 2. Striking Electrode : a) 2cm radius circular electrode; b) 2.5cm radius circular electrode; c) 3.5cm square electrode.

Assembly:

• Take the prepared base electrode (copper plate with Polyimide tape) and place it on a stable, nonconducting surface.

• Wield the Striking electrode (various referencing electrodes) at the end of the solenoid, ensuring that the aluminium faces the polyimide taped surface of other electrode.

• Ensure that the wire attached to the base electrode and striking electrodes are accessible for connecting to the respective output channel do not touch each other.

Once the electrode preparation steps are completed, the assembled electrodes can be further used for energy generation experiments or any other desired applications.

Note: The Result comprised of the collective module parts. Hence kindly refer to other modules so to understand the result with utmost reference of the whole experiment.

Mechanical Module:

The mechanical module deals with engineering the mechanism for the energy output generation. Here the solenoid holding ad circuital arrangement which back and forth hits the sample. The prototype makes an easy analysis of the energy output supporting the hardware requirements for the experiment.

Electronics Module:

The Electronics module deals with the software requirement for the experiment. It generates energy output waveforms as Voltage vs Time graph. The graph was studied using a software. The further deep discussion for the corresponding is done in respective modules.

Overview of the whole experiment

After the preparation of the sample and making of electrode is over, we started to make a CAD model for generating and evaluating the samples. The best among all the CAD model was chosen and we 3D printed that CAD model. The 3D printed model was a stand which holds the solenoid in linear position alignment. Then end of the solenoid is where we joined the electrode.

Now with help of a Relay-controller circuit we made the solenoid go back and forth striking the sample. The frequency of the striking is controlled with a software. The output so for generated are carried to the electrometer for further analysis through the graph plotting. Various graph is generated using this setup and studied. So, the following are the graphs for the referencing striking electrode.

1. 5 cm diameter circular electrode.
2. 4 cm diameter circular electrode.
3. 3.5 cm length square electrode.

4. Result and Discussion:

1) 2.5 cm radius circular electrode.

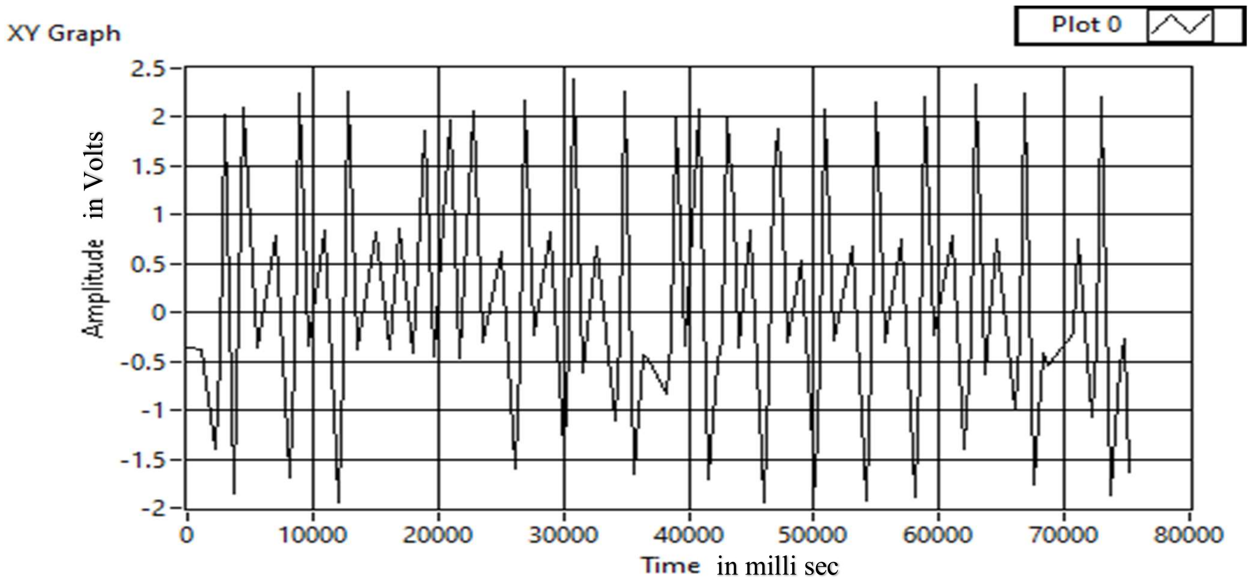

Fig 3. Voltage vs time output plot for 2.5cm radius circular electrode.

2) 2 cm radius circular electrode.

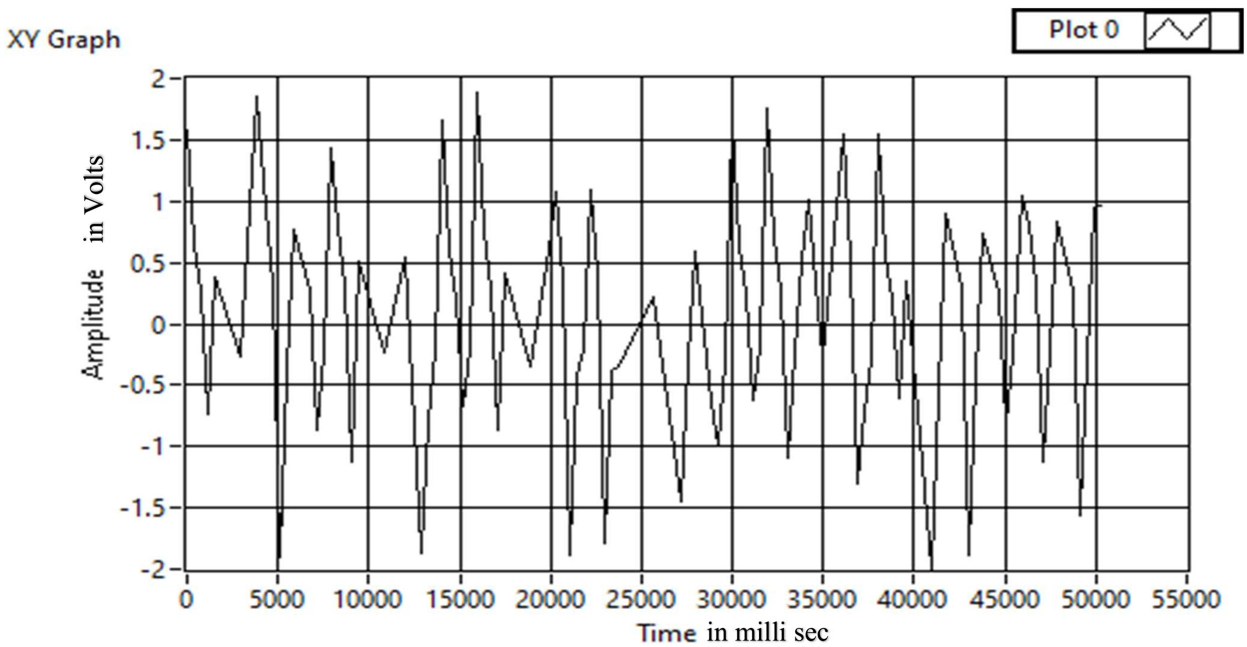

Fig 4. Voltage vs time output plot for 2cm radius circular electrode.

3) 3.5 cm length square electrode.

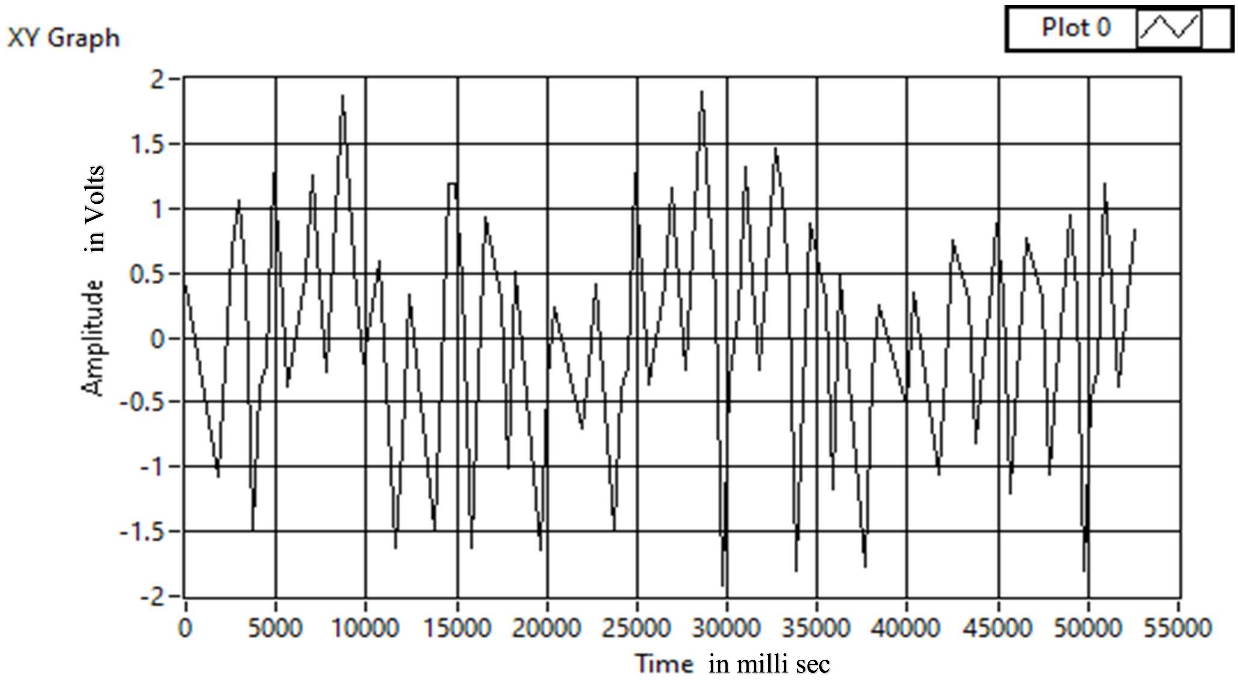

Fig 5. Voltage vs time output plot for 3.5 cm length square electrode.

5. Conclusion:

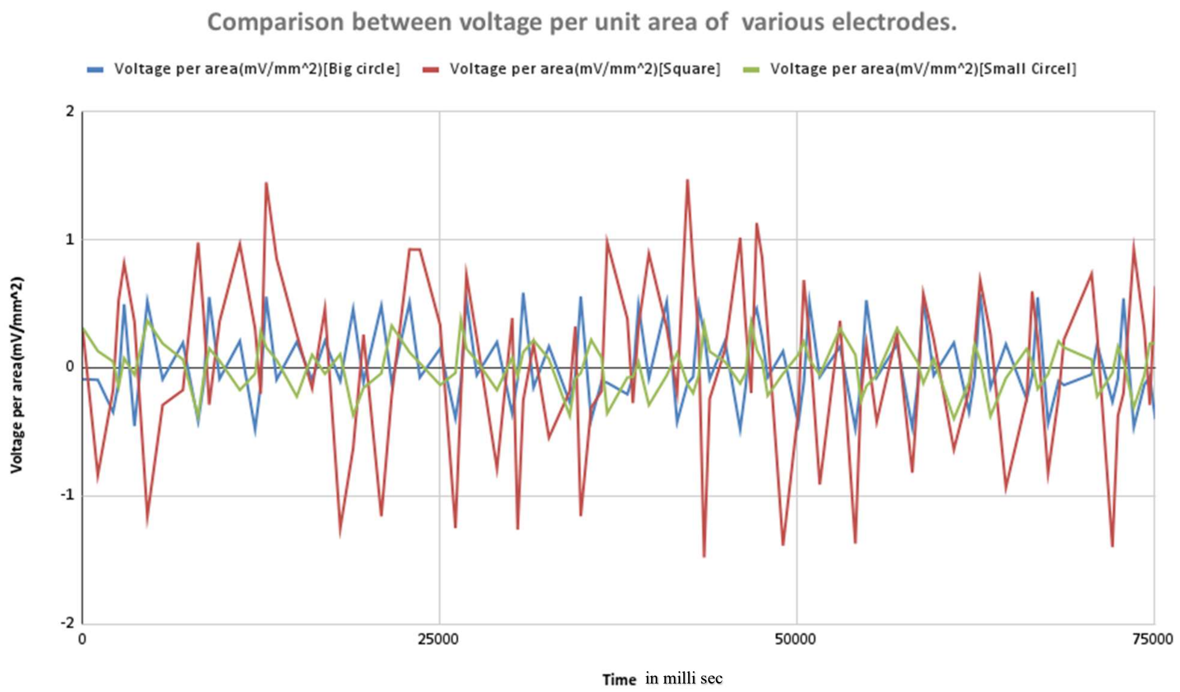

Fig 6. Comparison between voltage per unit area of various electrodes.

Figure1-3 Show voltage versus time of electrodes (kepton-Aluminium (1) 2cm radius circular (2) 2.5 cm radius (3) 3.5cm length square electrode).

Here, the maximum peak-to-peak voltage is 2-3.5 volts. It can be increased further by proper optimization. Due to different area and geometry it is not possible to compare the output. Hence, Output are compared per cm^2. It is found that 1.5 mV/mm^2.

The result of the comparison concluded that the energy output generated from The High Entropy Oxide sample is far more than the referencing samples. So, the traditional existing energy storing/ generation devices can be easily replaced by the HEOs for to get more output.

However, the standard sample are not most optimized one, there is big area for advancement and future further research in this field of energy generation that must be explored.

6. Limitation:

Here, we discussed about the HEOs as promising for giving high energy output generation because of their properties. But they also come with the limitations as discussed below.

HEOs has limited compositional flexibility as they compromised of more than four or more elements. As the number of elements are increased their compositional place is also drastically increases. Hence challenging us to study whole compositional space.

It is also hard to get the homogeneous composition of elements with different atomic sizes and electronegativities, making the processing parameters very crucial things to be maintained while their preparation.

HEOs comes with a difficulty of optimizing a specific property from all of the existing properties of the sample. They also exhibit a very complex microscopical structures and elemental composition.

As it is currently vast area of research and still developing, the lack of current comprehensive knowledge of the theoretical framework makes it hard to study the design and predict the material properties.

The preparation of HEOs sample requires use of powdered metallurgy techniques such as spark plasma sintering or mechanical alloying makes. At a small scale its possible to produce these materials. But for the production of these in bulk scale it would be not that possible.

7. Future Aspects:

We completed the prototype for the energy extraction. As due to time constraint we were not able to work on the different types of samples. In future we can work on the corresponding samples for to enhance their specific property and generating output through this kind of prototype which would be helpful in this area of research as discussed below.

- Optoelectronics:
  HEOs structure and unique composition can alter the bandgap and electronics properties, which makes them useful for LEDs, Photodetectors, solar cells, etc.
- Thermoelectric Materials:
  HEOs exhibits low thermal conductivity and high electrical conductivity and high degree of disorder makes the favourable for thermoelectric materials.
- Catalysis:
  HEOs have diverse chemical environment that favours them as catalyst. Tunability of composition helps in specifying application. Hence allowing it to use it in industrial, fuel and environmental remediation chemical reactions.
- Advanced Energy Storage:
  HEOs composition and unique structure improves their charge holding capacity, great charge-discharge rates, and cycling stability. These properties make them promising for energy storage devices.
- Biomedical Applications:
  Tunability properties of HEOs helps designing multifunctional platforms and regenerative medicine. Such as in bioimaging, tissue engineering, and drug delivery systems.
- High-Temperature Materials
  HEOs exhibits great thermal stability withstanding high temperature. So, they can easily be part of refractory materials, thermal barrier coating and high-temperature sensors also.

8. Contributions:

The project was a collective group project on the High Entropy Oxides Energy generation. So, the module dealing with the project are correspondingly divided between the three parts. The following students has been involved for the project under as mentioned module below.

1. Sample preparation by Piyush Shende
2. Mechanical Module by Tarang Kamble
3. Electronics Module by Lakshya Mittal

9. References:

HEOs:

[1]. C. M. Rost et al., “Entropy-stabilized oxides,” Nat. Commun., 6, 2015, 8485.

[TRiboelectric]

[1]. A. M. Padhan et al., “Triboelectrification based on NiO-Mg magnetic nanocomposite: Synthesis, device fabrication, and energy harvesting performance,” Nano Energy, 91, 2022, 106662.

[2]. S. Panda et al., “Piezoelectric energy harvesting systems for biomedical applications,” Nano Energy, 100, 2022, 107514.

[3]. K. Y. Lee et al., “Controllable Charge Transfer by Ferroelectric Polarization Mediated Triboelectricity,” Adv. Funct. Mater., 26, 2016, 3067–3073.

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