



A novel pyroelectric generator utilising thermal fluctuations from oscillating heat pipes (OHPs) for waste heat recovery and thermal energy harvesting

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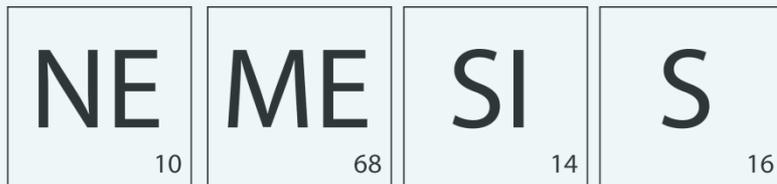
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Novel Energy Materials: Engineering Science and Integrated Systems



European Research Council

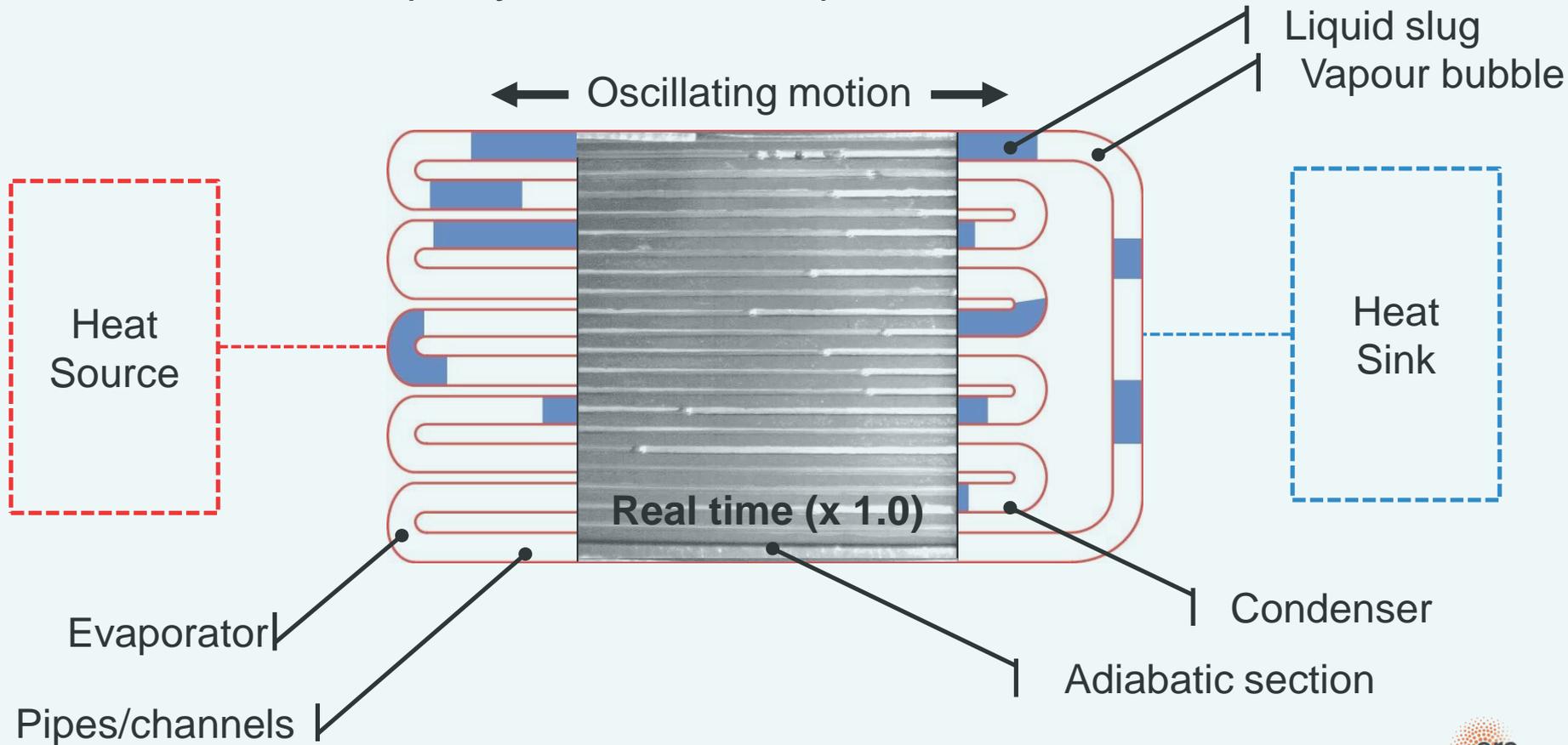
Established by the European Commission

- Extend battery life.
- Improve energy efficiency.
- Reduce thermal pollution.
- Reduce fan noise.

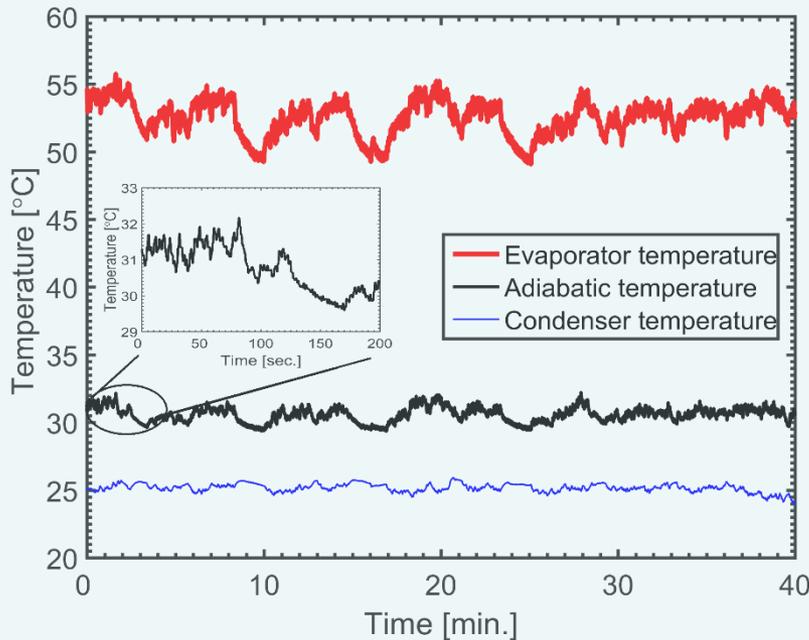


Definition: A **heat exchanger** is a piece of equipment built for efficient heat transfer from one medium to another.

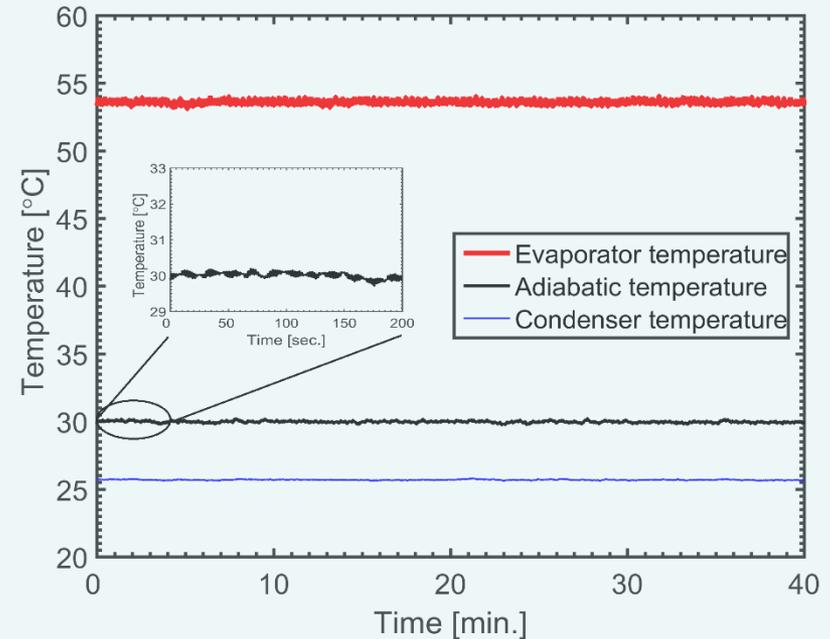
*“Two phase instability due to the **surface tension**,
the capillary effect and a temperature differences”*



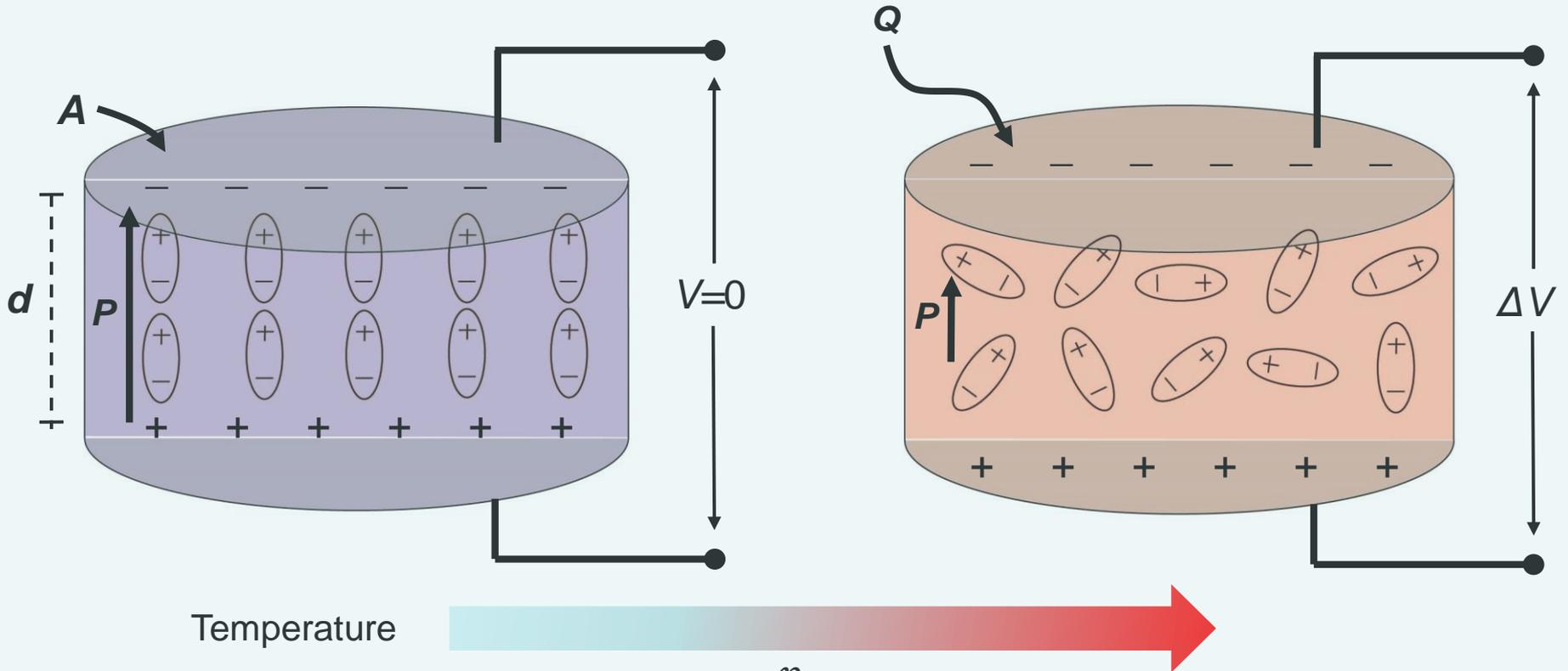
Chaotic mode with **random** temperature oscillation



Steady state mode with **harmonic** temperature oscillation



Under **constant thermal boundary condition** the OHP exhibits **rapid- and high-temperature oscillation**.



$$\Delta V = \frac{p}{\epsilon} d \cdot \Delta T$$

$$I = p \cdot A \frac{\Delta T}{\Delta t}$$

- Flexible, light and **cheap materials**.
- **Scalable in size, temperature range** and supply voltage.



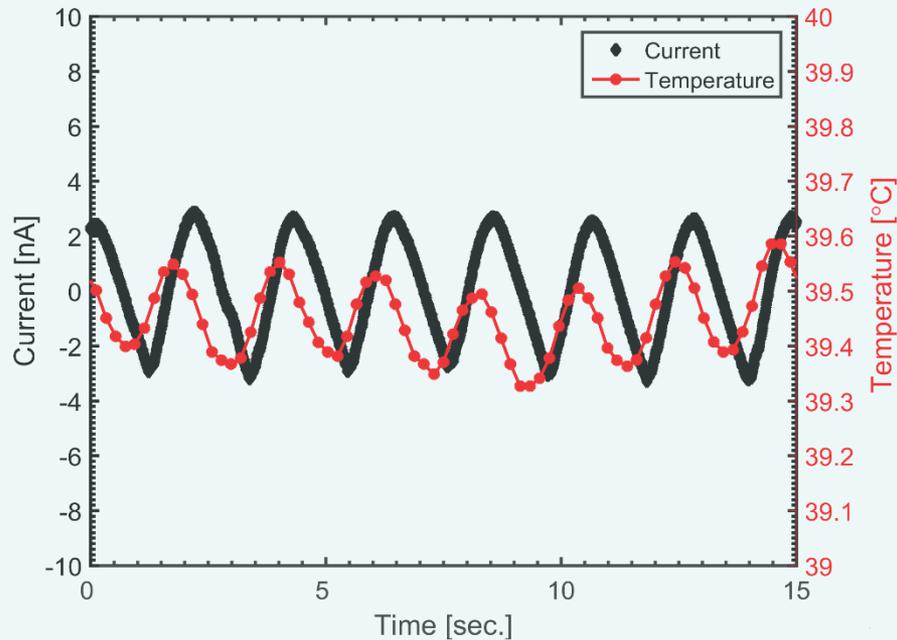
Change in thermo-fluid properties between **liquid** and **vapour phase**.

Pyroelectric element:

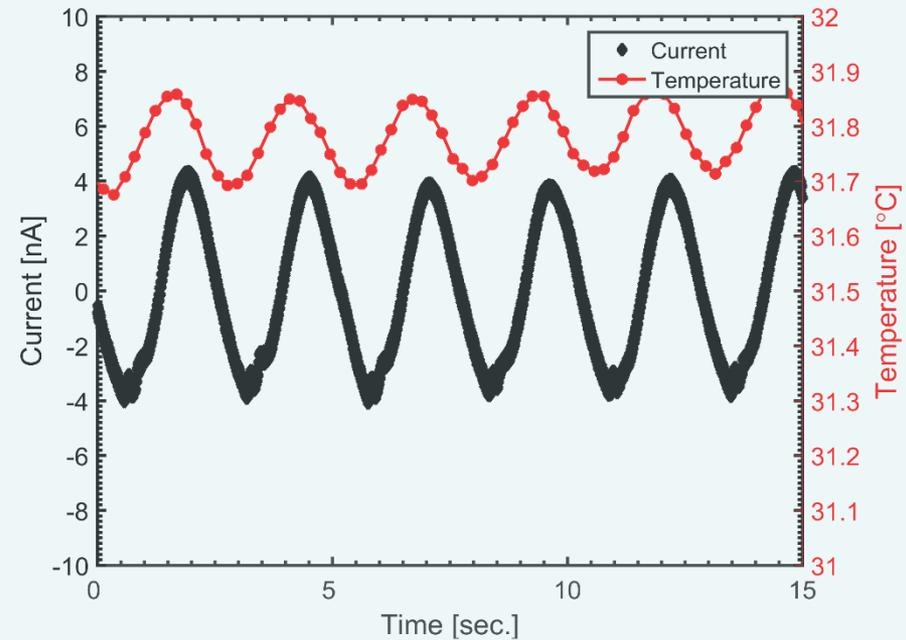


Proof of **concept**.

PZT current

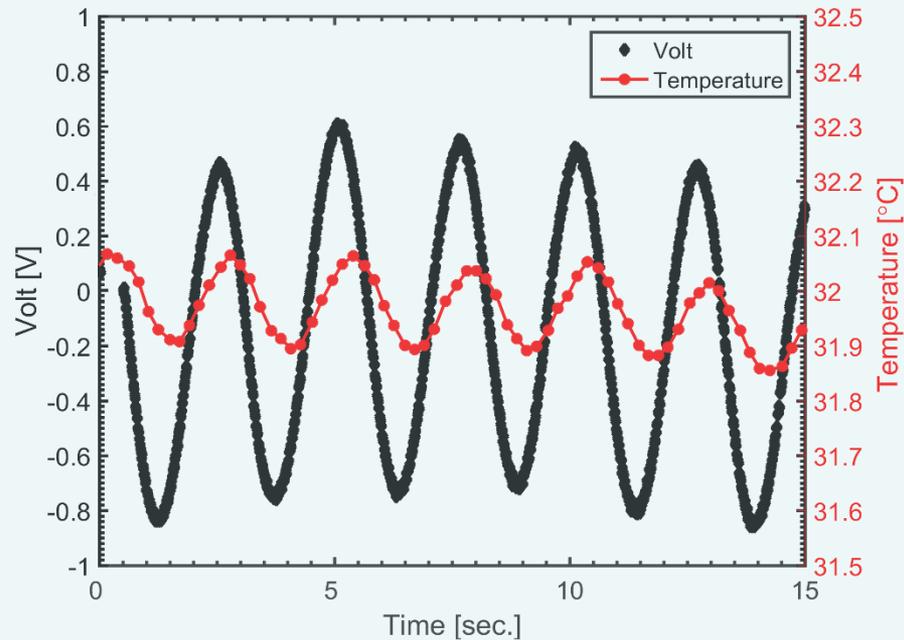


PMN-PT current

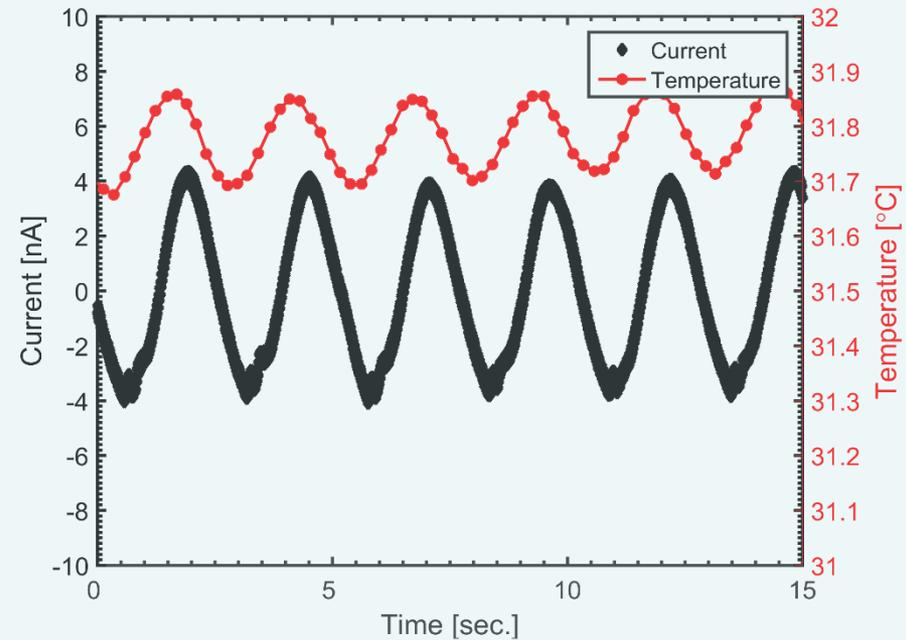


Due to better pyroelectric and heat transfer coefficients, **PMN-PT outperforms standard PZT** pyroelectric material with POHP.

PMN-PT voltage

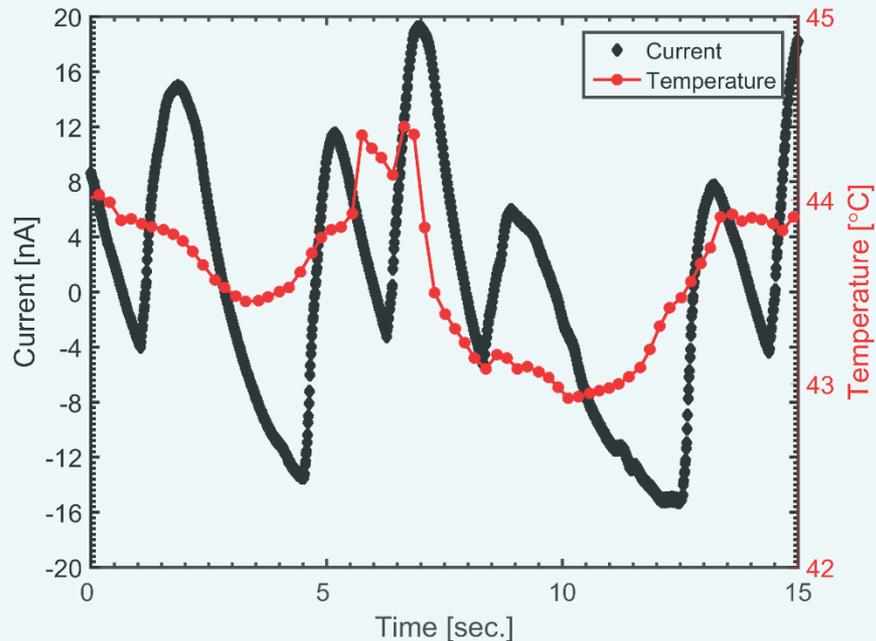


PMN-PT current



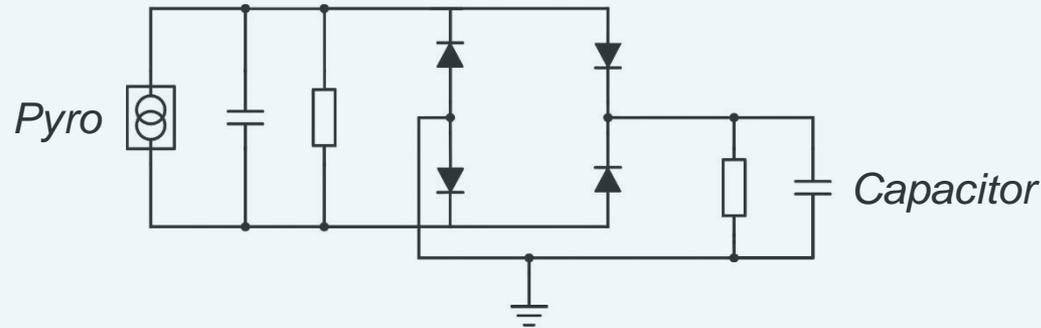
Steady state operation of POHP induces harmonic pyroelectric voltage and current at 0.45 Hz.

PMN-PT current

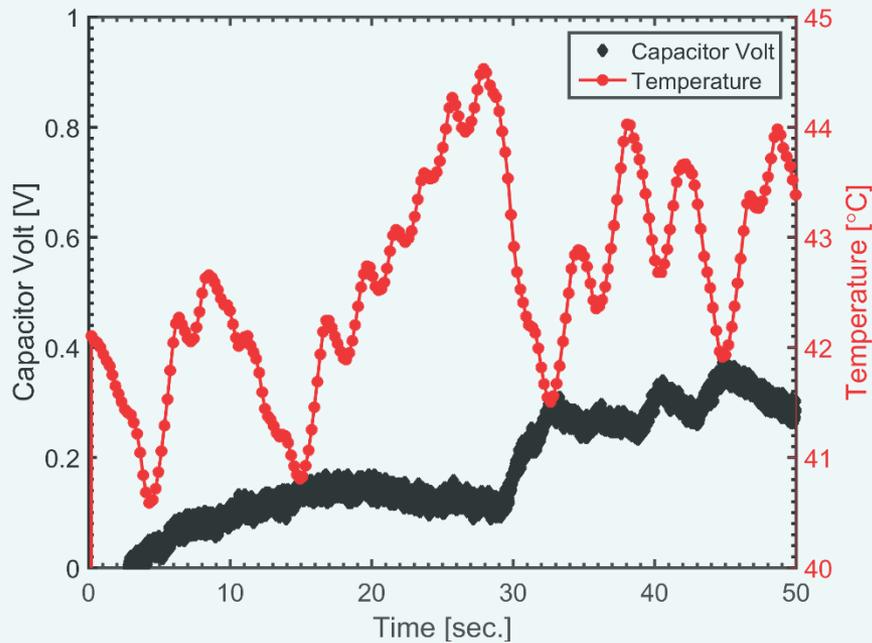


- **Large** changes in temperature.
- **Fast** changes in temperature.
- **High** pyroelectric current.

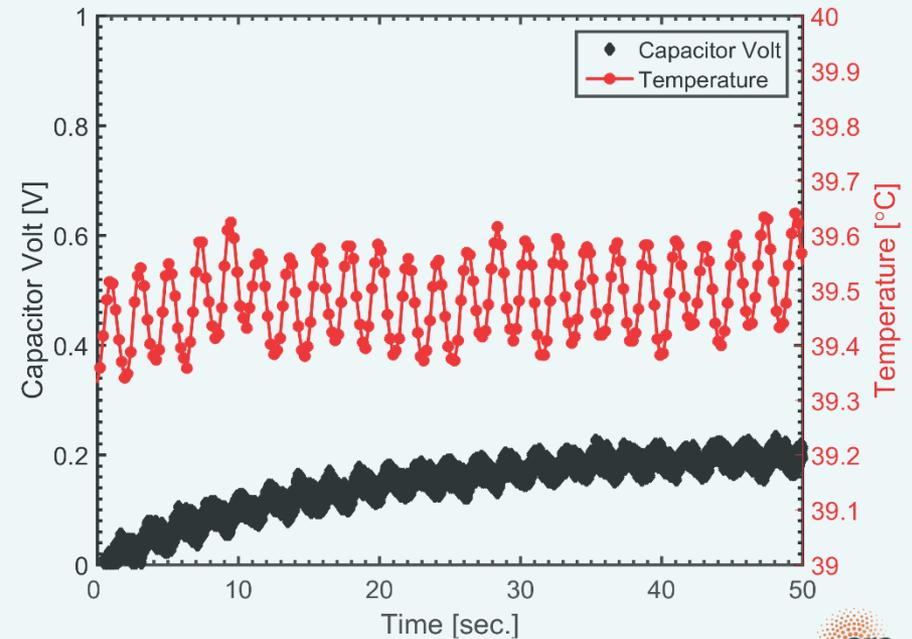
**Chaotic operation of POHP induces
random pyroelectric current.**



Rectified chaotic current



Rectified steady state current



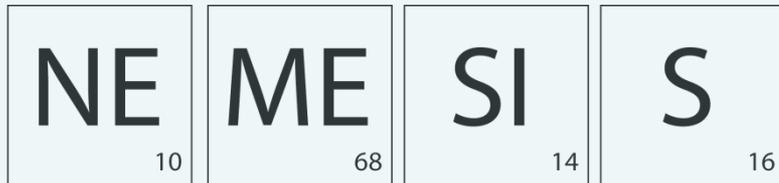
More energy recovered in chaotic operation than in steady state operation.

- First pyroelectric generator driven by **natural and self induced** temperature oscillator.
- **No mechanical motion.**
- Novel thermal generator utilising **low temperature heat.**
- Scalable in size, **temperature range** and supply voltage.
- Standalone low or ultra-low **electric power supply.**
- **Device $\eta = ?$** (input is zero since heat is free).
- Eg. could improve battery **life by 1 - 4 %.**

Acknowledgements



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Novel Energy Materials: Engineering Science and Integrated Systems



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