HYBRID THERMAL ENERGY HARVESTING MECHANISM

Miwon Kang and Eric M. Yeatman

Department of Electrical and Electronic Engineering, Imperial College London, Exhibition Road, London, SW7 2AZ, UK

Email: k.miwon14@imperial.ac.uk

INTRODUCTION

This study demonstrates a hybrid thermal energy harvesting mechanism for use adjacent to a heat source with small temperature variation at low frequency (below 1 Hz).

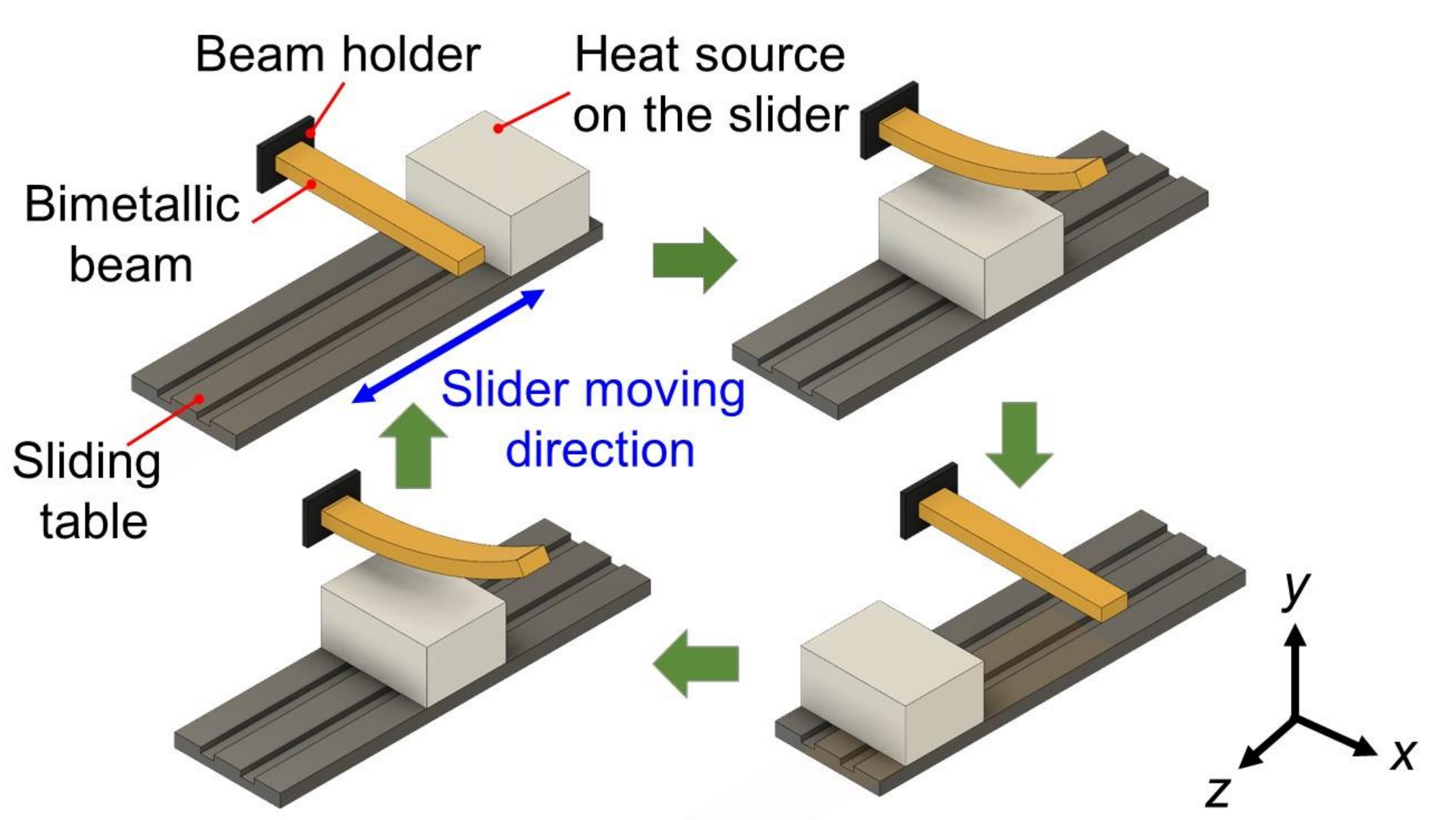
OBJECTIVES

Investigate the coupling effect between the piezo- and pyro-electric effects to improve output power

MECHANISM

Lead Zirconate Titanate (PZT-5H) is attached to bimetallic (Fe-Ni and Fe-Ni-Cr) beam. A 95℃ heat source is mounted on a slider for a repetitive temperature variation over time. The beam was tested in both fixed-free and fixed-fixed configurations.

FIGURE 1 Schematic of the heat cycle



EXPERIMENTAL SET-UP

FIGURE 2 Experimental set-up in fixed-fixed

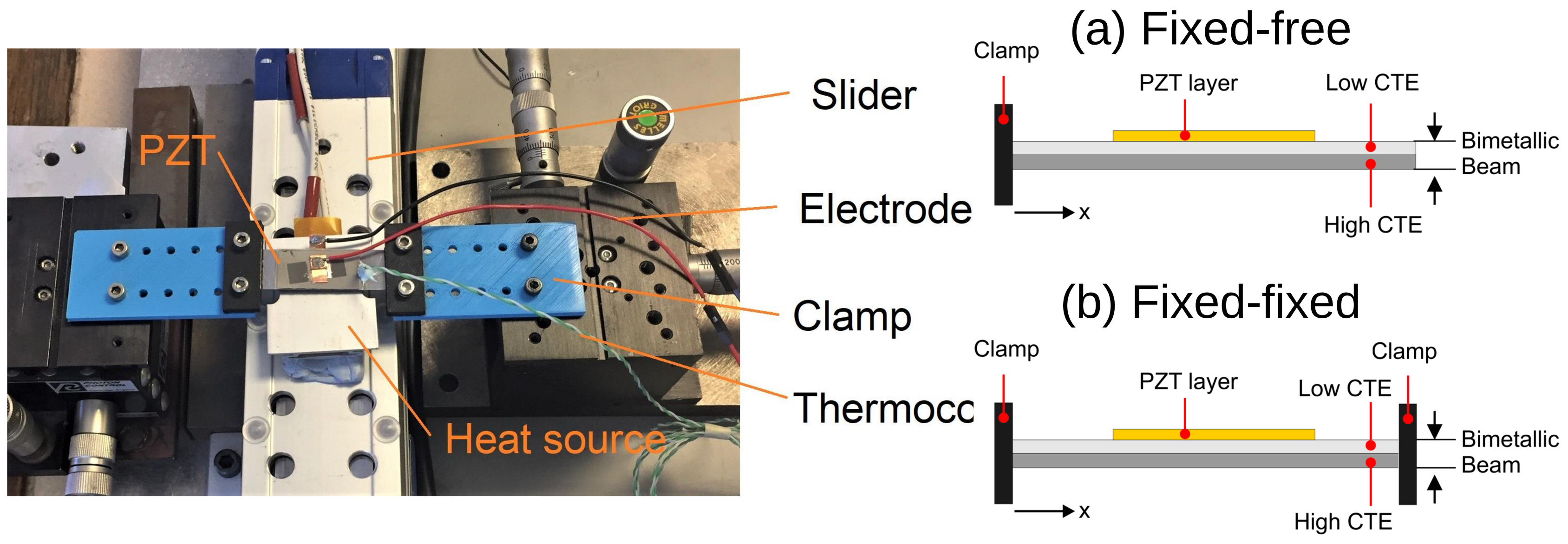
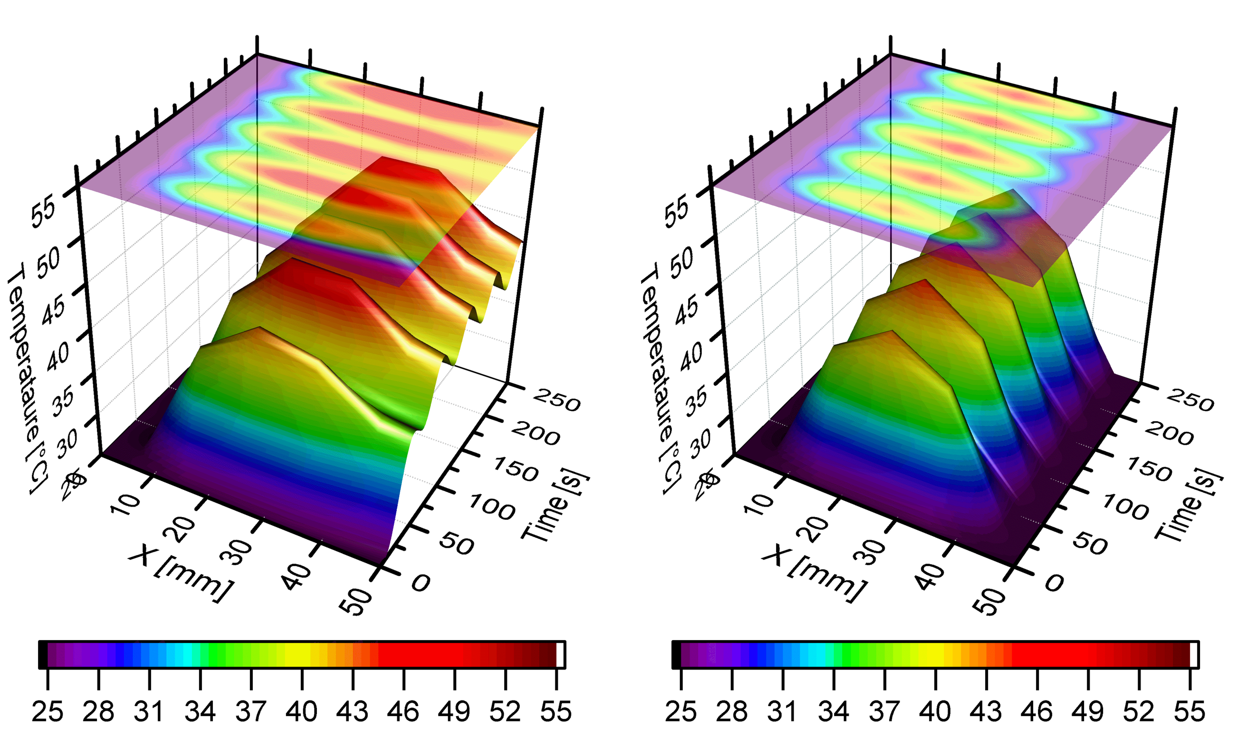


TABLE 1 Dimensions of prototypes [mm]

	Dimensions	Description
Prototype 1	70 x 10 x 0.6	
Prototype 2	70 x 10 x 0.3	Increase dT
Prototype 3	50 x14 x 0.3	Increase thermal load

➢ The PZT layer is half of the bimetallic beam area.

FIGURE 3 Prototype3 heat distribution at 0.02 Hz by COMSOL.

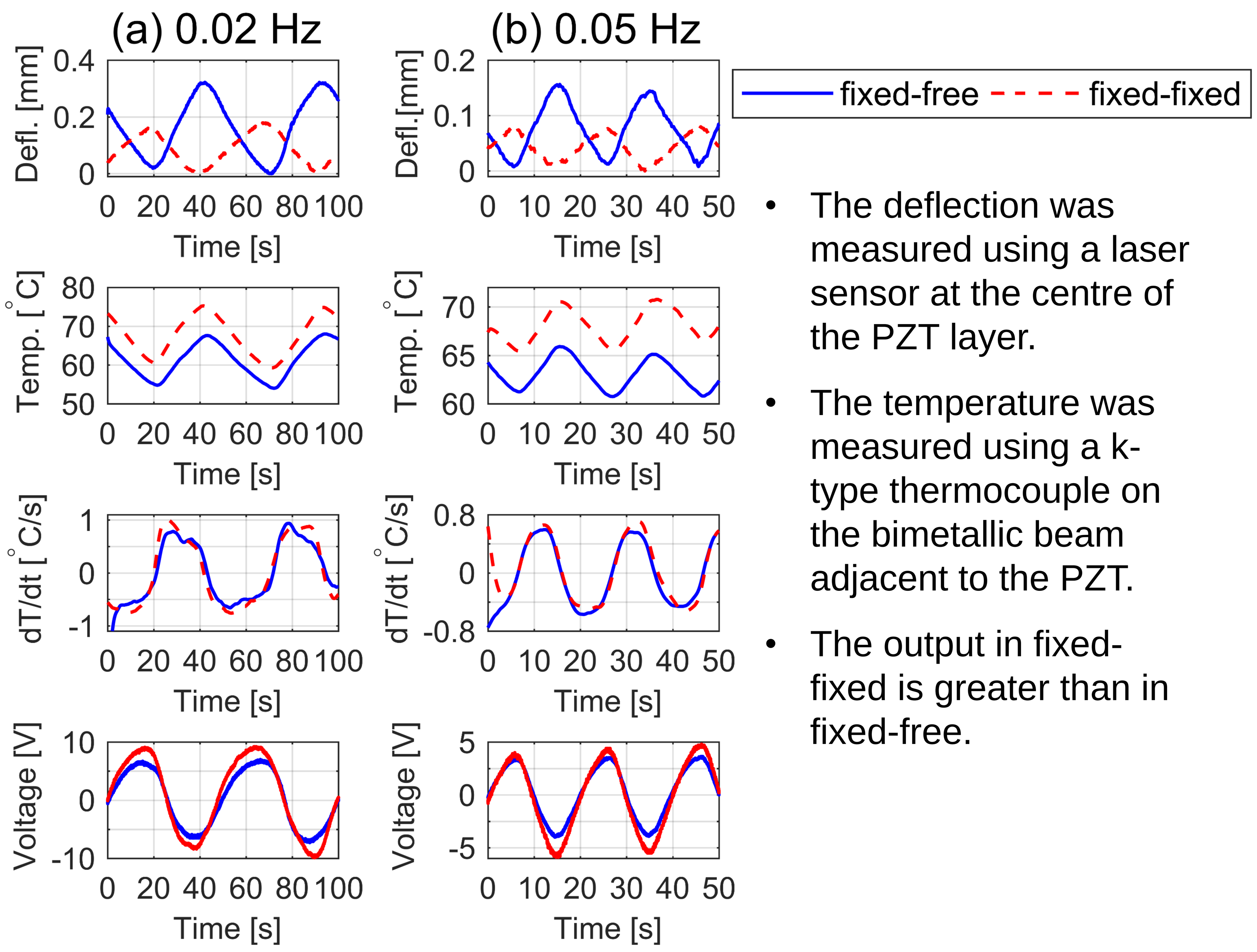


(a) Fixed-free (b) Fixed-fixed

This simulation shows the heat distribution along the length (*x-axis*) of the beam for 250 seconds.

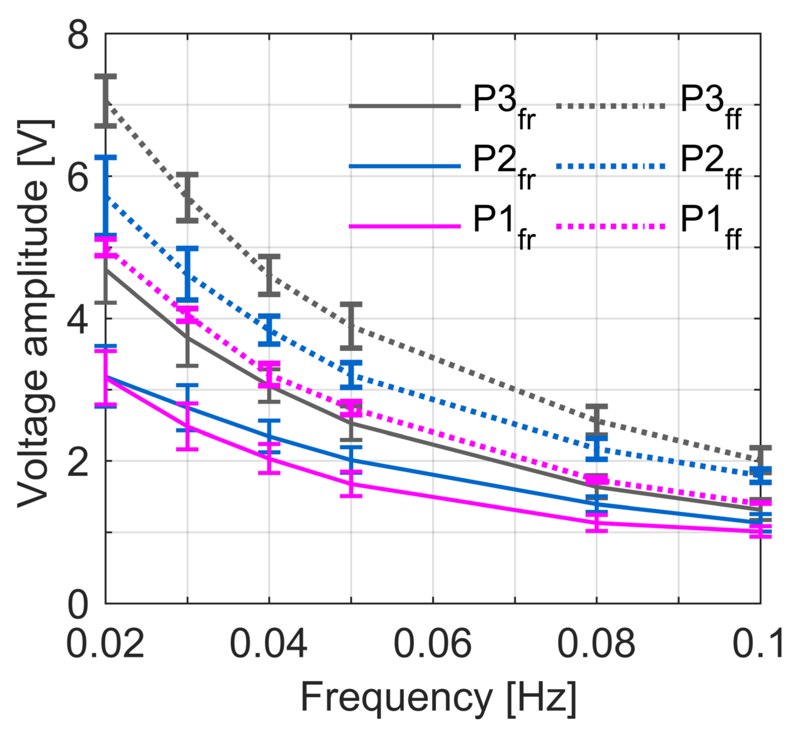
EXPERIMENTAL RESULTS

FIGURE 4 Experimental results of prototype 3



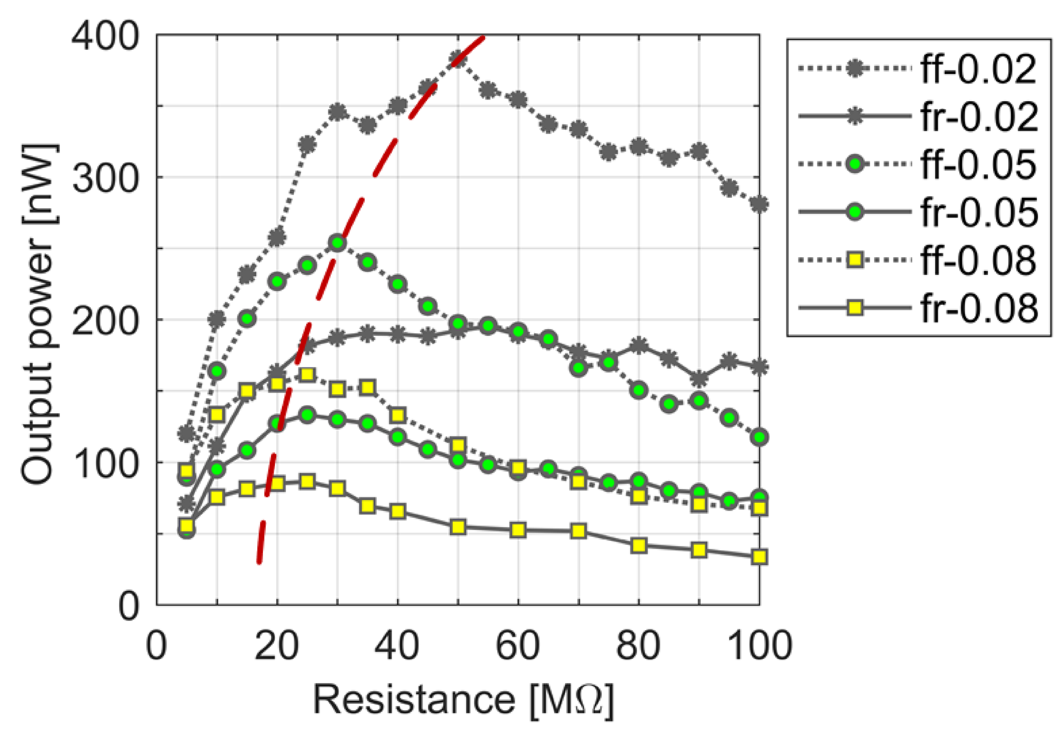
- The deflection was measured using a laser sensor at the centre of the PZT layer.
- The temperature was measured using a k-type thermocouple on the bimetallic beam adjacent to the PZT.
- The output in fixed-fixed is greater than in fixed-free.

FIGURE 5 Output voltage



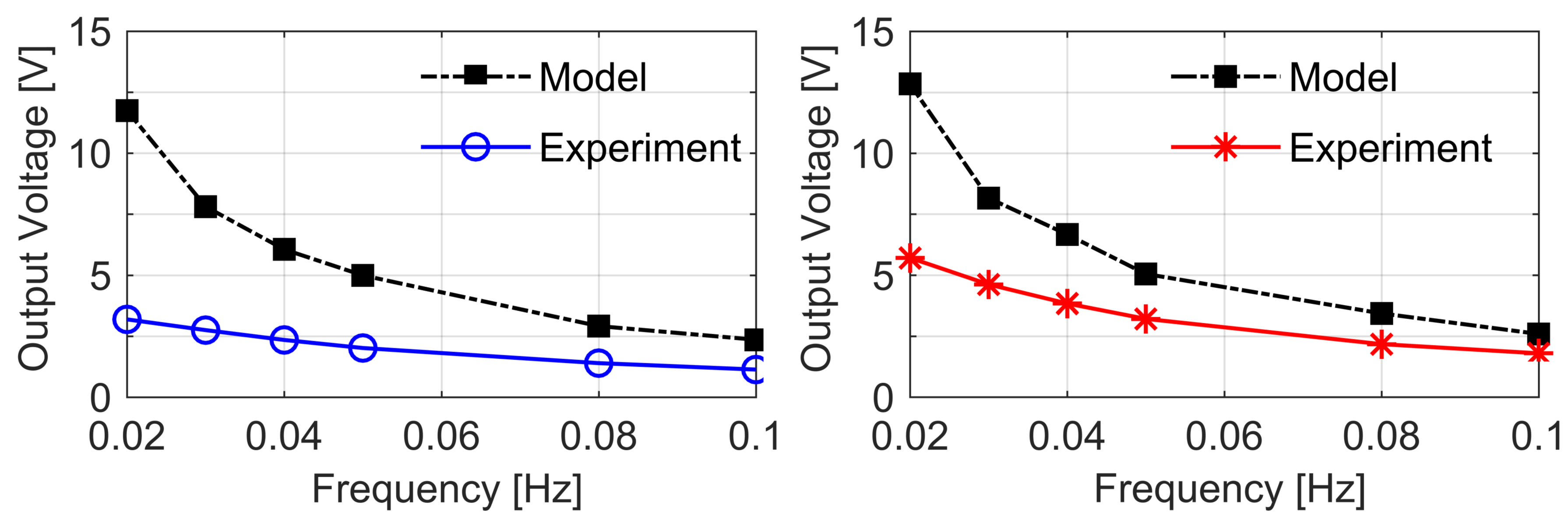
P3 in the fixed-fixed configuration shows the best performance.

FIGURE 6 Output power (prototype3)



As the frequency decreases, the internal impedance of PZT increases

FIGURE 7 Comparison of P3 between experiments and modelling



(a) Fixed-free (b) Fixed-fixed

At low frequencies, the gap increases due to the discharge during the heat cycle and the increase in internal impedance.

CONCLUSIONS

➢ Thermal energy harvesting mechanism is presented and analysed in a simple structure.

➢ The output voltage is about 40% higher in the fixed-fixed than in fixed-free. The thermal load is increased by changing the dimensions of the beam.

FUTURE WORK

Multiple beams will be aligned on a metal sheet with a rectifier.