

Multi-frequency sound energy harvesting using Helmholtz resonators with irradiated cross-linked polypropylene ferroelectret films

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Introduction

It is quite meaningful to reduce the noise in the environment and convert it into electrical energy for some electronic devices [1]. Xue *et al* have attached the irradiation cross-linked polypropylene (IXPP) ferroelectret films to the inner walls of a single Helmholtz resonator (HR) to harvest sound energy at its resonance frequency of 900 Hz [2]. In this work, HRs array, consisting of 9 HRs with different sizes, having a multi-resonance frequency, was developed. Improved output power was achieved by connecting several arrays in series. This work presents a useful way to enhance the output power of the acoustic energy harvesters.

Experimental and simulated details

Fabrication process of HRs with IXPP ferroelectret films

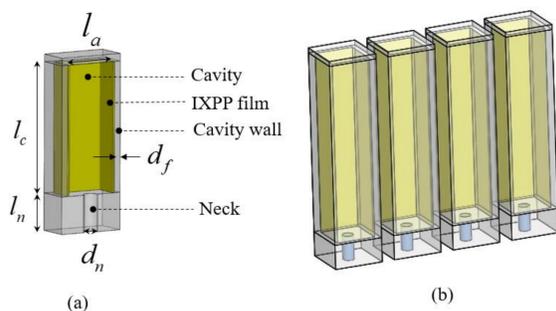


Fig.1 (a) Cross-section view of a HR with IXPP film attached to the inner walls of cavity. (b) Conceptual view of the four samples of the same size HR.

- Attach the IXPP films to one side of the PMMA panels by the conductive adhesive tapes (Fig. 1a).
- Bond PMMA panels together by epoxy adhesive to get the HRs with IXPP films (Fig. 1b).

Measurement of output power

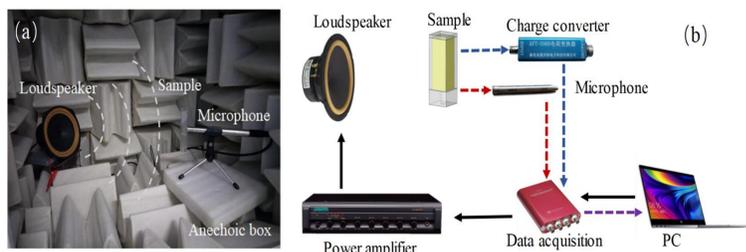


Fig.2 (a) Experimental diagram of measuring the sound pressure inside a HR in the Anechoic chamber, and (b) its scheme whereby both the sound pressure of the HR cavity (route 1) and the electric charge of the IXPP film (route 2) are recorded.

- The charge generated Q_r by HRs attached with IXPP ferroelectret films in short-circuit was measured, and the optimized output power P_{opt} are obtained by using a match load resistance R_l .

$$P_{opt} = R_l \omega^2 Q_r^2$$

where ω is the angle frequency.

Results and discussion

Energy harvesting with a single HR

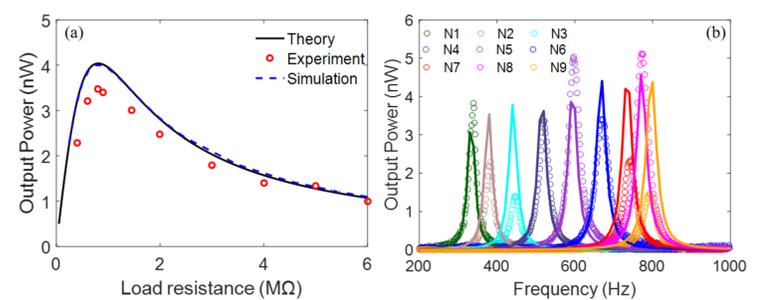


Fig.3 (a) Measured (circle), simulated (solid line) and theoretical (dotted line) results of output power of the HR acoustic energy harvester (sample N4) versus the load resistance at 522 Hz. (b) The experimental results of the output power for HR acoustic energy harvesters N1~N9 upon an input SPL of 100 dB (2 Pa).

- Fig.3(a) shows the relationship between load resistance and output power of the HR acoustic energy harvester (N4). The experimental data, theoretical prediction, and simulation results of are in agreement.
- Fig. 3(b) presents the measured (circle) and simulated (solid line) results of output power of IXPP films for each individual HR. (Fig.3b)

Energy harvesting with HRs in electrical series

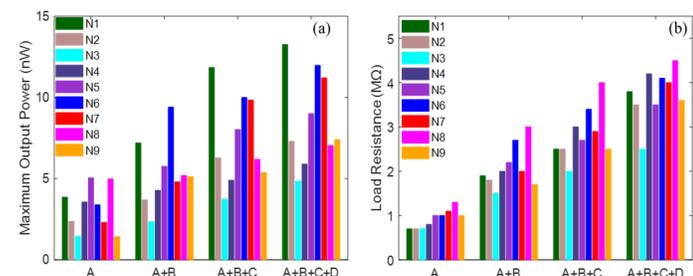


Fig. 4 (a) The maximum output power of four different series modes, marked as A, A+B, A+B+C, A+B+C+D, respectively, here, the mark of + is the meaning of series. (b) The corresponding optimal load resistances of four different series modes.

- When increasing the series number of acoustic energy harvesters, both the maximum output power and the match load resistance increases almost linearly.
- Connecting HRs with various resonance frequencies in electrical series is a useful way to improve the performance of acoustic energy harvesters.

Conclusions

The output power of the acoustic energy harvester can be improved by connection multi HRs in electrical series. The measured average output powers are 5.31, 7.36, 8.66 nW at resonant frequencies, respectively, for the devices with two, three and four HRs. The match load resistance increases in a quasi-linear way with increasing the number of HRs.

Acknowledgments

The authors gratefully acknowledge financial support from the Natural Science Foundation of China (NSFC, 11872282, 61761136004, 11772231, 5202780089).

References

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