Enhancement of piezoelectric MEMS vibration energy harvester for impulsive force using 2-degree-of-freedom system.

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[Introduction] Vibration energy harvesting is attracting much attention to support the demand for self-powered devices. For practical applications of the harvesters, it is important to effectively harvest energy from environmental vibration, which has low frequency and irregularity. Piezoelectric MEMS vibration energy harvester (MEMS-PVEH) is one of the promising solutions because of the simple device structure and high output power density. In our previous work, an impulsive force was utilized as the input vibration; the PVEH under impulsive force shows a weak dependence of the output power on the resonance frequency and high energy conversion efficiency.[1] In this work, the electromechanical properties of PVEHs with two-degree-of-freedom (2DOF) system, which has been reported to increase output power as the two resonance frequency of the vibration system getting close together,[2] were investigated under impulsive force by theoretical calculation and experiment.

[Results] The 2DOF pVEH consisted of a dynamic magnifier (DM) and PVEH, as shown in Fig.1. The U-shape DM was made of a stainless sheet plate. The cantilever type PVEHs using 450-nm-thick $BiFeO_3$ film was fabricated by the conventional MEMS process. The results of vibration mode analysis using the finite element method were also shown in Fig. 1. The PVEH has a resonance frequency of 153Hz, a mechanical Q factor of 766, and an electromechanical coupling factor of 0.1%. The DM has a resonance frequency of 158Hz close to the PVEH, and a mechanical Q factor of 405. Figure 2 shows the input impulsive force and responded output voltage waveform of 1DOF and 2DOF PVEH. In 2DOF PVEH, after applying impulsive force, the voltage slowly rises and then lowers periodically, which indicates the energy transferring process between the DM and the pVEH. The output voltage is enhanced about 5 times. The output energy was calculated by taking the integral of the output power during 2s, and it is found that the maximum enhanced output energy is 50 times. Further analysis and experiment results will be presented.

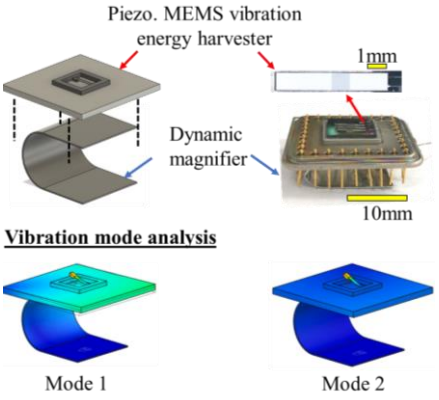

Fig.1: 2DOF-PVEH with U-shape DM.

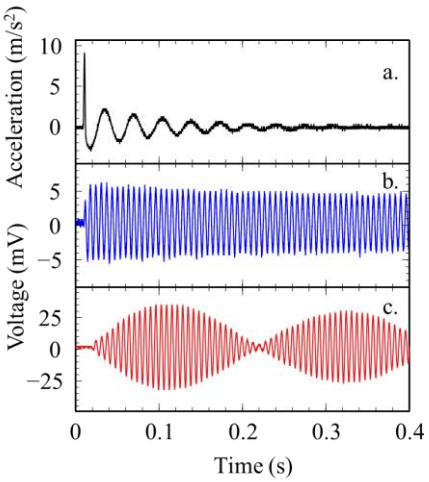

Fig.2: Waveforms of (a). impulsive force responded output voltage of (b). conventional 1DOF and (c). 2DOF PVEH.

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[References]

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