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PZT 캔틸레버의 길이와 면적에 따른 에너지 하베스팅 장치의 출력 특성

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Micro Power Properties of Harvesting Devices as a Function of PZT cantilever length and gross area

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Abstract - With recent advanced in portable electric devices, wireless sensor, MEMS and bio-Mechanics device, the new typed power supply, not conventional battery but self-powered energy source is needed. Particularly, the system that harvests from their environments are interests for use in self powered devices. For very low powered devices, environmental energy may be enough to use power source. Therefore, in other to made piezoelectric energy harvesting device, PMN-PZT thick film was formed by the screen printing method on the Ag/Pd coated alumina substrate. The layer was 8 layers and slurry where a-terpineol, ethylcellulose, ferro B-75001 as Vehicle, PMN-PZT powder used are fabricated by ball mill. The output power quality was be also investigated by changing the load resistance, weight and frequency. The made piezoelectric energy harvesting device was resulted from the conditions of 33kΩ, 0.25g, 197Hz respectively. The thick film was prepared at the condition of 2.75Vrms, and its power was 230㎼ and its thickness was 56㎛. The piezoelectric energy harvesting device output voltage was increased, when the load weight, load resistance was increasing and resonance frequency was diminishing. The other side, resonance frequency was diminished, when the weight was increasing. And output power was continuously it changed by load resistance, output voltage, weight and resonance frequency.

1. Introduction

In the last decade great affords have been made in the performance enhancement and miniaturization of electronics. Beside mobile phones, PDAs and MP3-players, an increasing number of smart systems are patched to our environment to improve comfort and security.[1-2] However, all of them rely on electric energy usually supported by batteries. Vibration energy can be converted into electrical energy through piezoelectric, electromagnetic and capacitive transducers. Among them, piezoelectric vibration-to-electricity converters have received much attention, as they have high electro-mechanical coupling and no external voltage source requirement, and they are particularly attractive for use in MEMS [3-4]. As a result, the use of piezoelectric materials for scavenging energy from ambient vibration sources has recently seen a dramatic rise for power harvesting The present work aims at a concept of low cost energy harvesting devices to push them forward to industrial grade. The Energy and power sources comparison is shown in Table. 1.

In this study, we propose electric properties of piezoelectric cantilever by changing substrate length. We have focused on the development of piezoelectric generators to convert mechanical power to electrical power from vibrations in dynamic environment.

2. Results and discussion

2.1 Experimental

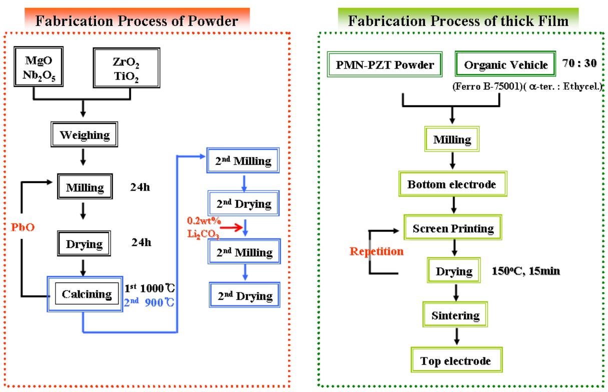
Industrial grade raw powders of PbO(99%), ZrO_2(99%), TiO_2(99%), Nb_2O_5(99.5%), MgO(99%) were used as the raw materials to prepare the powders and ceramics with the composition of $0.2Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.8Pb(Zr_{0.475}Ti_{0.525})$ (respectively abbreviated as PMN-PZT) and these specimens added 0.2wt% Li_2CO_3 by conventional method. The made-up piezoelectric cantilever was shown in Fig. 2 and experiment setup is shown in Fig. 3. A mechanical shaker obtained from Bruel and Kjaer Instruments (Model Type 4810) was used for

<Table. 1> Energy and power sources comparison

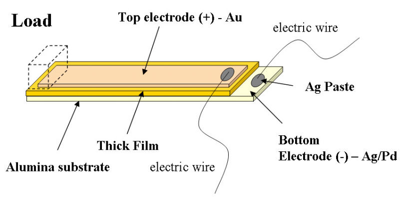
Power source	Power (μW)/cm3	Energy (Joules)/cm3	Power (μW)/cm3/yr	storage needed	Voltage regulation	Commercially available
Primary battery	N/A	2880	90	No	No	Yes
Secondary battery	N/A	1080	34	N/A	N/A	Yes
Micro fuel cell	N/A	3500	110	Maybe	Maybe	No
Ultra capacitor	N/A	50-100	1.6-3.2	No	Yes	Yes
Heat engine	1X1.06	3346	106	Yes	Yes	No
Radioactive(63Ni)	0.52	1640	0.52	Yes	Yes	No
Solar(outside)	15000 *	N/A	N/A	Usually	Maybe	Yes
Solar(inside)	10 *	N/A	N/A	Usually	Maybe	Yes
Temperature	40 *†	N/A	N/A	Usually	Maybe	Soon
Human power	330	N/A	N/A	Yes	Yes	No
Air flow	380 ††	N/A	N/A	Yes	Yes	No
Pressure variation	17 †††	N/A	N/A	Yes	Yes	No
Vibrations	200	N/A	N/A	Yes	Yes	No

* Measured in power per square centimeter, rather than power per cubic centimeter.
† Demonstrated from a 5℃temperature differential.
†† Assumes an air velocity of 5m/s and 5 percent conversion efficiency.
††† Based on 1cm3 closed volume of helium undergoing a 10℃change once a day.

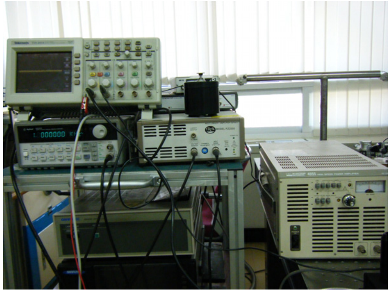
measuring the response of the piezoelectric cantilever under dynamic conditions. This shaker can apply a maximum of 10N force in a wide frequency range of DC to 10kHz. The shaker was driven at various voltages and frequencies by using the function generator (Agilent 33120A) and a high power amplifier (NF 4055) to produce a cyclic force of required magnitude and frequency. The output voltage from the piezoelectric cantilever is monitored on a Tektronix digital oscilloscope (TDS 2014). In order to avoid any interference from the noise in the surrounding environment, all the experiment were performed on an isolated bench.



<Fig. 1> Experimental procedure



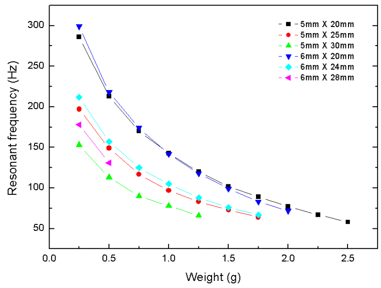
<Fig. 2> Schematics of piezoelectric cantilever



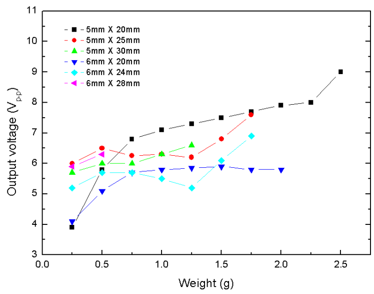
<Fig. 3> Experimental setup with the piezoelectric thick film cantilever and oscilloscope

2.2 Energy harvesting properties of piezoelectric cantilever

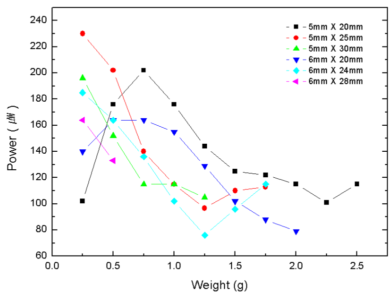
Fig. 4 shows the piezoelectric cantilever properties with the variations of substrate length and weight in resonance frequency and Fig. 4(a) shows the output power with the variations of load weight. It was continuously it changed by weight and substrate length. The maximum power is 230μW at 0.25g weight and 5mm X 25mm length. Fig. 4(b) shows the resonance frequency with the variations of weight. The resonance frequency was decreased without regard to substrate length, when the weight was increasing. Fig. 4(c) shows the output voltage with the variations of weight. The output voltage was increased without regard to substrate length uniformly, when the load weight was increasing.



(a)



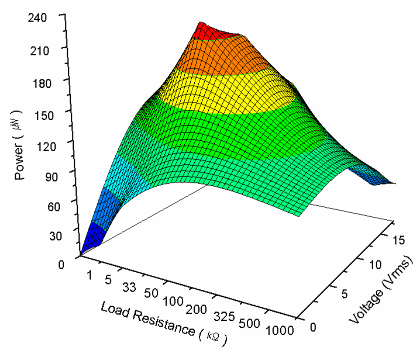
(b)



(c)

(a) Output power with the variations of substrate length and weight
(b) Resonance frequency with the variations of substrate length and weight
(c) Output voltage with the variations of substrate length and weight

<Fig. 4> Piezoelectric cantilever properties with the variations of substrate length and weight



Substrate length of 5mm*25mm, 197Hz

<Fig. 5> Variation of the substrate length, output power and voltage as a function of load resistance in maximum output power boundary

Fig. 5 shows the maximum output power in 5mm*25mm substrate length. The piezoelectric cantilever properties with the variations of load resistance and weight in resonance frequency. It was 33kΩ load resistance and 0.25g weight at 197Hz

To improve the properties of the achieved prototype generator such as upgrading power, boosting voltage and tuning itself to variable vibration frequency, suitable PZT film length to enhance the conversion of vibration strain to electricity, attempting variable cantilevers design to realize cantilevers complementary potency. It can also be anticipated that the required generator for different vibration environments and a high-powered one can be obtained by cantilever length and changing the load weight. The experimental results show that the method is promising in ambient vibration energy harvesting. It is indicated that a potential in the development of the power generator meets applications in wireless/embedded sensor networks.

3. Conclusions

Piezoelectric cantilever on economical screen-printed PMN-PZT films can be useful to convert vibration energy into electrical current through piezoelectric effect to supply low-power systems. Technological parameters as load mass, load resistance, frequency a significant role on increasing the performance.

- The made piezoelectric cantilever was ideal condition, when the 5mm X 25mm, 33kΩ, 0.25g, 197Hz respectively
- The thick film was prepared at the condition of 2.75Vrms, and its power was 230μW and its thickness was 56μm.
- The piezoelectric energy harvesting device output voltage was increased, when the load weight, load resistance was increasing and resonance frequency was decreasing and resonance frequency was decreased, when the load weight was increasing.
- The output power was continuously it changed by load resistance, output voltage, load weight and resonance frequency.

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