ON-CHIP ELECTRIC POWER GENERATION SYSTEM FROM SOUND OF PORTABLE MUSIC PLYERS AND SMARTPHONES TOWERD PORTABLE μTAS

Toyohiro Naito[1,2], Noritada Kaji[1,2], Séverine Le Gac[3], Manabu Tokeshi[4], Albert van den Berg[3] and Yoshinobu Baba[1,2,5]

[1]Department of Applied Chemistry, Nagoya Univestiy, Japan,
[2]FIRST Research Center for Innovative Nanobiodevices, Nagoya Univestiy, Japan,
[3]BIOS, Lab on a Chip Group, MESA+ Institute for Nanotechnology, University of Twente, the Netherlands,
[4]Division of Biotechnology and Macromolecular Chemistry, Hokkaido Univestiy, Japan and
[5]Health Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Japan

ABSTRACT

This paper demonstrates electric generation from sound to minimize and integrate microfluidic systems for point of care testing or in-situ analysis. In this work, 5.4 volts and 50 mW DC was generated from sound through an earphone cable, which is a versatile system and able to actuate small size and low power consumption devices like an electro osmotic pump.

KEYWORDS

Electric generation, Integrated microfluidic systems, Portable μTAS

INTRODUCTION

Although microfluidic devices have great potential, most of them are used in the lab since they require large peripheral devices such as pumps, microscopes, voltage control and so on. In the past five years various micropumps and components have been designed, and fabricated for lab-on-a-chip applications, [1,2] however, there is little research about improving electric sources. Compact electric sources, voltage controls and electric-generating systems are important techniques for portable "lab-on-a-chip (LOC)" devices under development. Functions required for these techniques are compactness and general versatility.

We have considered earphone cables and earphone jacks are perfect tools for meeting the requirements and sound can be used as a power source.

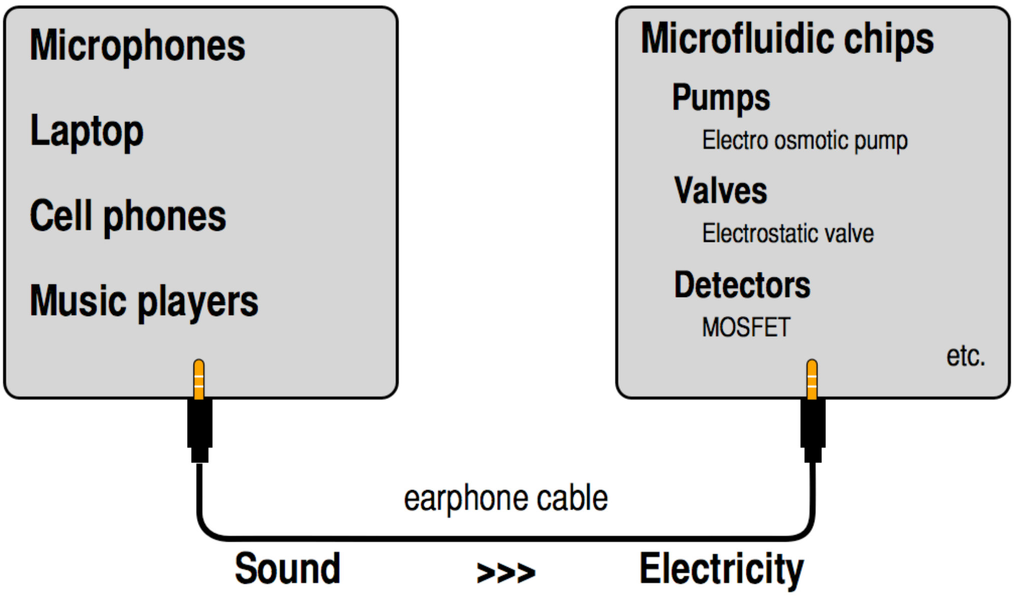

Figure 1. A concept of generating electricity system from sound. Sound can be used as power source and earphone plugs are general versatility tools for recent mobile devices. Low power consumption components that are used to LOC devices (e.g. pumps, valves, detectors) can be actuated and controlled by generated electricity from sound through earphone cables.

EXPERIMENT

Generated electricity was evaluated using output voltage from sound data on a laptop or a music player (iPod touch). The laptop or the music player was connected to a digital multimeter with an earphone cable and output sound data created by sound frequency generator software. There were sound data in 3 different waveforms, 15 different frequencies and 9 deferent software volume (0, -3, -6, -10, -15, -16, -18, -20 and -30 dB). We investigated relationships of an output voltage with waveforms, frequencies, hardware volume and software volume.

Finally, we tried to actuate a light emitting diode (LED) by the electric power generation system. Two deferent forward voltage LEDs, a red (1.8 V) and a green (2.4 V) LEDs, were used to confirm activation ability of the system.

RESULTS AND DISCUSSION

Figure 2 shows a waveform dependence of an output voltage. Square waves generated the highest voltage of 4 different waveforms (square, sine and triangle), however they reduced generating efficiency with the increasing frequency. That is because the output voltage is expressed by line integral along the waveform diagrams. The ratios of output voltages of square and sine curve, or square and triangle at the same frequency were 1.58 (square/sine) and 2.01 (square/triangle). These values are coincided with ratios of line integral along the waveform diagrams are 1.57 (square/sine) and 2.00 (square/triangle). In addition, reduction of generating efficiency with the increasing frequency is caused by greater switching loss of square waves than the other waveforms.

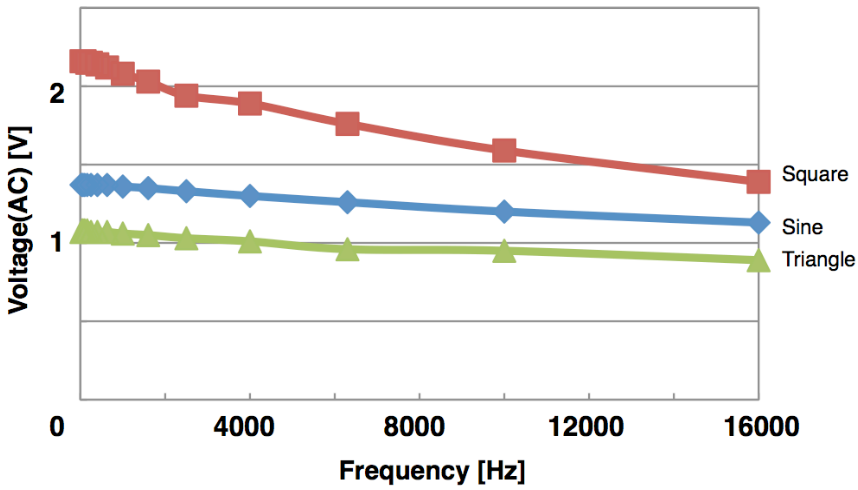

Figure 2. A waveform dependence of an output voltage. A red, a blue and a green lines indicate a output voltage from square, sine curve and triangle waveform respectively.

The output voltage was exponential depends on sound volume as shown in Figure 3a and b. The bel represents a ratio between two power quantities of 10:1, and we can control the output voltage with changing sound volume predictably

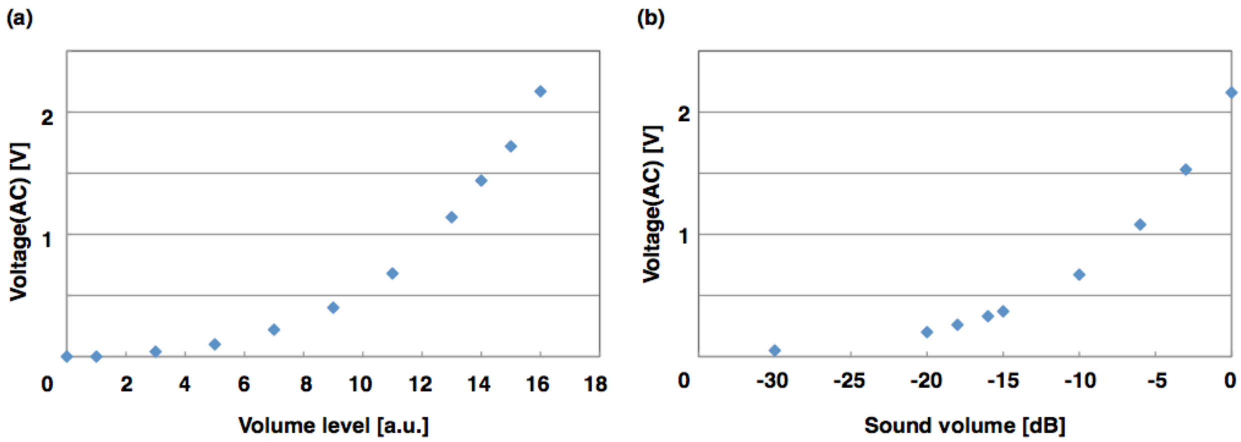

Figure 3. A hardware volume dependence of an output voltage (a) and a software volume dependence of an output voltage (b) at 63Hz.

Figure 4 shows an activation of a green LED with the system and a DC-TO-DC boost converter. The system activated a red LED without any circuits, and a green LED could be activated by the system with the DC-TO-DC boost converter that is 6×10×12 mm^3 in size. The output voltages were boosted to 5.4 V with 51 mW from sound on a laptop and 3.7 V with 19 mW from sound on an iPod touch, which is amply sufficient to actuate electro osmotic pumps. [3]

Furthermore, the system can be used as a programmable voltage control by changing the sound wave frequency. By using alternating waveforms derived from sound wave, the system can be used as an on-off controller for low power consumption components.

Figure 4. An activation of a green LED by our system with an DC-TO-DC boost converter.

CONCLUSIONS

Generating electricity from sound data achieved and it output 5 volts DC that is enough to actuate low power consumption micropumps. Portable music players will be electric sources and a device control because versatile phone plugs are used in our system.

The system can also generate electricity from living sound or natural sound, which has potential to be applied to in-situ analysis device like a water analysis device powered by the sound of a brook. In the future, LOC devices with low power consumption components (e.g. pumps, valves, detectors) will have earphone jacks and those components will be actuated and controlled by generated electricity from sound through earphone cables with microphones.

ACKNOWLEDGEMENTS

This research was partially supported by the Japan Society for the Promotion of Science (JSPS) through its "Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program)", Institutional Program for Young Research Overseas Visits, and Grants-Aid for JSPS Fellows.

REFERENCES

[1] P. Renaud, E. S. Hung, "Extending the travel range of analog-tuned electrostatic actuators," Journal of Microelectromechanical Systems, **8**, 497 (1999).

[2] M. B. Sinclair, M. A. Butler, A. J. Ricco, and S. D. Senturia, "Synthetic Spectra: a Tool for Correlation Spectroscopy," *Applied Optics*, **36**, 3342 (1997).

[3] M.B. Sinclair, M.A. Butler, S.H. Kravitz, W.J. Zubrzycki, and A.J. Ricco, "Synthetic Infrared Spectra," *Optics Letters*, **22**, 1036 (1997)

CONTACT

Toyohiro Naito (naito.toyohiro@f.mbox.nagoy-u.ac.jp)