

Low frequency properties of micro power generator using a gold electroplated coil and magnet

Seong-Il Kim ^{a,*}, Dong Ho Lee ^b, Yoon Pyo Lee ^a, Young Soo Chang ^a, Min-Chul Park ^a

^a *Semiconductor Materials and Devices Laboratory, Korea Institute of Science and Technology, P.O. Box 131, Cheongryang, Seoul 130-650, Republic of Korea*

^b *Department of Nano and Electronic Physics, Kookmin University, Seoul 136-702, Republic of Korea*

Received 5 December 2006; accepted 12 June 2007

Available online 21 July 2007

Abstract

Micro power generating devices were fabricated by using a gold electroplated coil and a permanent magnet. The electrical power was generated when the magnet reciprocated on the fabricated electroplated coil. The output power was increased as a function of vibration frequency. A measurement system, which convert a rotational motion of a motor into a linear motion, was designed and fabricated. The purpose of this work is to develop the micro power generating devices which convert the ambient vibration or oscillating energy into useful electrical energy. With changing vibration frequency from 0.5 to 8 Hz, the generated power increased linearly. The generated voltage was 106 mV at 3 Hz and 198 mV at 6 Hz. After using the step up circuit, the measured voltage was 81 mV at 3 Hz and 235 mV at 6 Hz. From above the frequency of about 4.5 Hz, the gain obtained by using the quadrupler circuit becomes larger than the loss without using that circuit.

© 2007 Published by Elsevier B.V.

PACS: 75.90+w; 81.15.Pq; 81.40.Rs; 81.70.Bt

Keywords: Micro power generator; Electroplating; Coil; MEMS

1. Introduction

Nowadays, energy harvesting device, which convert mechanical energy into an electrical energy, has actively investigated. There are many devices which generate electrical output power from vibrations, oscillations or thermal motions. These devices included inductive devices [1,2], capacitive devices [3], and piezoelectric devices [4,5], etc.

In this work, the micro power generator in which a permanent magnet moves horizontally on a flat wound coil was fabricated. The electric power output is generated due to the outer vibration. The winding coil made by electroplating can be a square type or a circular type spiral structure. This kind of self-power generating device can

supply power to sensors, electronic devices, and portable electronic devices. Also this device can recharge the secondary battery.

The most serious disadvantage in the self-power generator is that only small power is generated. Therefore to overcome this disadvantage, amplification of the voltage is necessary. And the generated output is alternating (AC) voltage, thus converting into direct (DC) voltage is necessary to be applicable to any portable DC electronic devices.

2. Experimental methods

In this work, a square type spiral coil structure was fabricated by using a gold electroplating technique. A 4-in pyrex 7740 glass wafer was coated with a chromium(200 Å)/gold(1000 Å) seed layer by thermal evaporation. In order to form a 15-μm-thick electroplating mold,

* Corresponding author. Tel.: +82 2 958 5706; fax: +82 2 958 5739.
E-mail address: s-ikim@kist.re.kr (S.-I. Kim).

an AZ4620 thick photoresist was used. Then 7 μm thick gold layer was electroplated into the form of coil shape using the photoresist mold. Non-cyanide neutral gold electroplating bath (NEUTRONEX 210, EEJA) was used for preventing the damage of the mold during electroplating. The current density was set to 4 mA/cm^2 , and the deposition rate was 0.25 $\mu\text{m}/\text{min}$. After stripping photoresist mold using acetone, remaining seed layers between the electroplated conductors were removed for electrical isolation by successive wet etching of gold and dry etching of chrome with Cl_2 plasma at an RF power of 150 W.

The electroplated coil structure was analyzed by using a scanning electron microscope (SEM). The SEM image was taken by Nova SEM 200, FEI Co. The thickness and width were 7 and 20 μm , respectively.

The magnetic field strength of the permanent magnet was 4200 G. The fabricated coil was placed to the magnet. The length and turns of the fabricated coil was 1.6 m and 197 turns, respectively.

To measure the alternating voltage and the rectified voltage of the micro power generator, MSO6034A oscilloscope of Agilent technology was used. The generated voltage was alternating as shown in the oscilloscope. Through the rectifying circuit, this alternating power was converted into direct power and the generated voltage was stepped-up into a higher voltage using a quadrupler circuit.

A measurement system, which convert vibration energy into electrical energy, was also fabricated for characterization of the micro power generating device. Fig. 1 shows the schematic block diagram of a measurement system for self-power generating device. The system composed of a motor

with a reduction gear, a speed or frequency controller, a circular plate, a connecting rod, and a linear sliding stage. After setting a permanent magnet on a holder of the sliding stage, the holder was reciprocated according to the set speed of the controller. As the motor rotate, the circular plate fixed on the axis of the motor rotate, and the rotation movement changes into the linear motion by the linear slider through the connecting rod. The coil is fixed on the preset position, the magnet on the holder reciprocate according to a preset speed or frequency.

In this micro power generator, the magnet reciprocate laterally, not vertically on a surface of a winding coil, which is different from the normal solenoid typed power generating devices by using a magnet and a coil.

3. Results and discussion

The key parameters, in the design of power generating coil structure, include the outer dimension, the width of the metal tracks, the thickness of the metal, the number of turns of the spiral and the substrate material. If the substrate is not a perfect insulator, there will be some parasitic loss in the substrate.

The magnetic field strength of the permanent magnet was 4200 G. The fabricated coil was placed to the magnet. The length and turns of the fabricated coil was 1.6 m and 197 turns, respectively.

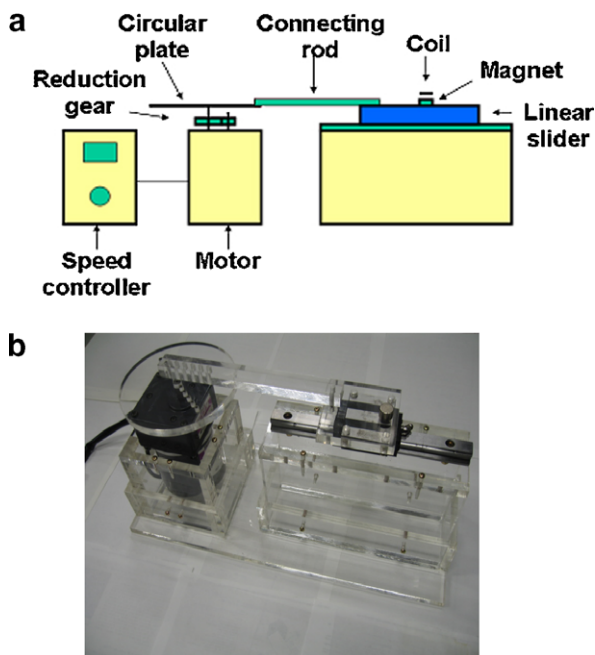


Fig. 1. Schematic block diagram (a) and a picture (b) of the measurement system for the fabricated micro power generating devices. The system composed of a motor with a reduction gear, speed and frequency controller, circular plate, connecting rod, and linear sliding stage.

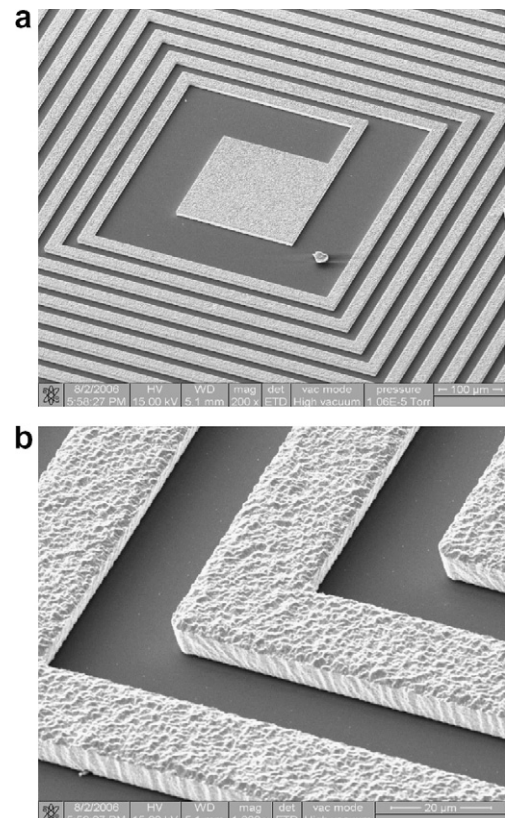


Fig. 2. SEM pictures of the fabricated gold electroplated coil structure: (a) A magnified picture (200 $\times$); (b) a magnified picture (1600 $\times$).

Download English Version:

<https://daneshyari.com/en/article/1787319>

Download Persian Version:

<https://daneshyari.com/article/1787319>

[Daneshyari.com](https://daneshyari.com)