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Development of an Adhesive Plaster Size Current Sensor for Power Monitoring

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Abstract

This paper reports a novel thin film based an adhesive plaster size flexible clamp-on type AC current sensor with 250 turns micropatterned Cu coil (line / space = 50 μm / 105 μm) formed by through-holes and flexible printed circuits technologies for wireless sensor networks. Microvias and fine stripe Cu patterns could be formed around permalloy film sandwiched between polyimide films with a high precision. Since the sensor has high flexibility, it can be used by winding the electric wire and drastically reduce the installation space. The output voltage changed linearly with variation of the value of primary current in the 0 to 20 A range.

1. Introduction

Smart grids represent an evolution towards a more optimized and sustainable energy system using the implementation of wireless sensor networks. Progressive sensing and measurement techniques are major technologies in a smart grid to successfully provide precise information for real-time monitoring and control of the entire distributed electric power system. Also, it is important to develop a mass production technology of small size and inexpensive sensors.

As we reported in previous study, a flexible current clamp sensor was fabricated by thin film materials and screen-printed coil, and a novel fabrication process of the sensor using the roll-to-roll systems was proposed [1,2]. We have successfully developed the thin film based flexible current sensor using the process technology in screen-printing as a low cost,

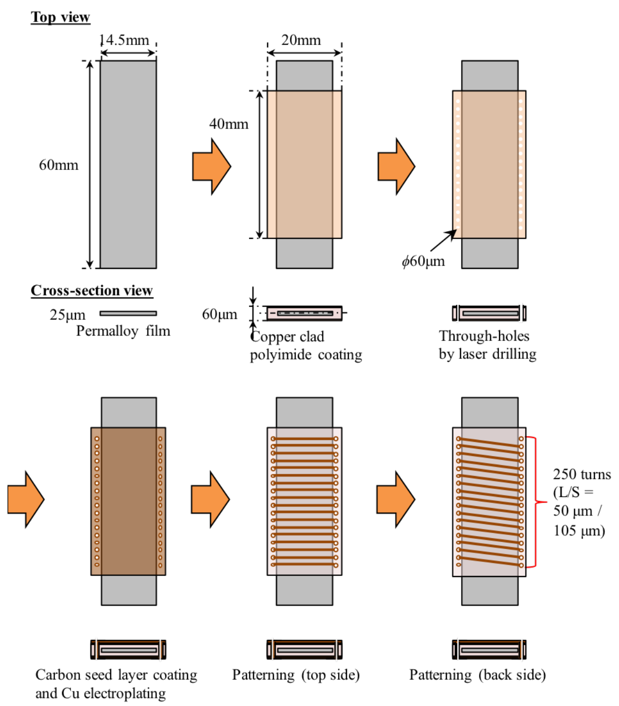

Fig. 1 Fabrication process for the adhesive plaster size flexible current sensor using a micropatterned Cu coil.

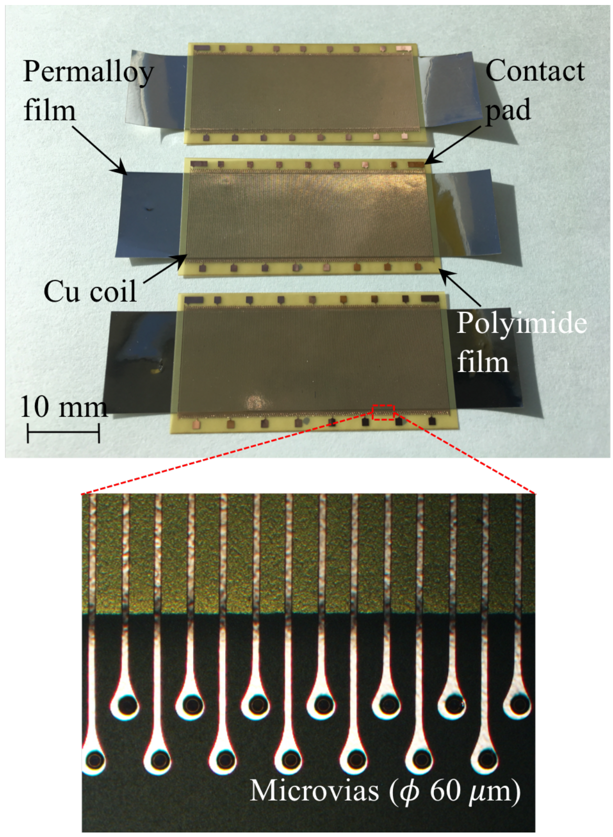

Fig. 2 Photos of the developed sensor sample with micropatterned Cu coil.

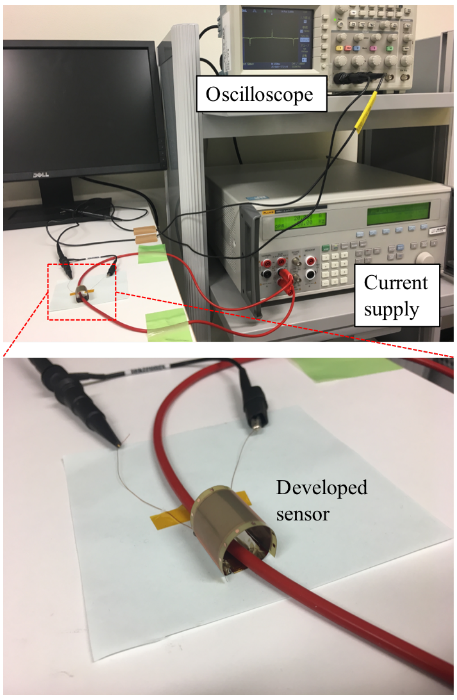

Fig. 3 Experimental setup for measurement of electrical properties of the sensor.

simple, and rapid method, but the has low yield due to occurrence of printing defects such as misregistration, printing blur, oozing or missing in the case of fine pattern printing. This study will show a novel fabrication process for sensor using the proven flexible printed circuits (FPC) technology and the electrical properties of the sensor.

2. Fabrication

The detail fabrication process flow begins with the application of a 40-mm-long, 20-mm-wide and 12.5-µm-thick coat of polyimide film bonded to 6-µm-thick Cu foil by thermal compression bonding on both sides of a 60-mm-long, 14.5-mm-wide and 25-µm-thick PB permalloy film (45% nickel, TECHNO TAKA Corporation) as a magnetic core. We made through-holes 60 µm in diameter and height of 50 µm in the polyimide film at 155 µm intervals along the lateral border of the permalloy film by laser hole drilling. After carbon seed particle coating, polymer through vias were formed by electrolytic Cu plating. Finally, 250 turns micro coil pattern was formed by FPC technologies such as photolithography and etching. These fabrication processes are schematically shown in Fig. 1. Figure 2 shows photos of the processed sensor samples. The sensor has high flexibility because it is formed by only thin film materials.

3. Evaluation

In this measurement, a current calibrating apparatus (5080A Calibrator, FLUKE Calibration), the maximum current of which is 20.5 A, was used. An electric wire connected to the apparatus was clamped by the developed sensor. The sensor was taped together on both sides after clamping. We

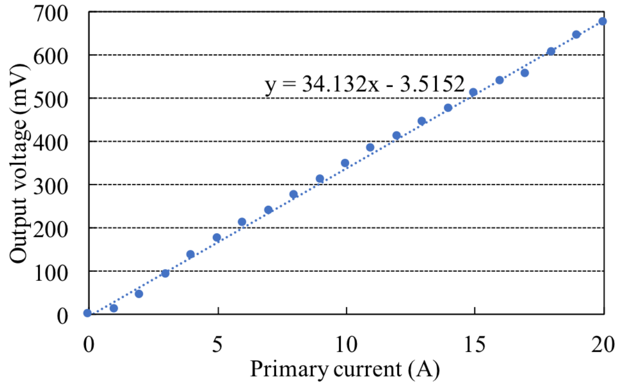

Fig. 4 Output voltage as a function of primary current in the 0 to 20 A range.

measured output voltage (V_o) generated in the coil by connecting an oscilloscope with contact pads in the sensor. Figure 3 shows schematic diagram of the experimental setup used to measure the output voltage. Figure 4 shows the output voltage in the coil as a function of primary AC current (C_p) in the 0 to 20 A range, frequency of 50 Hz. When the value of primary current was 20 A, the output voltage was 675 mV. Furthermore, the output voltage changed linearly with variation of the value of primary current. C_p-V_o sensitivity was about 34.1 mV/A.

4. Summary

In summary, thin film based flexible current clamp type sensor for wireless sensor networks was developed using the process technology in FPC, and its electrical properties were measured. The output voltage changed linearly with variation of the value of primary AC current in the 0 to 20 A range. C_p-V_o sensitivity was about 68.3 mV/A. When the current was 20 A, the output voltage was 675 mV. From the results, the developed sensors have the practical applicability as nodes in green wireless sensor networks because the sensor can be fabricated by roll-to-roll FPC mass production facility because it is developed using only FPC technology.

References

[1] T. Yamashita *et al.*, *Proc. IEEE sensors 2014* (2014) 742.
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