Development of All-In-One Tactile Sensor Based on Piezoelectric Properties and Thermistor

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I. Introduction

We studied a multi-functional tactile sensor device to mimic the human tactile sense that can detect pressure, temperature, and primary parameters. This tactile sensor is fabricated using P(VDF-TrFE) to generate a voltage by applied pressure without the external power supply. To solve the problem of crosstalk between the sensing cells an island type of P(VDF-TrFE) was fabricated. Because of simplifying cell and enhancing reliability, the top electrode of piezoelectric cell was designed to act as a thermistor.

II. Device Design and Fabrication

The tactile sensor we designed is shown in Fig. 1(a). Both the top and bottom electrodes were fabricated with Al. In the case of the top electrode, a flexible PI film was used as a substrate so that topography and roughness information could be well measured. Also, it is designed as a thin and long metal wire to act as a thermistor for temperature sensing. The bottom electrode was designed to have 25 sensing cells with a size of $1mm^2$. The P(VDF-TrFE) is spin-coated on the patterned bottom electrode. And it is dried in an oven at 130°C for 2hour to form the β-phase of P(VDF-TrFE) with piezoelectric properties. Furthermore, P(VDF-TrFE) was etched to prevent crosstalk using RIE except for sensing cell areas (Fig. 1(b). The sensor fabricated by combining the top and bottom electrodes is connected to the FPC for measurement, as shown in Fig. 1(c).

III. Result and Discussion

The tactile sensor measured the voltage change in real time through the DAQ system. Due to the piezoelectric properties of P(VDF-TrFE), a positive peak occurs when the sensor is pressed, and a negative peak occurs when it is released (Fig. 2(a). 7.8μm P(VDF-TrFE) was etched perfectly using dry etching around 60 min process time. However, as the etching time increased, the P(VDF-TrFE) denatured, and the voltage peak when the sensor was pressed decreased. Therefore, as shown in Fig. 2(b), 30 minutes (≈4.0μm etching) etching was optimal condition considering cross talk and efficiency of piezoelectric properties. As shown in Fig. 2(c), when only one sensing cell (c3) was pressed, no peak occurred in other cells

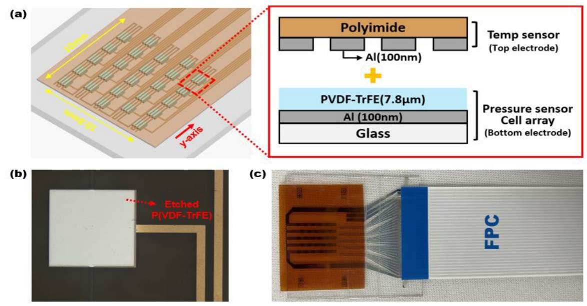

Figure 1. Schematic diagram of the structure of the tactile sensor. (b) Optical image of etched P(VDF-TrFE) on sensing cell. (c) Picture of the tactile sensor connected to the FPC.

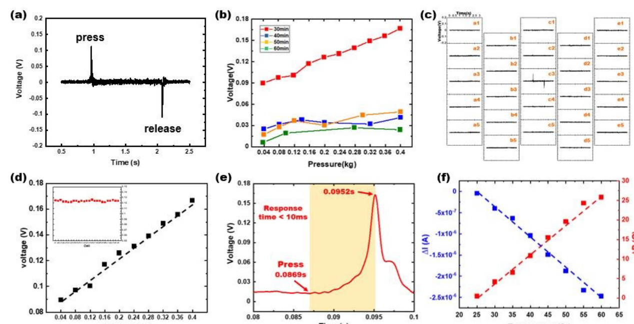

Figure 2. (a) The voltage signal when pressed. (b) Voltage peak generated according to pressure when etching time is different. (c) Signals of all sensing cells when only c3 one cell is pressed. (d) Voltage generated according to pressure. The inset figure is the voltage generated in each sensing cell when pressed with the same pressure. (e) Response time when tactile sensor is pressed. (f) Change in current and resistance with temperature.

except for the pressed cell. The pressure sensitivity was measured at pressing conditions from 0.04kg from to 0.4kg (Fig. 2(d). The generated voltage increased linearly with increasing pressure. All cells showed good uniformity within 4mV. In addition, the cell had a fast response time about 8.3ms for pressing. This response time is shorter than the human tactile system, known as 15ms [1]. Fig. 2(f) shows the characteristics of the temperature sensor part of the fabricated tactile sensor. Current and resistance were measured through the SMU system. As changing temperature from 25°C to 60°C by 5°C increments, the change in current and resistance decreased and increased linearly, respectively. Therefore, this sensor can detect the topography, roughness, and temperature of a target object with linear relation characteristics of pressure and temperature.

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