

## FABRICATION OF PRESSURE-SENSITIVE RESISTOR AND ITS APPLICATION TO DIGITAL DOOR-LOCK KEY

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**Abstract** – We fabricated a pressure sensitive resistor (PSR). As the name implies, they vary the resistance between their two electrodes according to the applied pressure changes. The PSR resistance goes down as the applied pressure (force) increases. Practically, we applied PSR to a dual-action single-key mechanism. It shows new possibility to use as the digital door-lock key button.

**Keywords:** pressure sensing, resistor, force sensing, button

### 1. INTRODUCTION

The term 'piezo-resistive effect' describes a change in the electrical resistance of the material from deformed to its original shape by the external force, e.g., elongation, compression, etc. This phenomenon has various applications of sensors for monitoring pressure, vibration, and acceleration. In contrast to the piezoelectric effect, the piezo-resistive effect causes a change only in electrical resistance, not in electric potential. Although there are many materials which have the piezo-resistive effect, rubber (nano) composites with conductive fillers have attracted a great deal of attention because the piezo-resistive effect appears at the various range of pressure by controlling the type of filler, particle size, particle shape, aspect ratio of particles, and filler content. Especially one can obtain the composites with elasticity and flexibility by using the rubber as a matrix. We manufactured a pressure-sensitive resistor by using PDMS as a matrix. Polydimethylsiloxane called PDMS is a flexible elastomeric polymer widely used in industry. It is a mineral-organic polymer (a structure containing carbon and silicon) of the siloxane family. Ni, Sn and C particles were used as conductive filler.

### 2. PRESSURE SENSITIVE RESISTOR

In order to fabricate a pressure sensitive resistor, we used one of the most common PDMS elastomers, Sylgard 184 from Dow Corning as the base material. Sygard is a two part resin system containing vinyl groups and hydro-siloxane groups. Mixing the two resin components together leads to a cross-linked network of dimethyl siloxane groups.

Figure 1 is the schematic of a PSR. Electrode on FPCB has an interdigitated electrode structure. PSR has a feature whose resistive polymer is attached with double sided tape on the edges. This means that the PSR material does not contact the electrodes when no force is applied. The PSR material is a resistive polymer with metal particle (nickel, tin) and

non-metal particles mixed together.

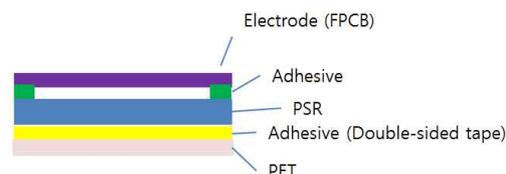


Figure 1. Schematic structure of PSR.

The force vs. resistance characteristic is shown in Figure 2. This provides an overview of PSR typical response behavior. An active diameter of PSR is 12.7mm. A stainless steel weight with a 5 mm diameter flat tip rubber was used to actuate the PSR.

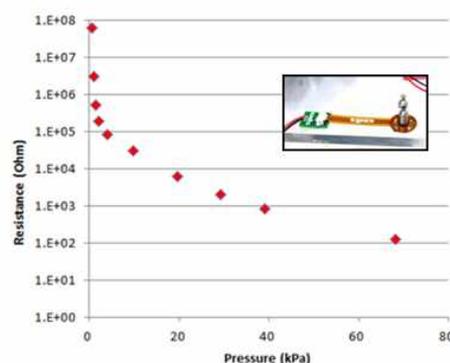


Figure 2. Characteristic of a PSR with 12.7 mm diameter.

At the low pressure end of the pressure-resistance characteristic, PSR behaves like insulator. This turn-on threshold is determined by the geometry and material property of FPCB membrane. Also, it depends on the mixing ratio of metal and nonmetal particle. At the high pressure end of the range, the resistance becomes small and behaves like near-metal. It eventually saturates to a point where increases in pressure yield little or no decreases in resistance. Under the test conditions of Figure 2, this saturation pressure is around 80 kPa. A simple circuit like a voltage divider can provide a voltage output directly.

### 3. APPLICATION TO DOOR-LOCK KEY

In electronic devices, there may be different functions corresponding to various keys with which the user interacts. For example, in a camera device, one key may allow the user to control the on/off functionality, while an ancillary key

controls the camera shutter. As the number of functions of electronic devices increases, it is expected that the number of user control keys would also increase, which can lead to over crowding of keys and increased user interface complexity. We developed a switch device that combines two separate switches into a single key. It operates by receiving a first downward force on a switch device to activate one function. After that, if it receives a second downward force greater than the first downward force, the other function is activated.

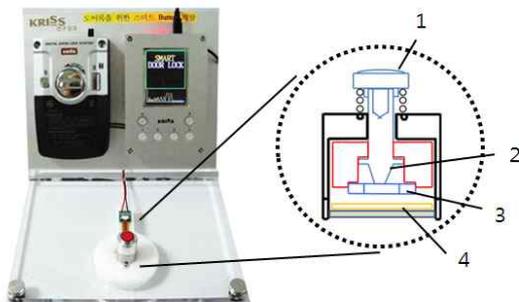


Figure 3. Digital door-lock device (Left) and a two-stage switch assembly with built-in PSR.

Figure 3 shows the two-stage door-lock switch assembly made by us. A switch assembly is designed to actuate a dual function using a single push button. The assembly comprises an upper dome switch (1), a central push-rod (2), ring magnet (3), and a pressure-sensing resistor (4). When the dome switch receives a first small downward force, the ring magnet

touches to the PSR. Then a first large resistance circuit is completed. This stage can be treated as a logic 0 (low). When the button cap receives a second large downward force that is greater than the first force, the dome switch collapses and a second low resistance electric circuit is completed. This stage can be treated as a logic 1 (high). If one wants to make five-digit passwords using the digits 0 and 1, 32 passwords can be made with only one key.

#### 4. CONCLUSIONS

We successfully fabricated a pressure sensitive resistor (PSR). It is a polymer mixed with metal particles. It exhibits a decrease in resistance with an increase in the pressure applied to the surface. Additionally, we made a two-stage switch assembly with built-in PSR as one of applications. It shows a potential to be a new digital door-lock key.

#### ACKNOWLEDGMENTS

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