Fabrication of the Ultrasensitive Flexible Capacitive Pressure Sensing Coating

Tianyu Shao [†] , Yuhan Zhang [†], Peng Zheng [†], Zhuo Li[†,*]
[†] Department of Materials Science, Fudan University, Shanghai, 200433, China.
* E-mail: zhuo_li@fudan.edu.cn

Abstract

The Internet of Things is recognized as one of the most important areas of future technology and has received wide attention. As an important component receiving information from the outside world for the Internet of Things, the development of wireless sensor networks has always been an important factor restricting the popularity of the Internet of Things. Sensors based on different working mechanisms including piezoresistive, capacitive, piezoelectric, and triboelectric ones have been fabricated. Among them, capacitive pressure sensors have been widely used because of their low energy consumption, simple structure, and high reliability.

At present, methods to improve the sensitivity of the capacitive flexible pressure sensor mainly focus on preparing the microstructure on the surface or inside of the dielectric layer to increase the change of thickness when pressed, or increasing the facing area between the electrodes. These methods have certain limitations: the high sensitivity can only be maintained in a small pressure range, and it is difficult to fit well with the curved surface. In addition, the nonlinear response of those capacitive pressure sensors increase the difficulty in data interpretation. In this work, we innovatively propose two methods for preparing the dielectric layer of capacitive pressure sensor, and study its performance furthermore.

1. The percolative composite material is used as the dielectric layer of the capacitive flexible pressure sensor, so that the dielectric constant increases significantly under pressure, thereby offsetting the decrease of the sensor sensitivity due to the increase of the modulus, and achieving the linear sensitivity in pressure range of 100Pa - 1MPa. It has a very short response time (50ms) for pressure and excellent repeatability. The sensor can be used to measure the wrist pulse, and can easily measure the depth of water thanks to its linear response. At the same time, the dielectric layer can be applied in the form of a coating to a large-area complex curved surface in combination with the flexible stretchable silver conductive adhesive. We prepared a pressure sensor array coated on an infrared bulb and achieved a good response to multi-point pressure touch.

2. The porous composite material was prepared as a dielectric layer of a pressure sensor by adding expandable microspheres into a polymer substrate. It achieves a sensitivity of up to 0.274 kPa^{-1} and the largest measurement range so far from 10Pa to 4.5MPa. The expanded microspheres perform just like foaming agents to reduce the modulus of the dielectric layer, while the thermoplastic shell provides better resistance against collision and collapse. The coating also features good stability against repeated compression and temperature change. Moreover, the pressure sensing coating can be applied to detect from tiny pressure of a water droplet to large load of a running motorcycle, and the format of coating allows simple applications on complex curved surfaces. It is promising in the application of large-scale electronic skin of high load areas.

In summary, we have prepared two dielectric layers for flexible pressure sensors with the advantages of high sensitivity, low cost, large detective range, short response time, and high stability. The pressure sensor array can be applied to large-area curved surfaces, which have expanded application scenarios of pressure sensors in the field of flexible electronics.