Film-based shear force sensor using electrolyte

Shigeru Toyama, Yasuhiro Tanaka, Sayoko Utsumi, Takashi Nakamura
Research Institute, National Rehabilitation Center
4-1 Namiki, Tokorozawa, Saitama 359-8555, Japan
Terumasa Noguchi, Yasuhiko Yoshida
Department of Applied Chemistry, Faculty of Science and Engineering, Toyo University
2100 Kujirai, Kawagoe-shi, Saitama 350-8585
Tokio Umino
Department of Electrical and Electronic Engineering, Faculty of Engineering, Tokyo Denki University
5 Senju Asahi-cho, Adachi-ku, Tokyo 120-8551, Japan

Film-type thin shear force sensor seems useful to evaluate fitness of prosthetics. Therefore, we have been developing a film-based shear force sensor [1]. The characteristic point of our sensor is that it uses electrolyte solution as a force-sensitive conductive material. It is advantageous to use electrolyte because it easily deforms shape upon the application of forces. Moreover, the contact impedance between electrode and electrolyte is stable. However, thin-layer electrodes are easily degraded due to electrochemical oxidation. We adopted LiCl dissolved ethylene glycol solution to preserve intactness of Au thin electrodes deposited on a plastic film. Although the actual structure of the prototype sensor was more complicated, the basic structure of our sensor is an electrolyte-filled cell, which was sandwiched between upper and lower plastic films (Fig.1).

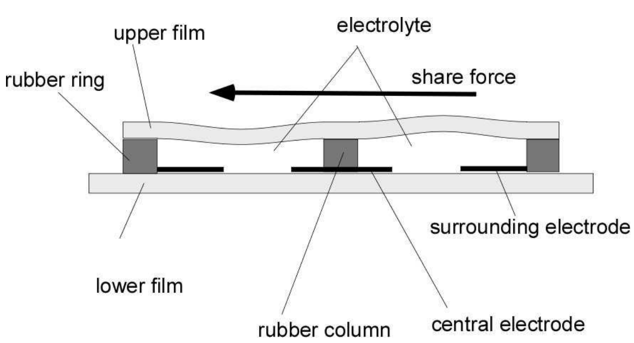

Fig.1 Basic structure of shear force sensor.

On the lower film, a central electrode and four surrounding electrodes (Au / Cr) were fabricated by electron beam vacuum-evaporation on a transparency film and patterned according to the reference [2]. A rubber ring was used to make a gap between the films, and a rubber column was placed at the center of the central electrode. The sensor is designed so that when a shear force is applied at the surface of the upper film, it deforms the upper film and changes the thickness of electrolyte layer, causing variation of impedance between the central electrode and the surrounding electrodes. From the response of each surrounding electrode, it is possible to estimate both the magnitude and direction of shear force. The impedance measurement was done by applying alternative voltage (Vpp = 160 mV (-80 to 80 mV), 5 kHz) between the central electrode and each surrounding electrode. The measurement condition was carefully chosen to prevent electrochemical damage of Au thin electrodes.

Figure 2 shows one of the prototype sensors. In the most successful case, a prototype sensor (thickness = 2 mm) exhibited linear response to the shear force, while it does not change upon the pressure. Furthermore, we did not observe any apparent degradation of electrodes. Minimization effort is currently undergoing.

This work was financially supported by a Grant-in-Aid for Scientific Research (C) (23560060) from JSPS.

References

[1] S. Toyama, et al., A novel shear-stress sensor using electrolyte as a conductive element, Sensor Letters (in press).
[2] S. Toyama, et al., Fabrication of electrodes for chemical sensors on overhead-transparency film, Electrochemistry, 74, 128 (2006).

Fig. 2 A prototype of shear force sensor.