Digitized Touch Sensor using Carbon Nanotube Thin-Film and Bio-mimetic Fingerprint Structure

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Abstract

Recently many groups have reported on various types of pressure sensors that attempt to mimic the human sense of touch. However, currently developed tactile sensors show limitations in sensing range and sensitivity, which is from the fact that the human fingertip shows high sensitivity to low pressures and decreasing sensitivity to increasing pressure [1], and may be difficult to realize a finger like sensor operation. We have developed a bio-mimetic touch sensor that can be controlled to have similar sensitivity and range of pressures to that of a human finger tip. Moreover, it returns a digitized output signal over various pressure ranges without A/D conversion. This type of output characteristics is analogous to the signals of tactile receptors. Also a bio-mimetic fingerprint structure was placed on the sensor surface for possible detection of surface dependent shear vibrational characteristics of the contact material.

Figure 1 shows the operating mechanism of our sensor. When pressure was applied to the PDMS surface, the carbon nanotube thin-film (CNTF) electrode made contact with the bottom electrodes closing the sensor circuit, and as the pressure increases consecutive electrodes make contact, producing a signal proportional to the applied pressure. The touch activation minimum pressure was controlled by changing the base size, the space between the electrodes and the elasticity of the polydimethyl siloxane (PDMS) layer, allowing sensors with different dimensions to have unique activation pressures. First the SiO_2 on Si substrate was etched to form a trenched circular base. Next, 13 electrodes with 10 μm step increases in separation with the ground electrode were placed on the surface of the trenched base (Figure 2). Finally, a fingerprint structure on the top surface and a CNTF flexible electrode layer coated on the bottom PDMS layer with a bio-mimetic m surface was used to cover the trenched base. Figure 3 shows that changing the base diameter from 200 to 350 μm allowed the tactile pressure sensing range to vary between ~ 2 Pa and 1500 Pa, closely mimicking the sensing range of a human finger-tip. We also measured shear vibration sensitivity using a polyethylene terephthalate (PET) strip and a Si wafer with periodic structures scanned over the sensor surface. The frequency dependent sensor signal showed accurate surface period sensing abilities (Figure 4.).

References

[1] L.L Johansson, et al, Ergonmics, **42** (1999) 1274.

Figure 1. Operating Mechanism

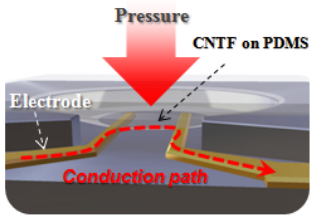

Figure 2. The scheme of bio-mimetic digitized touch sensor

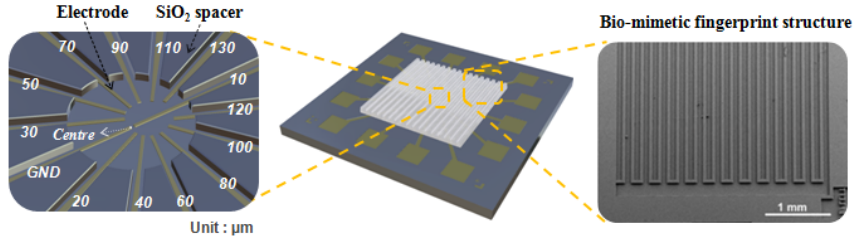

Figure 3. Output characteristics by a hole diameter

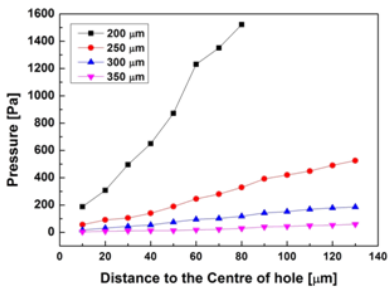

Figure 4. The tactile sensitivity about a PET tip and Si waver with periodic surface