The improvement of shear force transfer characteristics by controlling the elastic modulus of bio-mimetic fingerprint structure for tactile sensor application

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Abstract

Humans sense external stimuli as pressure, temperature, vibration, etc. with tactile corpuscles and perceive the information on contact material [1]. The human fingerprint amplifies the vibrations, which reflect surface texture, more than a dozen times compared to flat surfaces [2]. The fingerprint structure is a highly important component for sensing surface roughness of contact materials and research into the mechanical characteristics and structural dimensions should be conducted for tactile sensor application. In this study, we have conducted research on the material properties of bio-mimetic fingerprint structures for transferring effectively the contact vibrational pressure information. Controlling the Young's modulus (YM) of bio-mimetic tactile sensor's epidermal board and fingerprint structure, we measured and analyzed the shear force transfer characteristics of the bottom vibration sensor.

We fabricated four types of bio-mimetic tactile sensors which have different combinations of Young's Modulus for the fingerprint structure and the epidermal board. A tactile sensor with fingerprint structure showed about 26 times amplification than a tactile sensor without fingerprint structure. We also found that the low modulus epidermal board efficiently transferred 300 Hz vertical vibration at the fingerprint to the bottom sensor, which is the frequency range that the Pacinian corpuscle responds to most sensitively. When shear force was applied, the tactile sensor with a high modulus fingerprint and a low modulus epidermal board showed about 4 times higher fingerprint-to-sensor pressure transfer characteristics than that of previous tactile sensor with fingerprint structure and epidermal board which have same elastic modulus. These modulus characteristic is similar to the elastic modulus of the human fingerprint and epidermis[3]. When a polyester fabric and PET film was scanned, our sensor successfully detected the surface roughness and periodic structures of the contact surface. With further developments, it may be possible for our bio-mimetic sensor epidermis to be applied to various tactile sensors, giving them the ability to detect the texture of the contacting surface.

References

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Figure 1. The Image of (a) Sensor epidermis & (b) Tactile sensor

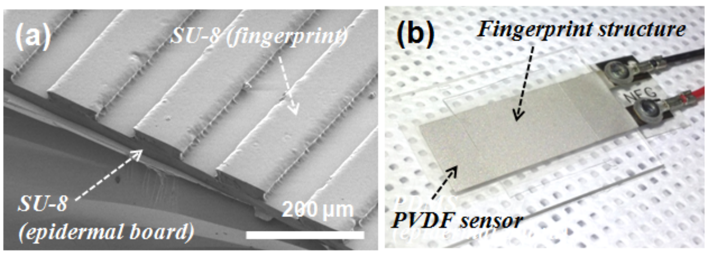

Figure 2. The tactile sensitivity by fingerprint

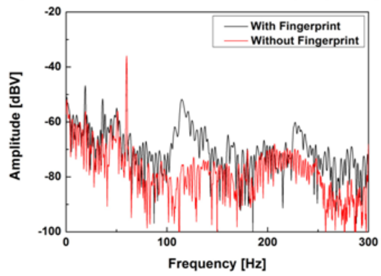

Figure 3. The tactile sensitivity by elastic modulus of sensor epidermis

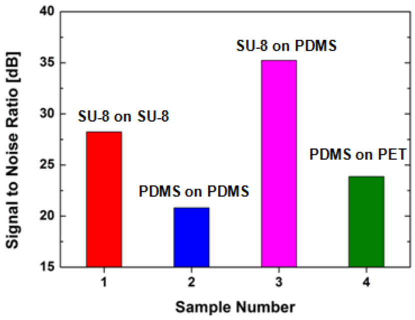

Figure 4. The tactile sensitivity about (b) a polyester fabric and (c) PET film