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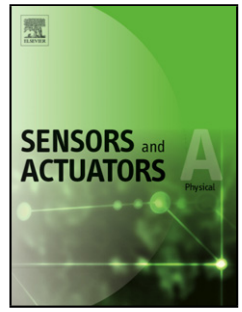

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A Flexible Multifunctional Tactile Sensor Using Interlocked Zinc Oxide Nanorod Arrays for Artificial Electronic Skin

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Highlights

- The artificial electronic skin was developed by constructing high-aspect-ratio interlocked ZnO nanorods, which can induce a change in the contact area to improve the sensor sensitivity under static and dynamic pressure.
- The e-skin with interlocked ZnO nanorods could monitor personal artery pulse pressure and artery stiffness in real time by using a noninvasive method.
- The proposed ZnO nanorod e-skin can differentiate multiple mechanical stimuli, normal force, bending, and torsion through different waveforms because of its unique interlocked geometry. For different types of repeated mechanical stimuli applied to the e-skin through finger touching, the corresponding signal intensity changes relative to the electrical resistance.
- ZnO nanorods are n-type semiconductors with a negative temperature coefficient, which provides high-temperature sensitivity to fabricate the sensor due to the lower thermal activation energy.
- This paper proposed 3 × 3 pixel sensor array on the flexible substrate for multitouch applications, which enabled to represent the corresponding location and magnitudes of the applied pressures in the graphic interface.

Abstract

In the development of artificial electronic skin (e-skin), a flexible tactile sensor is a critical component that imitates human skin response to dynamic and static stimuli. In this study, we developed a novel multifunctional tactile sensor to mimic human skin with high force sensitivity, high flexibility, and temperature measurable performance. The unique geometry of the interlocked structures enabled differentiation between different mechanical stimuli, including pressure, bending and torsion forces. The substrate was flexible because of the material properties of the polydimethylsiloxane (PDMS) layer. The top electrode and bottom electrode layers were interlocked by high-aspect-ratio zinc oxide nanorods (NRs), which were grown vertically on the PDMS surface, providing high sensitivity for the measurement of contact force and environmental temperature. Moreover, the sensor was applied for measuring and monitoring arterial pulse pressure. Thus, we successfully fabricated a 3 × 3 sensor array with multiple functions, which were verified through experiments. In the future, the proposed tactile sensor can be used in wearable health care devices, flexible interfaces, and bionic robotic skins in the industry.

Keywords: tactile sensor; flexible; ZnO nanorods; artificial electronic skin

1. Introduction

Tactile sensors are widely used in artificial electronic skin (e-skin) to mimic the sensing capabilities of human skin, and have been applied to prostheses and mechanical arms. In the past, these sensors were fabricated using silicon and glass substrates, resulting in limitations in the surface [1-4]. More recently, flexible tactile sensors have attracted increasing research attention because of their low cost, bendable and stretchable characteristics [5]. Most tactile sensors have been developed to detect pressure in a single device through changes in piezoresistivity, piezoelectricity, capacitance, and triboelectricity [6-18]. An integral artificial e-skin system should simultaneously possess the ability to perceive and distinguish mechanical signals, such as static and dynamic pressure stimuli, temperature, and continuous vibration sources. The traditional approach involves integrating various required sensors on heterogeneous substrates to mimic the behavior of human skin. However, multiple sensors require complex layouts to interconnect each component, making the volume of the sensing circuitry bulky. Human skin is actually an accurate sensory system that comprises the dermis, epidermis, and subcutaneous tissues to detect mechanical stimuli. Between the dermis and epidermis layers, microstructures are filled with various sensory receptors, and the major types of tactile mechanoreceptors (e.g., Merkel disk, Meissner corpuscle, Pacinian corpuscle, Ruffini endings, and free nerve endings) enable the detection of static

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