Bio-inspired Design Based on Hierarchical ZnO Nanowire Forest for Static and Dynamic Pressure-sensitive Electronic Skins

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Electronic skin (e-skin) has been attracted in various fields such as wearable electronics, robotics, and medical applications. Here, we suggest novel design of bio-inspired e-skin composed of hierarchical polydimethylsiloxane (PDMS) micropillar arrays decorated with ZnO nanowire (NW) forest in an interlocked geometry. The interlocked hierarchical structures enable a stress-sensitive variation in the contact area and the efficient bending of NWs. In addition, the bio-inspired e-skin can percive both static and dynamic tactile stimuli through piezoresistive and piezoelectric transduction modes. Our e-skin in a piezoresistive mode shows a high pressure sensitivity (6.8 kPa^{-1}) and an ultra-fast response time (<5 ms), which enables the detection of extremely small stimuli such as minute static pressure (0.6 Pa), vibration level (0.1 m/s^2), and sound pressure (~57 dB). On the other hand, the piezoelectric ZnO NWs decorated e-skin can percive fast dynamic stimuli such as high frequency vibrations (~250 Hz). We anticipate that our bio-inspired e-skin, which can simultaneously perceive the static and dynamic tactile stimuli, enables to apply the robotic hands for dexterous manipulations and various healthcare monitoring devices.