Highly Stretchable Strain Sensors for Structural Health Monitoring of Human Body and Bio-robotics

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Stretchable strain sensors are generally applied in wearable devices for monitoring and diagnose the condition of the human body, including the significant motions and subtle signals. Great challenges come into view when both tremendous strain (above 50%) and tiny strain (under 1%) need to be accommodated in one single type of sensor. Herein, we develop a flexible strain sensor inspired by the wrinkle structure of a worm that can be stretched over 100%. The strain sensor is fabricated by a two-steps process: 1) the vacuum filtration of the graphene/silver nanowires mixture suspension to produce the sensing film, and 2) wet transfer of the sensing film onto a pre-stretched PDMS substrate. The novel worm-inspired strain sensor is investigated to own the ultrasensitivity under tiny strain (Gauge factor of 63.2 bellow 1%) and the broad working range of 80% with a gauge factor of 1620.5, which surpasses most of the recent works. A percolation model that integrates conductive elements and insulated cracks is then utilized to analyze the excellent performance of the flexible strain sensor. Both the outstanding performance and theoretical model are verified in the practical experiment on detecting the large motions of the human body and subtle actions such as blinking and breathing. Further tests of the customized sensor are applied in monitoring the wings of a manta-shaped robot. Results show that the strain sensor in this work provides a new route to develop biosensors for structural health monitoring of the bionic robots.