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Abstract

Microstructured MWCNT/PDMS Composites for Multiple Sensing Applications †

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With the growing interest in flexible, lightweight, sustainable, and cost-efficient electronics, innovative and replicable manufacturing solutions are in demand. Pure silicon is still the most used semiconductive material in electronics. However, to address issues related to its processing, sustainability, and lack of flexibility, new materials are being developed. As a result, semiconductive alternatives based upon carbon allotropes, carbon-based composites, and electrically conductive polymers have emerged. Unfortunately, most of them are still difficult to process and lack reproducibility and their performances are not capable of competing with those of the traditionally used materials.

To contradict the abovementioned tendency, a new formulation is proposed herein to produce piezoresistive MWCNT/PDMS composites with versatile and tunable electric properties. The developed composite is obtained rapidly through fewer manufacturing steps and avoiding the use of hazardous solvents. To discover the percolation threshold of the composite, the MWCNT were first dispersed in IPA using an ultrasonic probe and then mixed with the PDMS pre-polymer in different weight percentages, ranging from 0.3 wt% to 8.0 wt%. Results evidenced that by using 3 wt% of MWCNT in PDMS, highly sensitive pressure sensors could be achieved. To further enhance the dispersion of the MWCNT and add microstructure to the composite, Triton X-100 (1 wt%) was used as a surfactant and sodium bicarbonate (10 wt%) as the foaming agent. By adding these substances during the dispersion process, not only were the piezoresistive properties of the composites enhanced but it was possible to obtain porous structures with interconnected pores, which improved the sensing range of the final material.

To produce the sensing units, the composite was blade coated and integrated with screen-printed silver interdigital electrodes. The resulting sensors presented a fast response rate, low hysteresis, high reliability, repeatability, and a sensing range of 0.5 kPa–70 kPa, with good linearity between 0.5 kPa and 15 kPa and resolution of 0.5 kPa. Thanks to the high sensitivity of the developed sensors, they have the potential to be used in applications such as prosthetics, soft grippers, electronic skins, and biomonitoring devices. As proof of concept, a heartbeat sensor and a pressure sensing matrix are presented in this work, thus illustrating the potential and versatility of MWCNT/PDMS composites for future flexible, conformable, and connected applications.

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