Cold Spray Deposition of Graphene Nanoplatelet-Based Flexible Wearable Sensors for Pulse and Sweat Monitoring

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Cold spray (CS) is emerging as a versatile solid-state deposition process, traditionally employed for structural coatings, yet holding significant untapped potential for functional applications in electronics and flexible devices. This study demonstrates its feasibility for fabricating flexible wearable components by depositing pure graphene nanoplatelet (GNP, ~5 μm) films onto polydimethylsiloxane substrates using a low-pressure CS system at room temperature with compressed air. The resulting ~5 μm films exhibited strong adhesion and no delamination after 5000 compressive cycles at 2.5 N, with an average sheet resistance of ~13 kΩ/sq, confirming the formation of a continuous conductive network. Integrated into a piezoresistive sensor architecture, the GNP film delivered a sensitivity of 12.13 kPa^{-1} across 0–35 kPa, with linear Ohmic behavior, fast response characteristics (~12.66 ms rise and ~16.62 ms fall time), and stable signal retention over 5000 cycles. In addition to strain sensing, the CS-deposited GNP films were configured as electrochemical electrodes and demonstrated sensitivity to varying NaCl concentrations, enabling sweat-based ionic sensing. The device was further validated for real-time pulse waveform monitoring using a microcontroller-based wearable system. The promising sensor performance, multifunctionality, and mechanical durability establishes CS as an effective, solvent-free, low-temperature, and maskless alternative to conventional fabrication techniques, enabling scalable flexible devices for integrated pulse monitoring and sweat sensing.

Keywords: Flexible electronics; Cold spray; Kinetic spray; Solvent free deposition; Maskless film fabrication; Sensors