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Development of interdigitated electrodes on polyimide substrate using laser reduction of graphene oxide

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Graphene-based interdigitated electrodes (IDEs) provide a unique and chemically inert platform for various sensing applications. Fabricating such electrodes on flexible polymer substrates offers significant advantages over rigid electrodes due to their conformability and versatility. However, the process of coating graphene oxide (GO) and subsequently reducing it to reduced graphene oxide (rGO) on such heat-sensitive substrates presents substantial challenges. This study focuses on utilizing a laser reduction technique to transform GO coated on polyimide (PI) substrates into laser-reduced graphene oxide (L-rGO) using a 785 nm Cobalt continuous wave laser. This research aimed to optimize the laser reduction process to achieve minimal electrical resistance, enhancing the performance of the electrodes. The optimisation was conducted using a design of experiments (DoE) method, examining the effects of three key variables: laser power, scanning speed, and the number of scans. The optimal parameters were identified as a power of 500 mW, a scanning speed of 17.5 mm s⁻¹, and 10 scans. Under these conditions, the resulting L-rGO lines exhibited a resistance of 4.4 ± 0.8 kΩ per centimetre, indicating an order of 10⁵ reduction in resistance. The effective reduction of GO to rGO was confirmed through a combination of scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). These characterization techniques provided detailed insights into the surface morphology and chemical changes occurring during the laser reduction process. The developed L-rGO IDEs were employed to detect sodium chloride (NaCl) in an aqueous solution using the electrochemical impedance spectroscopy (EIS) method. These IDE sensors showed excellent sensitivity and responsiveness to varying concentrations of NaCl, showing their potential for salinity sensing in water bodies. The optimised flexible rGO IDEs on PI substrates using a laser reduction technique, emphasise their scalability, cost-effectiveness, and suitability for advanced sensor technologies. This advancement opens new possibilities for the integration of flexible sensors in diverse fields, from environmental science to wearable technology, driving innovation in monitoring and detection systems.

Keywords: Interdigitated electrode, Graphene oxide, Laser scribed, Chemi-resistive sensors

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