Effect of Film Thickness on the Structure and Conductivity of Strained PEDOT:PSS Films on Stretchable Substrates

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Abstract:

Wearable and stretchable electronics, including organic solar cells and electronic skins, require conductive electrodes that maintain stable electrical performance under mechanical deformation. While poly (3,4-ethylenedioxythiophene):polystyrene sulfonate (PEDOT:PSS) has emerged as a promising conductive polymer owing to its tunable conductivity and mechanical stretchability, the film-thickness dependence of its structure and electrical conductivity under deformation remains insufficiently elucidated. Herein, PEDOT:PSS films were spin-coated onto thermoplastic polyurethane (TPU) substrates with controlled thicknesses of 100, 300, and 500 nm to systematically investigate their thickness-dependent electromechanical behavior under strain. Macroscopic conductivity was evaluated using a four-point probe technique, while crack formation and propagation were characterized by optical microscopy to correlate structural evolution with conductivity changes. Notably, all films exhibited comparable initial conductivities of approximately 200 to 300 S/cm up to a critical 20% strain threshold. Beyond this point, the conductivity of the thickest film (500 nm) suddenly dropped to 24 S/cm at 30% strain, consistent with crack propagation. In contrast, the moderate (300 nm) and thin (100 nm) films demonstrated intermediate (greater than 100 S/cm) and gradual (approximately 180 S/cm) declines, respectively, attributed to minor crack formation. These findings establish thickness-optimization guidelines for designing mechanically durable PEDOT:PSS electrodes for next-generation stretchable electronic devices.

Keywords:

PEDOT:PSS, film thickness, electrical conductivity, crack propagation, stretchable electrode.