Deposition of functional coatings on polymers using atmospheric pressure plasma liquid deposition (APPLD)

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The combination of atmospheric plasmas with liquid deposition can be used to deposit a range of nanometre thick plasma polymerised coatings. In this study these coatings were deposited using the Labline™ reel-to-reel atmospheric pressure plasma liquid deposition (APPLD) system. The influence of precursor plasma exposure on the mechanical, physical and chemical properties of the deposited coatings was examined. Coatings were deposited by directly injecting hexamethyldisiloxane, polydimethylsiloxane or tetramethyldisiloxane liquid precursors into a helium/oxygen atmospheric pressure plasma. A range of both organosiloxane and SiO_x coatings were obtained. The thickness of the resulting coating was monitored using spectroscopic ellipsometry. Coating growth rates ranged from 0.04 nm/s to 0.20 nm/s, with the lower deposition rates being obtained for the more inorganic SiO_x coatings, deposited at higher levels of plasma exposure. Surface energy measurements, obtained using the contact angle technique, were correlated with coating chemistry, as determined by XPS. An increase in the hydrophilic coating properties, observed with increasing plasma exposure, was found to be associated with a decrease in methyl functional groups in the coating and an increase in Si-O crosslinking. The effect of increasing precursor flow rate on applied plasma power was examined using optical emission spectroscopy. It was observed that for a constant applied plasma power, the intensity of the optical emission spectra decreased with increasing precursor flow rates.

The mechanical properties of the deposited coatings were examined using both pin-on-disc wear tests and fragmentation testing. For the purpose of these tests the coating thickness was maintained at approximately 21 nm. The fragmentation tests involved straining the PET substrate onto which the siloxane coating was deposited by 25%. Coating cracking patterns and crack density was examined using SEM. The more inorganic coating exhibited more brittle behaviour and this was also correlated with the rate and type of wear observed using the pin-on-disc treatments. The morphology of the coatings was examined using optical profilometry, AFM and optical profilometry. A systematic decrease in surface roughness (R_a) was observed as plasma exposure increased. Particulates were observed in the coatings, with a larger number of particulates being observed for the coatings deposited at higher flow rates and lower levels of plasma exposure. From this study it is concluded that the mechanical properties of siloxane coatings deposited using the atmospheric plasma technique are substantially enhanced at higher levels of plasma exposure due to increased plasma polymerisation and enhanced surface morphology.