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Plasma treatment of different polymer substrates for oxide barrier coatings

Jungheum Yun[1], Sunghun Lee[1], Yujeong Jeong[1], Jae-Hye Jung[1], Gun-Hwan Lee[1]

[1]Korean Institute of Materials Science, Changwon, South Korea

jungheum@kims.re.kr

The development of flexible substrates that are based on organic polymers is critically important for flat panel displays and photovoltaic applications. The combination of polymers with a thin oxide coating provides barrier properties against oxygen and moisture permeation. The formation of structural defects in the oxide coating mostly depends on the status of polymer surface and the adhesive strength between polymers and oxides. Since typically polymer surfaces have poor adhesion to oxide coatings, the surface pretreatment of polymers prior to the coatings is required for improving thereactivity of polymer surfaces. Plasma treatment is an attractive method to modify the surface chemistry and morphology of polymers. However, the difficulties in controlling the plasma-polymer interactions and their influence on subsequent oxide growth have limited the possible achievement of excellent barrier properties.
In this study, we investigated the correlation between the characteristics of Ar plasma treatment of different polymers (PET, PC, PEN, and PES) and the growth mechanism of SiOx barrier layers coated on the polymer surfaces using plasma-enhanced chemical vapor deposition. Effects of the plasma treatment on the polymer surface properties-including wettability, morphology, and chemistry-and on the oxide properties-including adhesion, mechanical durability, and moisture impermeability-were determined by contact angle and surface free energy measurements, field-emission scanning electron microscopy (FE-SEM), atomic force microscopy (AFM), transmission electron microscope (TEM), fracture tests in bending geometries, and moisture permeation tests using a Mocon instrument. It was found that the increase in the surface free energy of polymers without any apparent morphological modification after Ar plasma treatment improved the adhesion between the polymers and the SiOx layers and the barrier performance. High-quality SiOx layers with low water-vapor transmission rate values less than 0.005 g/m^2/day was grown by improving the smoothness and the wettability of polymer surfaces under optimized conditions of plasma treatment. However, extended exposure to Ar plasma produced a high density of protrusion on the polymer surfaces even without any noticeable chemical bond rearrangement. Then the three-dimensional growth of oxides was initiated on the top of the protrusions and caused the complete failure of barrier performance.

Keywords
Plasma treatment
Polymer
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