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Fracture mechanism of transparent conductive oxide and permeation barrier oxide multilayers on flexible polymers

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Oxide coatings on polymers provide excellent functional properties such as optical transparency, oxygen and moisture impermeability, and electronic conductance. However, the mechanical failure of oxide coatings on flexible polymers is a serious issue that limits their commercial uses. Since there is a large difference between the elastic properties of oxides and polymers, the formation of cracks and debondings in oxide films may be inevitable in situations in which bend geometries are required. Thus, it is important to have a clear understanding of the failure behavior of coatings in the case of bend geometries, in order to prevent the destruction of devices in which they are used. However, the failure behavior of complex multilayer structures in the bend geometries has not been well understood. The effects of film deformation on the performance of multilayer coatings, which include both conductive oxide and permeation barrier, on polymers are largely unknown.
In this study, we investigated the water vapor impermeability and the electrical conductance of an oxide multilayer structure, consisting of SiOx water vapor permeation barrier and indium-zinc-oxide (IZO) conductive layer, coated on polyethylene terephthalate (PET). Changes in the water vapor impermeability of barrier systems and the electrical resistance of subsequently grown IZO films were measured as functions of the film thickness and the bending radius in bend geometries. The pretreatment process of PET and subsequent interlayer deposition brought about an improvement in both the structural stability of the SiOx barrier and its adhesion with the polymer substrate, resulting in significant barrier enhancement. IZO films sputtered on the SiOx/PET system exhibited excellent mechanical stabilities in bend geometries, while IZO films grown directly on PET substrates underwent fatal crack formation. The IZO/SiOx/PET system maintained a resistance of 3.2×10^{-4} ohm cm and a WVTR of $< 5 \times 10^{-3}$ g m^{-2} d^{-1} after severe bending tests.

Keywords
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