

PO2067

Roll-to-roll deposition of silicon oxynitride permeation barrier layers using a rotatable dual magnetron systemAnika Himmler¹, Matthias Fahland¹, Tobias Vogt¹, Olaf Zywitzki¹, Kirsten Schiffmann²¹Fraunhofer FEP, Dresden, Germany ²Fraunhofer IST, Braunschweig, Germany

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High performance permeation barrier coatings are usually multilayer stacks consisting of inorganic and organic layers. Besides the water vapor transmission rate (WVTR) the optical properties of such layers have a high importance. This contribution focuses on the deposition of silicon oxynitride as inorganic layer. This material attracts widespread interest due to its varying refractive index depending on the oxygen and nitrogen content. The experiments were carried out in a roll-to-roll coating machine using a rotatable dual magnetron system. The substrate was conventional polyethylene terephthalate (PET) film. SiO_xN_y layers were deposited by reactive pulsed sputtering using silicon targets of one meter length. The system was powered in bipolar mode with a frequency of 50 kHz and at a power level of 20 kW. The gas atmosphere consisted of argon, oxygen and nitrogen. The ratio of nitrogen and oxygen varied between 25 % and 75 %. The discharge voltage was used as a reference value of a closed loop control for the reactive gas inlet. Thus the process could be stabilized in the transition mode. It was established that the ratio of oxygen and nitrogen in the layer was not only determined by the reactive gas mixture but also by the chosen setpoint of the closed loop control. Both the SIMS and GDOES measurements revealed a vertically different composition of the SiO_xN_y layers. This result can be explained assuming increased nitrogen incorporation in zones of high plasma density. Consequently the layer composition shows a W-shaped appearance. This could be supported by the simulation of the optical properties of the layer. The transmittance can be understood assuming a 5-layer stack with graded refractive index instead of a compact single layer. It had been demonstrated that a small amount of nitrogen in the reactive gas mixture could considerably improve the water vapor transmission rate compared to pure SiO_2 -layers.

Keywords

silicon oxynitride
roll-to-roll coating
rotatable magnetron
permeation barrier
reactive sputtering