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Plasma Activation and Plasma-assisted ALD Surface Modification of Polymers for Improved Bonding and Adhesive Strength

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Bonding strength is crucial on polymers of low surface energy, for clean surfaces limited to 0.5, 1, and 2 MPa for PTFE, PP, and PE. Plasma treatment may improve bonding strength by a factor of 2 (PTFE) or 5 (PP and PE). The efficiency of treatment is usually 10% as both low pressure and atmospheric pressure processes show low topographic conformity. Besides, lifetime of activation/modification is rather short. Hence, bonding has to be carried out immediately after plasma treatment.

The concept of plasma-assisted ALD (atomic layer deposition) interlayers was introduced in the project HARFE of SENTECH (modification/deposition/in-situ monitoring) and BAM (bonding, characterization, testing). ALD deposition has a high surface conformity and for dielectric films of Al₂O₃ also a good long-term stability given that the films are dense enough. Based on TMA and O₂/O₃ precursors, ALD layer stacks from 60 to 375 monolayers were prepared under different conditions. For a transfer time of 24 hours from deposition to measurement, bonding strength could be increased up to 5 MPa (PTFE) respectively 10 MPa (PP, PE). The huge potential of ALD layers as adhesive interlayers was demonstrated for Al₂O₃ on stainless steel with bonding strength beyond 15 MPa, i.e. interface strength within the ALD stack is also in this range.

This is a prerequisite for subsequent PVD/CVD-deposition in hybrid systems. By means of the SI ALD LL system of SENTECH thermal and plasma-supported ALD processes can be alternatively realized. Ellipsometric in-situ monitoring provides monolayer sensitivity and reveals that the efficient bonding of the lower ALD layers on the polymer has to be further improved. Testing of bonding strength was realized by CAT (centrifugal adhesion testing) technology. It was shown that ALD modification correlates with the increase of surface energy and bonding strength.

Keywords

plasma activation
plasma-assisted ALD modification
adhesive ALD interlayer
bonding strength
adhesive strength