EFECT OF INTERPHASE ON THE MICRO-MECHANICAL PROPERTIES OF PLASMA DEPOSITED COATINGS ON POLYMER SUBSTRATES

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Polymers are increasingly used in numerous technological applications. However, their advantages due to desirable bulk properties are frequently restricted by unfavourable surface characteristics, such as low hardness, low resistance to abrasion and scratching, and low surface energy, that generally leads to poor adhesion. Among different techniques for the improvement of surface properties of polymers, low-pressure plasma treatment provides an attractive possibility to enhance the mechanical characteristics of polymer surfaces, and to increase the adhesion of films [1,2]. The performance of polymeric materials can further be enhanced by applying functional coatings, such as optical filters, antireflective and protective coatings, gas permeation barriers, and others.

It has recently been demonstrated that a physically thick (about 50-100 nm) interfacial region ("interphase") is formed between plasma deposited films and the underlying polymer substrate due to synergistic effects of energetic ions, photons and radicals involved in plasma-surface interactions [3-7]. The presence of interphase has an important effect on the performance of various film/substrate systems used.

In the present work, we study the micro-mechanical properties of the interphase. We particularly focus on N_2 and He plasma-treated polycarbonate (PC) surfaces and plasma deposited silicon nitride using complementary low-load mechanical testing methods, with loads ranging from several nN to 10 N. The main approaches applied in this work are: (i) scratch techniques: CSEM micro-scratch tester, "MST" (0.5-10.0 N), and low-load micro-scratch tester, "LLMST" (0.5-5.0 mN); (ii) indentation techniques: CSEM depth sensing indentation, "NHT" (0.1-10 mN), Digital Instruments nanoindenter, "NanoScope" (1-100 μN), and Topometrix atomic force microscope (AFM), "Discover III" (~nN). The evaluated characteristics include hardness, elasticity, tribology and adhesion. The results clearly indicate that the presence of "interphase" contributes to lower wear, higher scratch resistance, higher surface hardness and enhanced adhesion, primarily due to mechanical stabilization and uniform distribution of stress across the graded interfacial region. We show that multipass scratching, using a subcritical load, provides a more sensitive information on the adhesion and wear behavior than does the usual progressive load approach. The results are discussed with respect to the limitations (contact pressure, deformation, location of stress concentration) of the test methods applied [8], as well as with respect to the preparation conditions and structure of the interphase. We will show examples of plasma surface treatments which use an optimized combination of vacuum ultraviolet radiation and surface chemical activation, leading to improved mechanical performance such as adhesion and scratch resistance.

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