PO1072

Cross-linking of PDMS thin films in hydrogen CC-RF plasma

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The cross-linking of thin composite films from the suspension of liquid polydimethylsiloxane (PDMS) and functional nanoparticles, e.g. Ag, TiO_2, in low pressure capacitively coupled RF plasma in hydrogen was investigated. This method exhibits high potential for developing of innovative coatings with antibacterial, anticorrosion or photocatalytic properties. In order to develop such plasma hybrid coating technology it is necessary to study the underlying mechanisms and the parameters influencing the PDMS cross-linking due to the interaction with a low-temperature plasma.The thin PDMS films were spin-coated on glass substrates covered by aluminium and their thickness was between 10 nm and 600 nm. The modification was performed in CC-RF plasma in hydrogen. In this case the main factor affecting the film modification is the VUV radiation which have penetration depth of hundreds nanometers. The most contribution to the intensity comes from Lyman band system ($B^1\Sigma_u^+ \rightarrow X^1\Sigma_g^+$) in the range between 140 and 165 nm. Under its action the scission of Si-C bond leads to the release of CH_3 groups which constitute gaseous products of degradation like H_2, CH_4 and C_2H_6. Intensive radiation causes the high rate of accumulation of these products and leads, finally, to the film damage by explosion of bubbles filled with them. By variation of pressure and forward power the VUV emission intensity can be optimized to avoid the damage effect.The corresponding chemical modification of the thin PDMS films was investigated by Fourier-Transform-Infrared-Reflection-Absorption-Spectroscopy (IRRAS) under variation of the plasma treatment time and initial film thickness. It was found that one of prominent effects is the removal of methyl, which for the top layer results in the total demethylation. Another effect is the film compression; it was investigated by spectroscopic ellipsometry. By comparison of all results it was found that the plasma modified films consist of strongly compressed methyl-free SiO_x top layer (10 – 50 nm), followed by partially demethylated region with moderate film shrinkage, and an underlying weakly-modified PDMS layer.
Funded by the Volkswagen Foundation, Plasma Hybrid Coating, grant no. I/83275.

Keywords
radio frequency plasma
organosilicon precursors