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Surface modification of Polymers by Plasma-assisted Atomic Layer Deposition

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The inhomogeneous and hydrophopic surface characteristics of many polymers can be incompatible with other substances which are required for their further functionalization. Various plasma methods have been used to overcome this problem and to enable functionalization to take place. Plasma modification can nevertheless lead to a nonuniform and chemically unstable surface which results in only a moderate performance in the final application. Deposition of ultrathin layers by atomic layer deposition (ALD) as a surface modification of the polymers has been shown to be a useful way to bring the desired functionality to polymer surface. ALD at low temperature suffers from slow reaction rates, consequently giving low deposition rates. Among the different ALD methods, plasma assisted ALD (PA-ALD) has been shown to be suitable for depositions at low temperatures with faster chemical reactions compared to thermal ALD. In PA-ALD the control of the plasma conditions is very complex due to the presence of many molecules such as various hydrocarbons. In this work tetrakis-dimethyl-amido titanium (TDMAT) and plasma excited O_2 precursors were used to deposit TiO_2 on Si(100) and polymethylmethacrylate (PMMA) substrates. Changes in the process conditions were studied by means of varying plasma power, oxygen pulse length and the point in time of plasma ignition during the ALD cycle. Depending on the exact plasma conditions, the polymer modification can be beneficial or detrimental to film properties and adhesion.In the case where a mixture of nitrogen and argon was introduced into the reactor to act as a purge gas between precursor pulses and also to facilitate the generation of a plasma during the plasma cycle, the plasma did not show detrimental effects on film adhesion on PMMA substrate, whereas using only argon as a carrier and plasma gas was found to generate detrimental plasma conditions causing poor film adhesion to the PMMA. The growth rate of the film increased with increasing plasma power and with increasing pulse length before saturating at higher power and longer O_2 pulse length. ATR-FTIR analysis showed lower levels of carbonaceous compounds for the film grown at lower plasma power. The films grown with lower plasma power also showed higher refractive index which suggests the low plasma power to be more beneficial for this particular PA-ALD TiO_2 process. The interaction between film properties and different plasma conditions will be further discussed.

Keywords
Plasma-assisted Atomic Layer Deposition (PA-ALD)
TiO2
Polymers