

OR0902

The reaction of nitrogen traces in plasmas with polymer surfaces

Andreas Holländer¹, Stefan Kröpke²

¹Fraunhofer IAP, Potsdam, Germany ²Fraunhofer-Institut für Angewandte Polymerforschung, Potsdam, Germany

andreas.hollaender@iap.fraunhofer.de

A plasma treatment exposes the substrate to a variety of highly energetic species. In the case of polymers they initiate reactions which result in a complex mixture of functional groups in the surface region of the material. Some of these reactions are known like the oxidation chain reaction. Many other reaction paths and details of the reactions like rate constants are unknown. Although this knowledge would be very beneficial for industrial processes, the vast complexity of real treatment processes makes it difficult to investigate.

This situation is even more complicated for the reaction of trace amounts of substances present in the process gas. For example, the treatment of polyethylene with a nitrogen low-pressure plasma often results in the incorporation of oxygen into the surface while nitrogen is found only in very small concentrations. The process gas contains only some ppm of oxygen and water and these gases can desorb from the reactor walls. The total amount of oxygen containing substances is small compared to the nitrogen. The reactivity of molecular oxygen with radicals and the even higher reactivity of oxygen atoms are widely accepted as reasons for the initially unexpected oxidation in these examples.

Nitrogen (N₂, N atoms) is much less reactive. After some kinds of plasma treatments, however, nitrogen is found in the surface of polymers although there was no nitrogen in the process gas except for some trace impurities. The treatment of polyolefins with argon or with sulfur dioxide plasma results in the formation of nitrogen functional groups in the sample surface.

In the paper we will discuss possible reaction paths for the nitrogen incorporation in these treatments. In particular, the role of nitric oxide as an intermediate will be considered. The XPS N1s spectra of SO₂ plasma treated PE were found to be very similar to the spectra obtained from samples which were treated with nitric oxide for the purpose of radical analysis.

Keywords

nitric oxide

nitrogen

sulfur dioxide

polyethylene