Low temperature plasma deposition of thin films/nanoparticles from methyl methacrylate

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We present herein investigations on the low temperature low pressure volume polymerization of nanoparticles and thin films from methyl methacrylate . The investigations are performed in a capacitively coupled discharge with variable plasma parameters. The observations of the gas phase species by means of mass spectroscopy and optical emission spectroscopy were correlated with the material analysis of the deposits in order to establish a correlation between the plasma parameters and the material properties.

For technological and biomedical applications the surface properties of polymer coatings are of crucial importance: they define the hydrophobic/hydrophilic state of the materials, their stability and via the presence of different chemical functional groups at the top surface their chemical (and physical) reactivity. In contrast to conventional polymers which are characterized by regularly repeating units, plasma polymers define a new class of materials (randomly branched, high degree of cross-linking). Due to fragmentation processes in the plasma volume – as a result of electron impact dissociation – resulting structural properties of the plasma polymer often do not resemble those of the original monomer. Our aim is to investigate plasma processes leading to the preservation of the building units of polymers and gain the control over the polymerization of nanoparticles from complex monomers.
In order to obtain more insight we started with the well known monomer methyl methacrylate (MMA), which has been used for plasma polymerization processes since decades [1].
MMA based deposits (polyMMA-PMMA), however rise nowadays a new interest not only due to the use of PMMA films as photoresist masks for microelectronics, but also due to its potentials in the rapidly developing field of biomedical applications, for example structured PMMA films as substrates for protein attachment, microfluidic devices…[see e.g. [2,3]).
The deposition of nanoparticles/thin films from MMA monomer diluted in argon were performed in low pressure capacitively coupled RF plasmas. Depending on the plasma characteristics (e.g. power variation from 1-10W, pressure from 0.06-1mbar) we can observe either the volume polymerization of nanoparticles or the deposition of thin film-nanoparticle coatings.
The processes were followed in-situ by means of mass-spectroscopy and optical emission spectroscopy. These diagnostics were used in order to follow the decomposition of the monomer.
The CW deposition in our case allowed the preservation of most of the building units, as proved by the comparison of the IR spectra from our deposits with the spectra of the monomer material itself and with IR spectra of spin coated PMMA.
PMMA coatings as presented in this work showed a surprisingly high stability (low degradation of surfaces, almost no changes in the O/C ratio), which can be explained by the specific experimental plasma set-up and the chosen plasma parameters (see in comparison e.g. Ref [4]).

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