Low temperature plasmas as a source for nanostructured organic surfaces with controlled wettability

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This contribution deals with the formation and controlled deposition of plasma synthesized nanoparticles. The investigations are performed in a capacitively coupled discharge operated with different hydrocarbon precursors. The results show that the behaviour of the resulting deposits strongly depends on their surface morphology. In particular the wetting behaviour can be effectively controlled by the amount of nanoparticles deposited on the substrate. A proper post processing of the deposits makes it furthermore possible to produce patterns of alternating superhydrophobic and superhydrophilic surfaces.

Plasma technology is known to be an important tool for the production and surface modification of synthetic polymers used for the control of bio-interfacial interactions [1]. Either as thin films, as nanoparticles or nanocomposites: plasma produced or processed materials have found an increasing number of applications in biomedical research. Despite the intensive research related to plasma polymerisation processes the production of polymers with specific surface properties (functional groups) is still a challenging task. A basic requirement for the control of these processes is therefore the understanding of the underlying plasma processes. An important technique used for the control of plasma based polymerisation processes is the application of pulsed discharges. The pulse frequency and the duty cycle are key parameters that strongly influence the polymerisation process. Recent experiments show for example that the density of negative ions, which are of crucial importance for volume polymerisation processes (i.e. for the formation of nanoparticles) strongly depends on the proper choice of the pulse frequency [2]. Under certain circumstances even slightest changes of the pulse frequency can lead to drastic changes in the density of negative ions. The proper choice of pulse frequency and duty cycle allows in addition to control the flux of nanoparticles (or submicron particles) towards walls and substrates - with respect to particle size, particle density and particle properties. This contribution deals with experiments performed in a capacitively coupled discharge. The polymerisation process is studied for different process conditions either with acetylene or with MMA as a precursor material. The resulting polymers are analyzed by means of *FTIR spectroscopy* and N*ear-Edge X-ray Absorption Fine Structure spectroscopy (NEXAFS or XANES).* In addition we performed for the different materials contact angle measurements. An example for the latter method is given in figures 1a -1d. The figures show the contact angle of water on polymers that were synthesized in a mixture of argon and acetylene. The difference between the individual figures concerns the amount of nanoaparticles deposited onto the material: it is increasing from figure 1a to figure 1c. Depending on this amount the contact angle can be varied between 65° and about 165°. Figure 1d shows a water droplet on the same material that was used for figure 1c. The difference concerns the post treatment of the material. In the case of figure 1d the polymer was treated after its production for 2 minutes with a nitrogen plasma. The resulting surface shows a stable superhydrophilic behaviour with a contact angle smaller than 10°. Depending on the duration of the treatment the contact angle can be continuously tuned from 165° to values smaller than 10°. At the same time the sliding angle is also drastically changing: while the unprocessed films (figure 1c) can have sliding angles smaller than about 5° the postprocessed samples become strongly adhesive. The postprocessing of the materials by different kinds of plasmas allows in addition the controlled and simple production of surfaces with patterns of (super)hydrophobic and (super)hydrophilic areas.

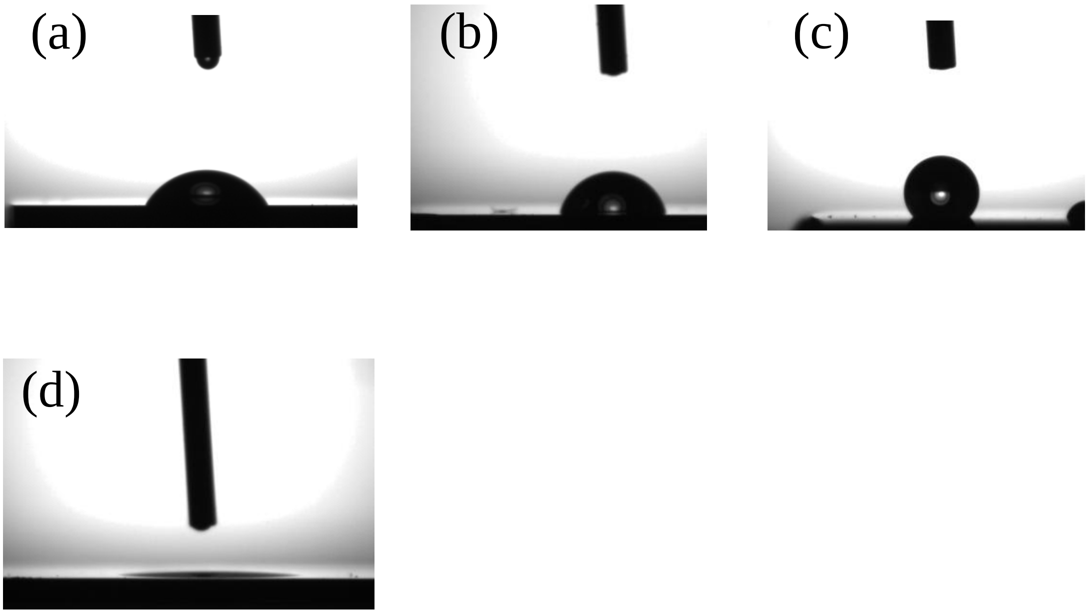

Figure 1a-d: Water droplets on different plasma polymers. The materials in figures a-c are made of plasma polymerized nanoparticles which are synthesized in mixtures of argon and acetylene. The particle density is increasing from figure a to figure c. Figure d shows a water droplet on a material that was postprocessed by means of a nitrogen plasma.

References

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