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Versatility and Deposition Mechanism of Siloxane-Based Plasma Polymer Films

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Deposition of plasma polymer films (PPFs) occurs via plasma activation of a monomer (here: hexamethyldisiloxane) creating excited intermediates and highly reactive film-forming species. Such processes are governed by the available energy per monomer molecule in the gas phase, E_{pl}, which holds both for low and atmospheric pressure plasmas. Up to a threshold energy, E_{th}, of ~15 eV, the deposition rate is linearly increasing with E_{pl} yielding PDMS-like coatings with low film density (~1.2 g cm^{-3}) and good hydrophobicity. Increasing E_{pl} accompanied by increasing energy deposited during film growth enables denser films up to about 1.8 g cm^{-3} with reduced hydrocarbon content. Maximum conversion of the monomer into film growth can be reached depending on the used plasma source.

The film growth at highly non-equilibrium conditions can be controlled starting from a thickness range as low as 1 nm. Hence hydrophobic nanolayers with defined density can be deposited on similar materials such as PDMS or SiOx fully covering their surface. 2 nm-thick hydrophobic cover layers on PDMS substrates of different crosslinking degree are used to clarify the role of viscoelastic properties on bacterial growth indicating the lack of mechanosensing abilities. Likewise, hydrophobic cover layers with varying film density are explored to control water intrusion. Thus, barrier properties of dense SiOx films can be enhanced or a defined volume of water can be allowed to penetrate a porous SiOx base layer. Protein adsorption of BSA is found to be affected by this hydration effect due to orientation of water molecules in the subsurface. Moreover, controlled drug release from a Ag reservoir is enabled for long-term antibacterial properties.

Recent progress in the understanding of plasma polymerization processes enables increased control and usability of functional plasma polymer films at the nanoscale. Dry and environmentally friendly processes can thus be implemented meeting the requirements for industrial applications.

Keywords
diffusion control
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