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Analysis and control of the nanoporosity of PE-ALD and PE-CVD SiOx-films on polydimethylsiloxane (PDMS) membranes

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The aim of the here presented work is the correlation of fundamental plasma parameters with surface chemical changes of plasma modified PDMS membranes and the resulting membrane properties. The goal is to be able to control the selectivity and permeability of the composite membrane, through tailoring of the micropores within the SiO_x film. The parameters that control the micropore size distribution are determined both by the plasma characteristics, and the characteristics of the PDMS surface. Plasma process characteristics i.e. oxygen fluence and average incorporated ion energy are separately controlled; additionally, the deposition is performed onto differently pre-treated PDMS membrane films. The plasma-pretreated PDMS and the SiO_x-coated membranes were investigated by means of surface spectroscopy (XPS, FTIR, ToF-SIMS) and AFM. The film structure was later correlated with the intrinsic pore structure as determined by Positron Annihilitation Lifetime Spectroscopy (PALS) and electrochemistry. The analysis revealed the existence of micropores in the nanometer and subnanometer range with silanol groups terminating the relevant interfaces. Moreover, the results illustrate how the gradual conversion of siloxane groups to a SiO_x network during plasma oxidation as a pretreatment step influence the nanoporosity and therefore the permeation of small molecules. Additionally, plasma-enhanced Atomic layer deposition (PE-ALD) was used for the deposition of SiOx on the PDMS and a comparison to the PECVD-deposited SiOx was done in terms of size distribution of micropores in the thin SiOx films and the film/substrate interphase. The PALS investigations proved to be an essential approach to understand the membrane properties of plasma polymer films.

Keywords
PDMS
SiOx
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