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Mechanical characterization of silicon-containing plasma polymer coatings and the influence of environmental conditions

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Residual stresses in vacuum-deposited thin films is still a major cause for device failure. Deposition of stress free coatings requires an in-depth knowledge of the stress formation mechanisms. The residual stress is usually a combination in intrinsic stresses, process induced stresses and environmental stresses. Especially the latter one not always taken into account.
This research presents a novel method on the measurement of residual stresses for highly curved sample as well as the expansion and compression of coatings under influence of humidity. Hollow cathode based PECVD was used to deposit silicon-containing plasma polymer coatings with different carbon contents, which were analyzed regarding their residual stress and coefficient of hygroscopic expansion. The results show that the carbon content increases the residual stress whereas the coefficient of hygroscopic expansion decreases. All coatings expand with increasing humidity. The coating with the highest oxygen content ($SiO_2C_{1.5}H_x$) tested in this research has an expansion coefficient of $29.2 \pm 1.9 \cdot 10^{-6}$ (% R.H.)$^{-1}$. Increasing the relative humidity from 20% to 70% affects the total residual stress more than 20%.

Keywords
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