Influence of spherulite distribution on the nanoindentation of semi-crystalline POM

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Nanoindentation (NI) is a contact method to investigate localized micromechanical properties of materials. The main advantage of NI compared to macroscopic mechanical test methods is the easy sample preparation. Also processing-related influences on mechanical properties are considered accordingly. NI of semi-crystalline polymers is a special challenge. The influence of morphological structures such as spherulites or crystal-lamellae on localized NI depth-force behaviour is discussed controversially in literature. Hence, the main objective of this study is to determine the influence of crystalline zones on NI results.

Polyoxymethylene (POM) exhibits high crystallinity with the spherulitic structure on the micrometer scale and was therefore chosen to proof the influence of spherulite distribution on NI results concerning modulus. To the author's knowledge, there has been no study about the correlation between morphology and mechanical heterogeneity of POM. Furthermore, the correspondence between the mean elastic modulus from two different NI experiments and from macroscopic compression tests will be demonstrated.

A POM tensile bar was investigated by NI with a large sphero-comical indenter tip at different positions of its cross-section. Here, it was found that regions at the edge of the sample have a lower elastic modulus than regions in the middle of the cross-section. This agrees well with light optical polarization microscopy results, which reveal a skin layer with less crystallinity and more amorphous zones close to the sample edge. Therefore, the NI measurements in this edge zone result in a lower elastic modulus compared to the more crystalline middle of the cross-section.

In summary, semi-crystallinity influences the NI results obtained for POM and the mean of the elastic modulus distribution over the cross-section of the POM sample is in good agreement with compression test results.

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