Structure-Property Relationships in Polymer Composites with Micrometer and Submicrometer Graphite Platelets

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Abstract

The objectives of this work were (a) to investigate the influence of micrometer and submicrometer scale graphite platelets of different aspect ratios and volume fractions on the effective and local quasi-static and dynamic properties of composites with micrometer and submicrometer scale reinforcement, and (b) to compare and evaluate mechanical property measurements of inhomogeneous materials via local (microscale) and bulk (macroscale) experimental methods. Small platelet volume fractions (0.5%) provided proportionally larger increase of the elastic and storage moduli compared to large volume fractions (3.0%). Randomly distributed 15 μm platelets provided marginally higher composite stiffness compared to 1 μm platelets while small volume fractions (0.5%) of 15 μm platelets had a pronounced effect on the effective Poisson's ratio. It was found that local property measurements of inhomogeneous materials conducted by nanoindentation are not representative of the bulk behavior even when the characteristic length of the inhomogeneity is an order of magnitude smaller than the indentation contact area. In this case, statistical averaging of data from a large number of indentations does not result in agreement with bulk measurements. On the other hand, for small aspect ratio platelets with dimensions two orders of magnitude smaller than the nanoindentation contact area, the nanoindenter-obtained properties agreed well with the effective material behavior. It was found that platelets residing at the specimen surface contribute the most to nanoindentation data, which implies that this technique is only valid for well-distributed nanoparticulate and microparticulate systems, and that nanoindentation cannot be used for depth profiling of microstructured composites.

Key Words: Polymer composites - graphite platelets - mechanical properties - local properties - nanoindentation