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HIERARCHICAL COMPOSITES WITH SECONDARY NANOPLATELET REINFORCEMENT: 3D COMPUTATIONAL FATIGUE STUDIES

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Abstract

3D multiscale computational models of hierarchical fiber reinforced composites with secondary nanoscale reinforcements, which are generated automatically using Python based software, were developed, and used to explore the effect of secondary nanoclay reinforcement, its distribution and geometry, on the fatigue behavior of the composites.

The effect of the nanoclay reinforcement (localized in the fiber/matrix interface (fiber sizing) and distributed throughout the matrix) on the crack path, fatigue damage mechanisms and fatigue behavior is investigated in numerical experiments. Various damage and toughening mechanisms at the nano-level were observed, among them, crack deflection, crack blocking, bridging, and debonding.

Crack bridging by nanoparticles was observed mainly in composites with randomly oriented nanoplatelets and clusters, while the crack path deviation was strongest in the aligned nanostructures. It was observed that the composites with secondary nanoreinforcement show much better lifetime and damage resistance properties than the ones without nanoreinforcement.

Composites with the nanoplatelets localized in the fiber/matrix interface layer (fiber sizing) ensure much higher fatigue lifetime than those with the nanoplatelets in the matrix.

Composites with exfoliated nanoplatelets reinforcement ensure the better fatigue lifetime than those with clustered particles. Further, composites with aligned nanoplatelets or clusters ensure also higher lifetime than those with randomly oriented nano-reinforcements.

The multiscale composites with aligned exfoliated nanoplatelets in the fiber sizing ensure the highest fatigue lifetime among all the considered structures.