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Monitoring Damage Progression in Ceramic Matrix Composites

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Recent work at the NASA Glenn Research Center at Lewis Field has focused on using various nondestructive evaluation (NDE) methods to assess damage in high temperature composite materials. During this time, the main fiber/matrix material systems studied were based on silicon carbide/silicon carbide (SiC/SiC) composites, although, some data were produced for a carbon/silicon carbide (C/SiC) composite. Damage was induced by conducting room temperature load/unload/reload tensile tests and elevated temperature creep experiments. The NDE techniques included acousto-ultrasonics (AU), acoustic emissions (AE), thermoelastic stress analysis (TSA), and impedance based structural health monitoring. The approaches were used to continuously monitor the specimens during the tensile tests at room temperature and intermittently for the elevated temperature creep experiments. The studies were primarily for assessing the capabilities of the various NDE approaches, while at the same time providing material characterization data. Each of the in-situ NDE techniques used (i.e., AU, AE, TSA, and impedance based SHM) during the tensile tests correlated well with the progressive, distributed damage observed in the composites (e.g., transverse cracks, delaminations, fiber breaks), thereby, showing potential as structural health assessment and monitoring tools. Furthermore, a new guided wave scanning system based on the AU methodology was employed for the interrupted creep tests. It showed great potential by clearly identifying aberrations at the final fracture location prior to failure. Lastly, the NDE results were also used to draw conclusions related to damage induced stress relief at notch tips as well as assessing residual and crack closure stresses.

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