

**Stony Brook University  
The Graduate School**

Doctoral Defense Announcement

**Abstract**

**Characterization of Damage due to Environmental Conditions in Heterogeneous  
Material Systems**

By

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Heterogeneous materials including fiber-reinforced composites and thermal sprayed coatings have the potential of offering tailored mechanical properties for specific engineering applications; however their susceptibility to different mechanisms of damage is a cause for concern. The various damage mechanisms addressed in the present study are exposure to harsh environments that include cyclic exposure to ultra-violet (UV) radiation and moisture, thermal cycling and erosion due to foreign particle impact. There is a need for characterization of damage resistance of a heterogeneous material system. With this as a motivation, first, a new inverse analysis based procedure is proposed and applied to real material systems. Strain-damage relations are formulated and followed by an iterative technique to identify damages caused by environmental exposure/physical damages in fiber-reinforced composites. Verification analyses are carried out to check the validity of the proposed procedure. Next, real cross-ply composite laminates are considered and damages identified. Furthermore, failure tests are performed to examine the residual strengths and early onset of delamination. In the second phase of work, interlaminar fatigue crack propagation is characterized in thermally cycled fiber-reinforced composites with recourse to 3D finite element modeling in conjunction with previously performed experiments. It was observed that energy release rates correlate to crack growth behavior through a Paris law relation.

In the final phase of work, erosion of coatings subjected to hard particle impact is addressed. First, experiments are performed using a test rig to obtain mass loss curves for heterogeneous thermal barrier coatings. Next, the erosion phenomenon is modeled for the first time via 2D finite element simulation and damages characterized. Current study offers significant insights regarding the mechanisms of damage and approximate erosion extents using 2D models. Comparisons made with results obtained from experiments qualify the current procedure albeit with refinements for modeling solid particle impact erosion problem in thermal barrier coatings.

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