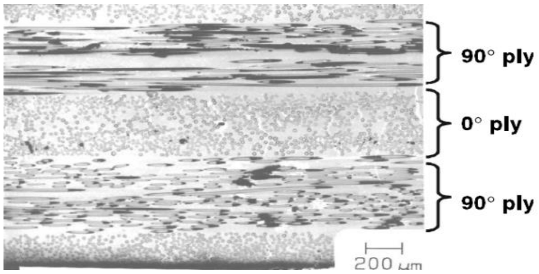
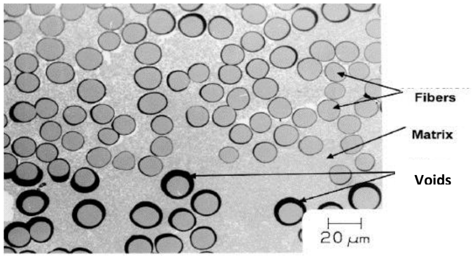
Ceramic Micro Structure

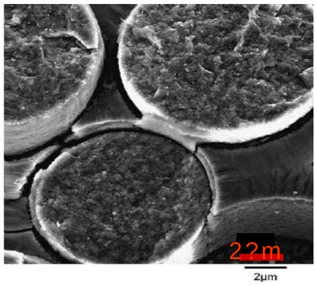


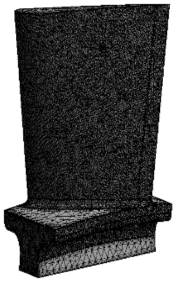
Layers within one element

Magnified 10x

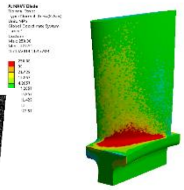


Magnified 100x





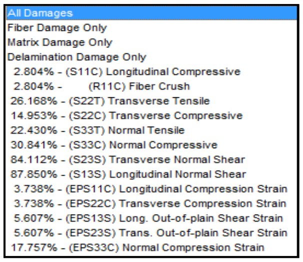
Component



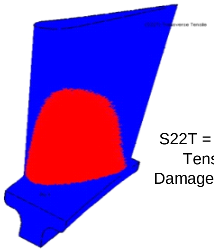
Fiber Tow Stress

Overall Damage

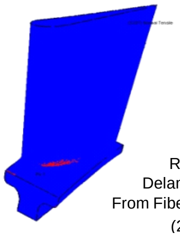
Damage Roadmap



All Damages
Fiber Damage Only
Matrix Damage Only
Delamination Damage Only
2.804% - (S11C) Longitudinal Compressive
2.804% - (R11C) Fiber Crush
26.168% - (S22T) Transverse Tensile
14.953% - (S22C) Transverse Compressive
22.430% - (S33T) Normal Tensile
30.841% - (S33C) Normal Compressive
84.112% - (S23S) Transverse Normal Shear
87.850% - (S13S) Longitudinal Normal Shear
3.738% - (EPS11C) Longitudinal Compression Strain
3.738% - (EPS22C) Transverse Compression Strain
5.607% - (EPS13S) Long. Out-of-plain Shear Strain
5.607% - (EPS23S) Trans. Out-of-plain Shear Strain
17.757% - (EPS33C) Normal Compression Strain

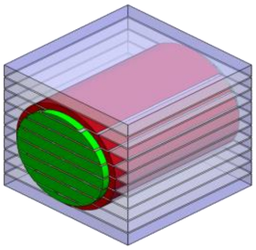


S22T = Matrix Tension Damage (26%)



R11C = Delamination From Fiber Crushing (2.8%)

| Oxidation |
|---|
| Recession |



**MCQ Ceramics** is a multi-scale material modeling, characterization & qualification software that predicts ceramic material performance. This tool enables engineers, designers and material specialists to quickly and accurately predict mechanical properties of advanced ceramic composite laminates considering environmental degradation effects. A building block reverse engineering approach is used to calibrate the "effective" constituent properties, architecture and interphase definitions. Using the effective properties to validate against the minimum available test data, MCQ Ceramics is independent of finite element modeling as it utilizes a unit cell approach.

## ***Key Features:***

- ✓ Supports full breadth of 2D/3D composite architectures
- ✓ Determines laminate properties such as Young's Modulus
- ✓ Determines at lamina/laminate limit loads, stresses, and strains
- ✓ Supports many failure criteria (default and advanced user control)
- ✓ Supports anisotropic matrix
- ✓ Generates material properties used with commercial FE software and has been validated for several classes of Ceramic Matrix Composites
    - ○ Oxide/Oxide
    - ○ SiC/SiC-MI
    - ○ SiC/CAS
    - ○ SiC/SiC-CVI
    - ○ SiC/S200(SiNC)

## ***Key Benefits:***

- ✓ Rapid assessment of properties
- ✓ Reduction in testing with cost savings
- ✓ Validated material library
- ✓ Strength allowable for reliability
- ✓ Identification of damage initiation/propagation to failure
- ✓ Identification damage/failure modes
- ✓ Results verified with test data

**AlphaSTAR Corporation**
Long Beach, CA, USA
alphastarcorp.com

## Modules

| | |
|---|---|
| • **Fiber/Matrix/Ply Calibration** | Reverse engineer the in-situ Young's modulus, Poisson's Ratio, Strength of transversely and isotropic fibers and isotropic matrix from tested in-plane ply properties. |
| • **Architecture/Fiber/Matrix Calibration** | Reverse engineer the braid architecture from coupon test data. It can be used for reverse engineering the in-situ Young's modulus, Poisson's Ratio, Strength of transversely and isotropic fibers and isotropic/anisoptropic matrix from tested in-plane laminate properties. |
| • **Ply Mechanics** | Verify ply properties from fiber and matrix constituent properties and variation in fiber and void volume ratio. The analysis relies on micro-mechanics theory. |
| • **Ply Characterization** | Graphically verify the variation in ply properties and dominant failure zones with variation in fiber and void volume fraction and loading direction orientation with respect to the fibers. |
| • **Laminate Mechanics** | Predict laminate level material properties using fiber/matrix, ply properties as input along with braid cards for fabric, woven or 3D architecture. Analysis relies on progressive failure analysis, micro-mechanics and classical laminate theory. |
| • **Material Non-Linearity** | Predicts the in-situ matrix stress strain curve from in-plane shear ASTM standard test data. The analysis can be used to reverse engineer any fiber or ply nonlinearity as well. The analysis relies on progressive failure analysis, micro-mechanics and classical laminate theory. |
| • **Progressive Failure** | Performs the analysis for the input using material degradation models and iterative process based on user input to ultimately predict the strength, modulus, and laminate and layer-by-layer damage evolution process. |
| • **Design Failure Envelope** | Predicts failure envelope for lamina or laminates based on the chosen failure criteria after the above calibration process. |
| • **Parametric Carpet Plot** | Predicts graphical representation of strength and other material properties of laminates containing symmetric and balanced plies in three different orientations. |
| • **A- & B-Basis Allowables Calculator** | Predicts A- and B-basis strength allowables based on simple test data. |
| • **A- & B-Basis Allowables Simulator** | Predicts A- and B-basis strength allowables based on material and fabrication uncertainty in the composite laminate material. You can directly enter the scatter from the unidirectional ASTM standard tests as the variation in the constituents. |
| • **Manufacturing Defects Mechanics** | Predicts effect of manufacturing defects; fiber waviness on ply level properties. |
| • **Manufacturing Defects Characterization** | Graphically predicts effect of manufacturing defects on ply level properties as a function of variation in fiber waviness. |
| • **Constituent Fatigue Life** | Reverse engineer in-situ stress versus cycles to failure curve for the matrix using in-plane shear, transverse tension, and longitudinal tension fatigue life curves obtained typically from ASTM standard tests or literature. |
| • **Progressive Fatigue Life** | Predicts fatigue life curve for laminates from ply or constituent level fatigue life input. |
| • **Recession (Ceramics Only)** | Recession occurs when surface material vaporizes due to high temperature and chemical reactions with the environment and material and is removed when gas velocities are sufficient to carry material away. This is accounted by this capability by providing users with thickness degradation of the material with respect to time. |
| • **Oxidation (Ceramics Only)** | Oxidation occurs when the composite is infiltrated by oxygen/moisture through diffusion. For example SiC reacts to form SiO2, which eats away fibers. In oxidation, initially weight increases due to diffusion/reaction, followed by weight loss due to volatilization. This is accounted by this capability by providing users with thickness degradation of the material with respect to time. |
| • **Strain Rate Effect** | Calculates Strain Rate of materials/deformation for many materials. |