Heavy Vehicle Propulsion Materials

Microstructure-based FEA (μ-FEA)

Background

Microstructure-based FEA (μ-FEA) is a copyrighted, Oak Ridge National Laboratory (ORNL)-developed, LabView-executable program that enables stress analysis of real and simulated material microstructures via direct integration with ANSYS finite element analysis (FEA) software.

μ-FEA enables the user to capture the complexity of actual microstructures through simple and automated input of digital images taken with a SEM or optical microscope.

μ-FEA enables the user to readily examine and interpret resulting stresses in microstructures or compare stresses through simple changes in boundary or initial conditions or architectures. "What-if?" analysis is easily performed.

Because ANSYS is used as the FEA Solver, the full multi-physics suite of ANSYS features is exploitable (e.g., linear and nonlinear properties, steady-state and transient analysis, piezoelectric effects, phase changes and swelling, sensitivity and probabilistic analysis, etc.).

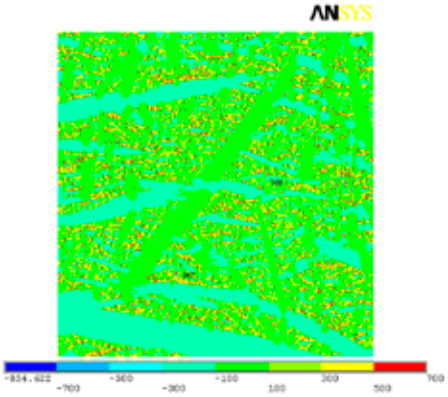

Figure 1. *Thermoelastic residual stresses in an Si_3N_4 microstructure.*

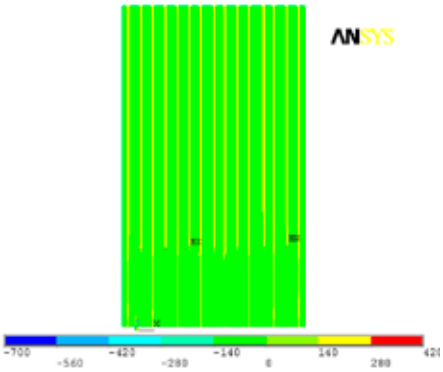

Figure 2. *Thermoelastic residual stresses at the margin in a PZT piezostack.*

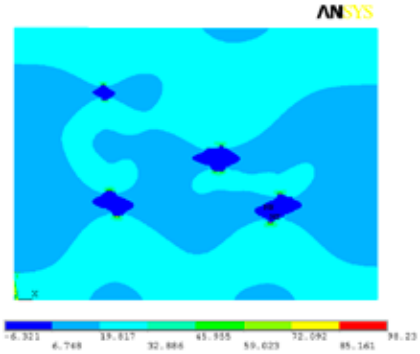

Figure 3. *Stresses about microstructural pores in a poled PZT piezoceramic*

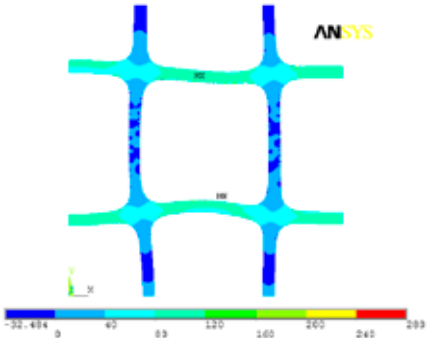

Figure 4. *Residual stresses about a diesel particulate filter unit cell.*

If the user can take a picture of a microstructure, then μ-FEA can be used to help analyze it.

Benefits

- Microstructural engineering.
- Device design optimization.
- "What-if?" design refinements.
- Virtual characterization.

Technology

μ-FEA is currently used to explore stress fields and for microstructural engineering in material systems and devices relevant to a variety of transportation-related applications:

- Tribological coatings
- Thermal barrier coatings
- Piezoelectric devices
- Thermoelectrics
- Advanced silicon nitrides
- Diesel particulate filters
- Graded microstructures resistant to contact damage

Commercialization

μ-FEA software was copyrighted in June 2005.

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.