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U.S. Army Research, Development and Engineering Command

Solving the Inverse Problem of Resonant Ultrasound Spectroscopy on Dumbbell-shaped Compression Samples Using COMSOL Multiphysics ®

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COMSOL CONFERENCE BOSTON2013

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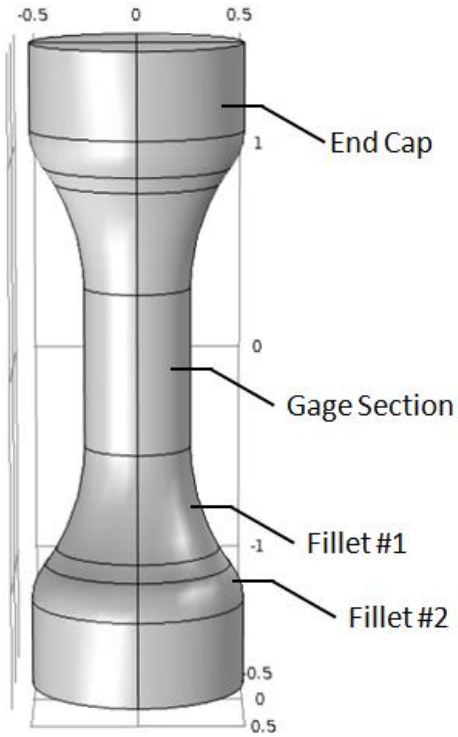
Introduction

- Accurate compressive strength measurements are important when characterizing advanced ceramic materials.
- Dumbbell geometry encourages compressive fracture to occur in the gage section.
- Machining defects may introduce fracture nucleation sites.
- A strength value can be obtained, but what about the elastic properties?



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Resonant Ultrasound Spectroscopy (RUS)

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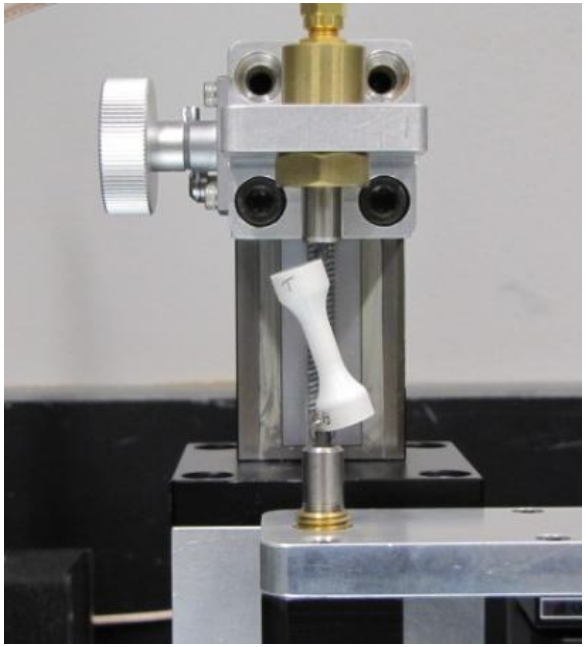
- **Resonant Ultrasound Spectroscopy is an extremely accurate method for obtaining the elastic properties of a specimen.**
- **Resonance frequencies of a sample are determined by geometry, density, and the elastic properties.**
- **Elastic tensor is found by finding the best match between a numerical model and the resonance peak locations.**



Alumina sample between transducers of the Magnaflux Quasar RUSpec system.

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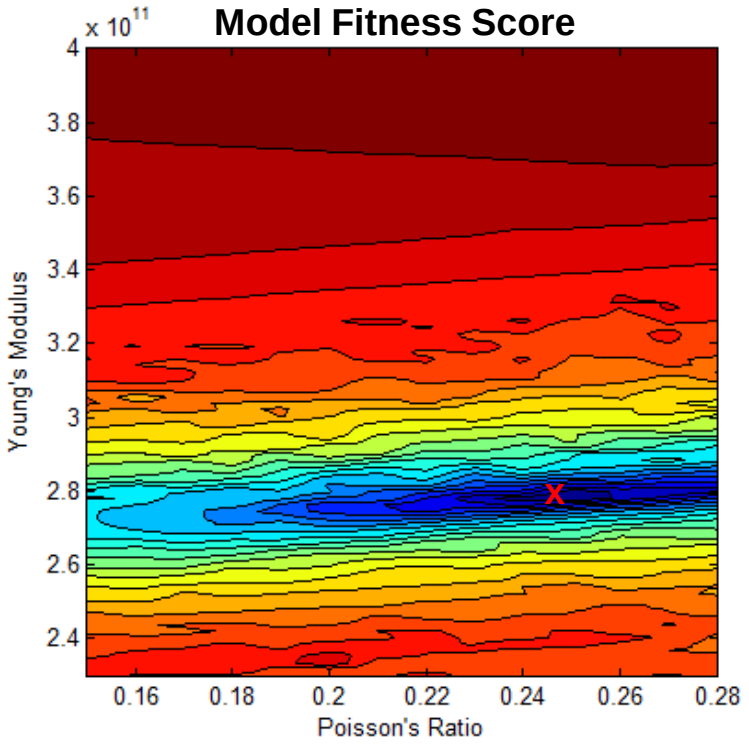
COMSOL Modeling

- **COMSOL, in coordination with MATLAB provide an ideal environment for solving the inverse problem.**

- **Method:**
  - 3D geometry parameterized in COMSOL
  - Structural mechanics module physics definitions (linear elastic solid, free boundaries)
  - Model is solved in COMSOL through the MATLAB LiveLink
  - Jonker-Volgenant algorithm for solving the linear assignment problem of matching the modeled eigenfrequencies to the most appropriate measured resonance frequencies is used to determine a fitness score for the current model
  - Smallest score indicates best match (optimization problem)



Response surface of the mismatch score between experimental and simulated resonance frequencies.

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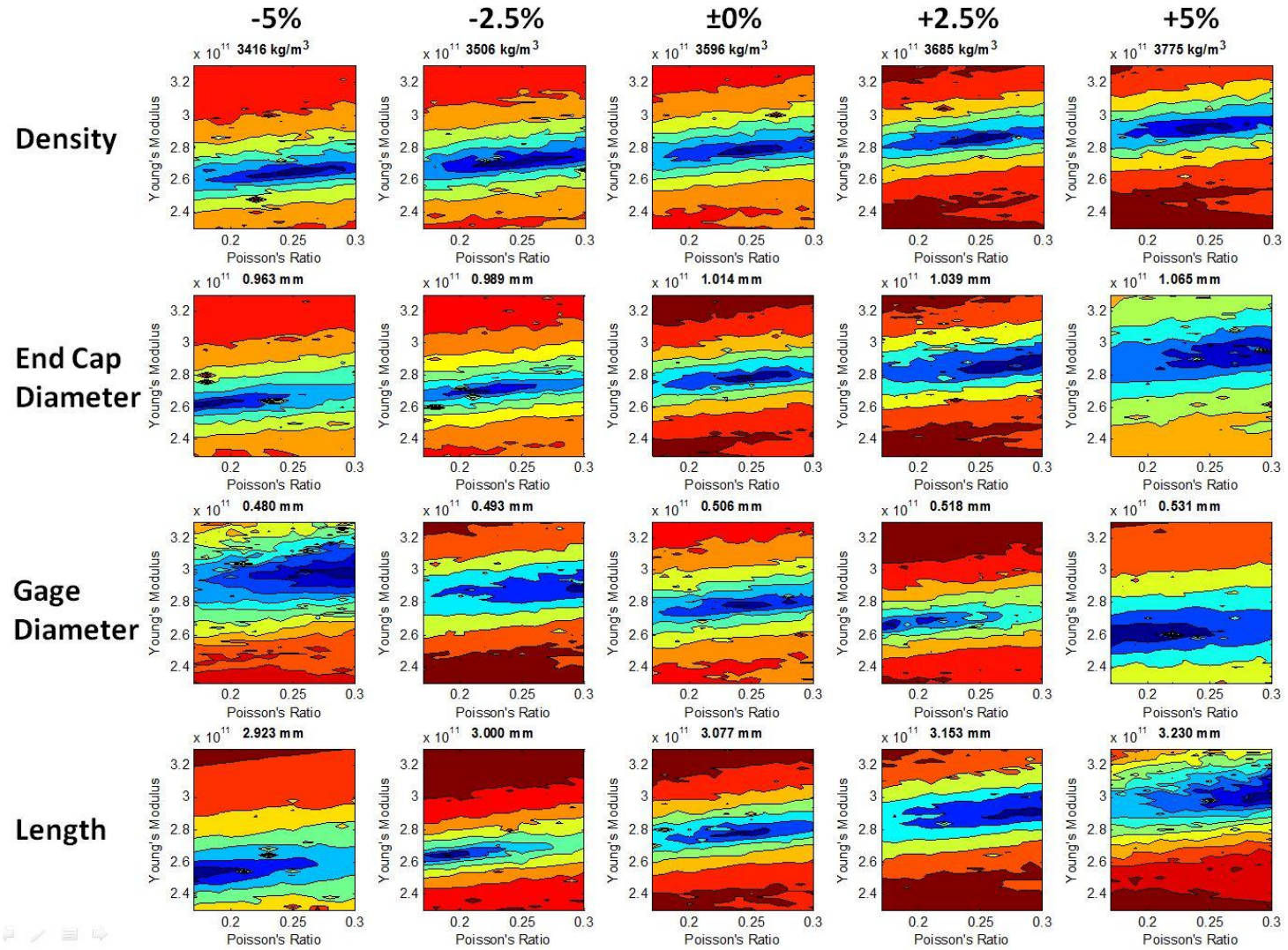
Sensitivity Analysis

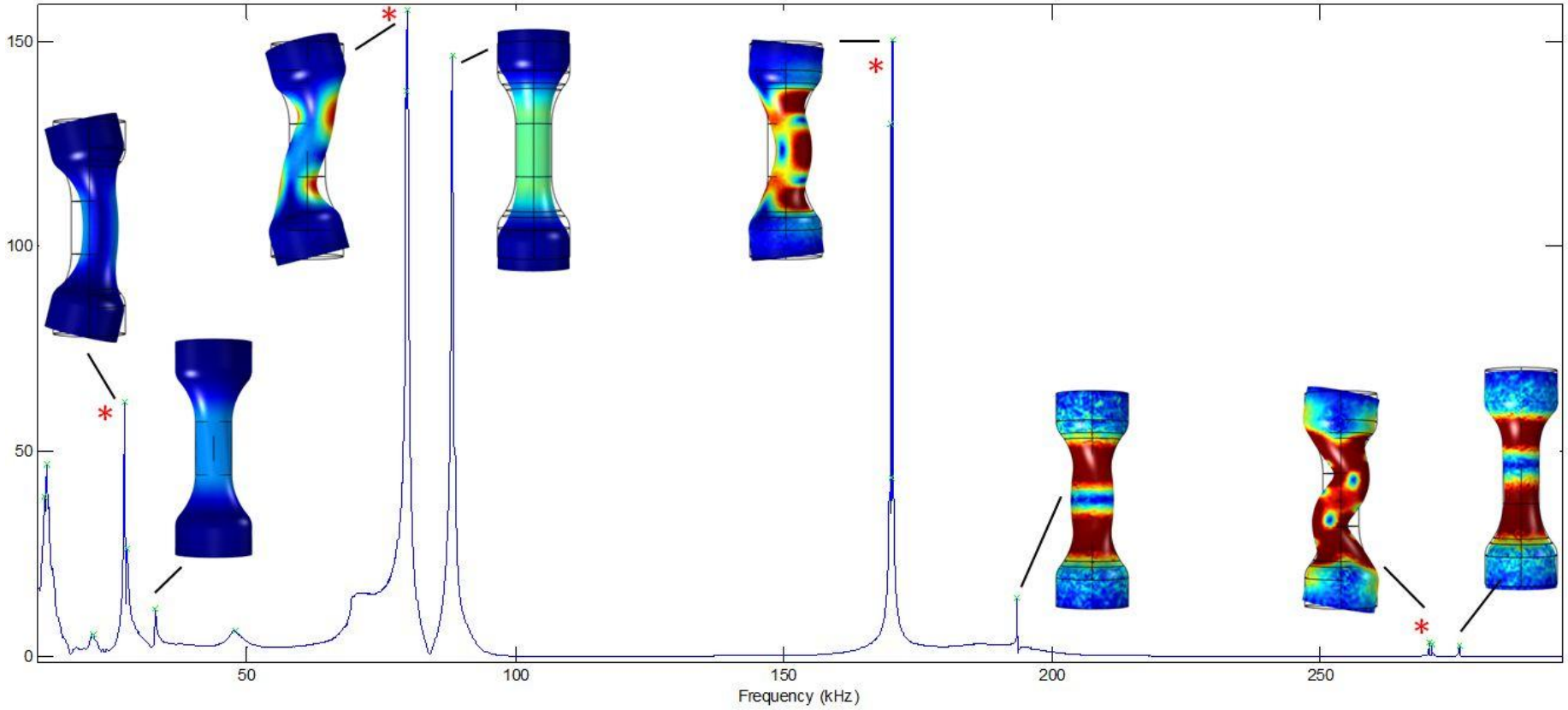
Measurement Error

Measured Model Parameters



Vibrating Mode Modeling

Measured Spectrum and Vibrating Modes



* Degenerate Bending Location

Color indicates von Mises stress

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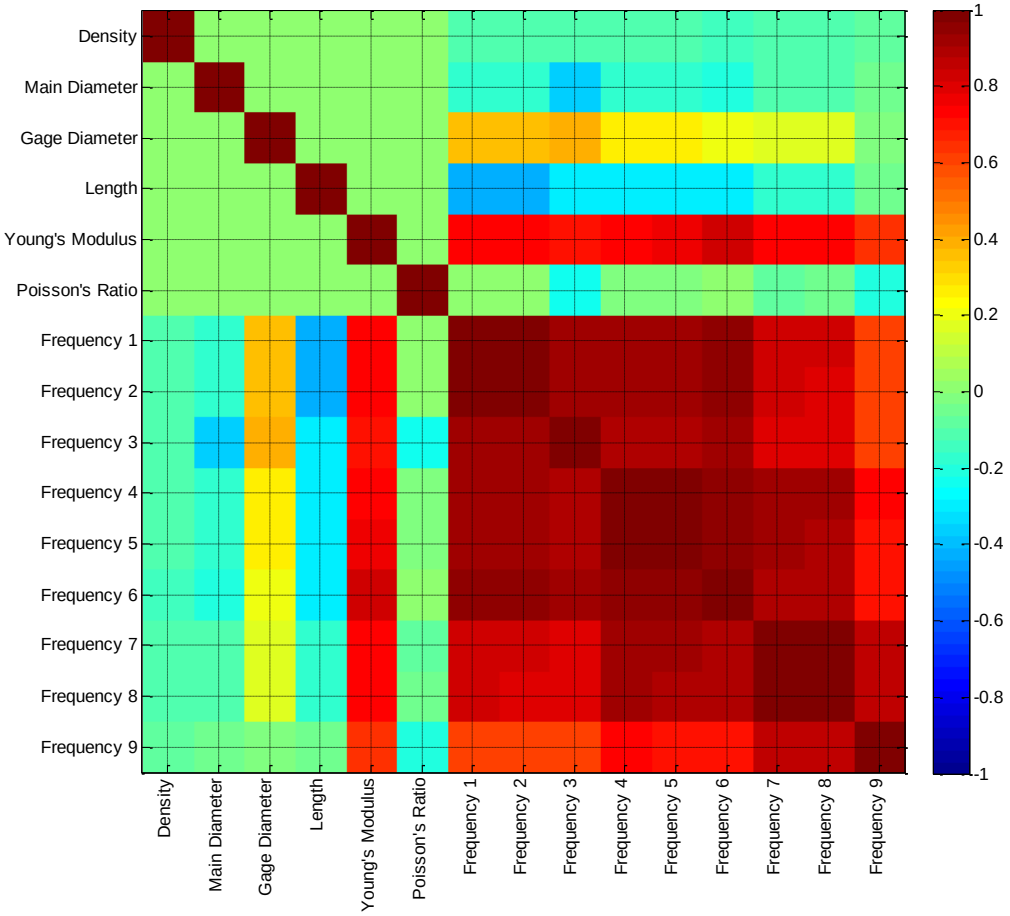
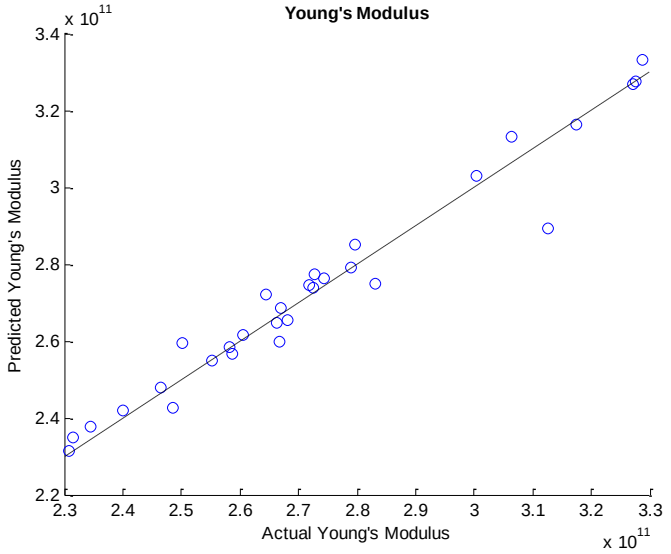
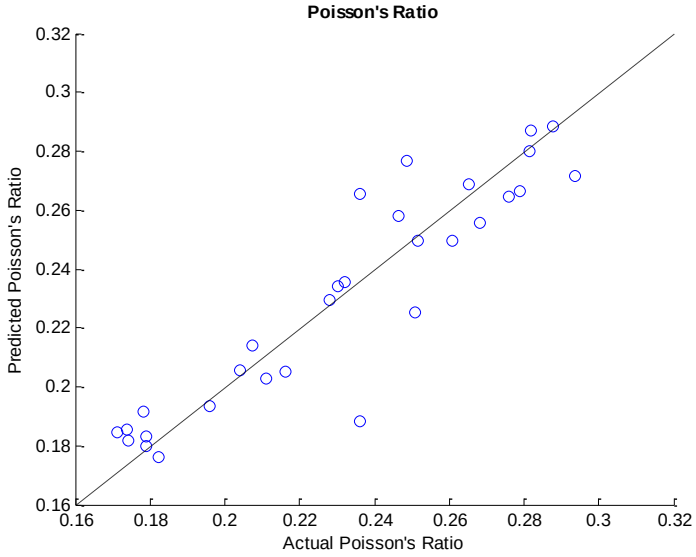
Linear Model Development

Model Parameter Correlation







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Thank You!

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QUESTIONS?

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