SPAWAR
Systems Center
ATLANTIC

Space and Naval Warfare Systems Center Atlantic

Analysis of 3-D Printed Structural Components for Cube Satellites

COMSOL CONFERENCE
2014 BOSTON

Presented by

Claudio Herzfeld

NISE TIKI 2014 Research

SPAWAR Systems Center ATLANTIC

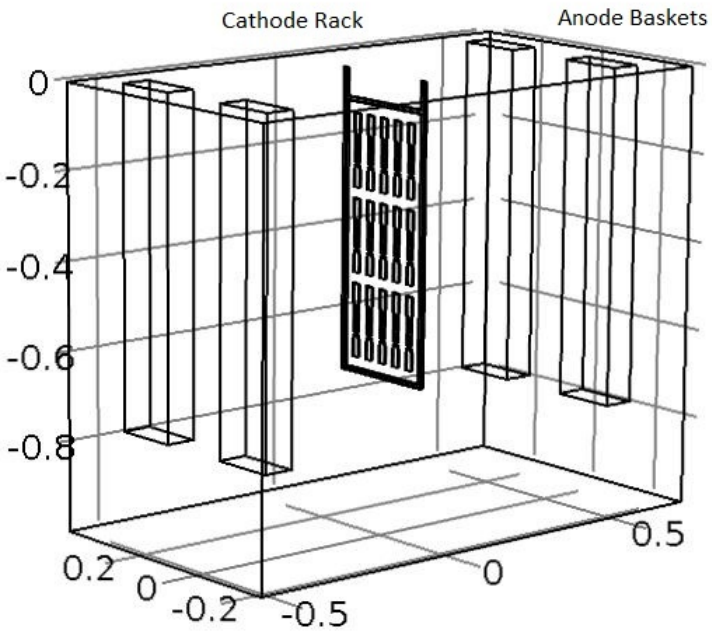
Objectives

- Solve a Multiphysics problem using COMSOL

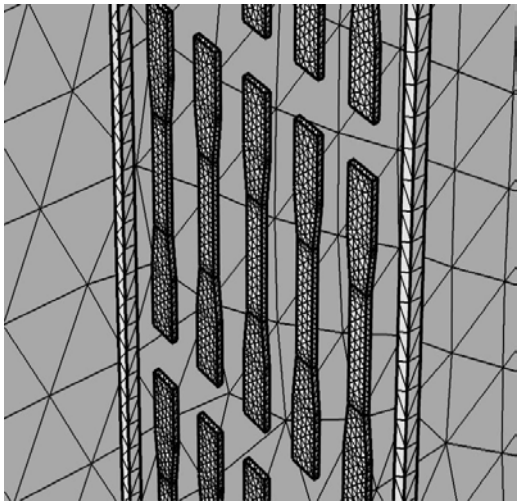
- Import and manipulate multiple 3-D CAD geometries
- Use Electrodepostion module to electroplate Cu and Ni on 3-D printed thermoplastic components
- Use Structural Mechanics module to analyze stress distribution under load
- Validate model

Model Geometry

Fig. 1 Electroplating Tank Configuration



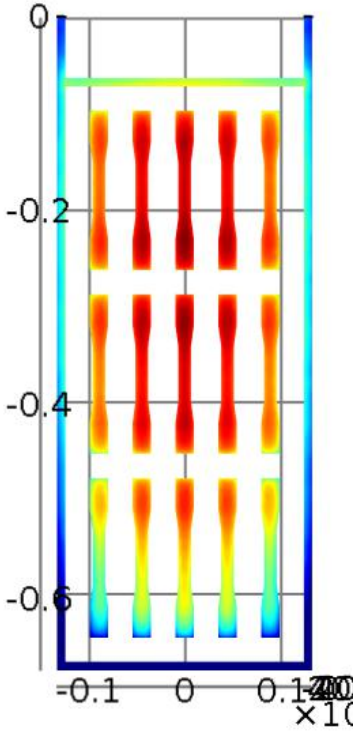
Fixed CAD Import Geometry: Plating Tank
Variable CAD Import Geometry: Tensile Bars



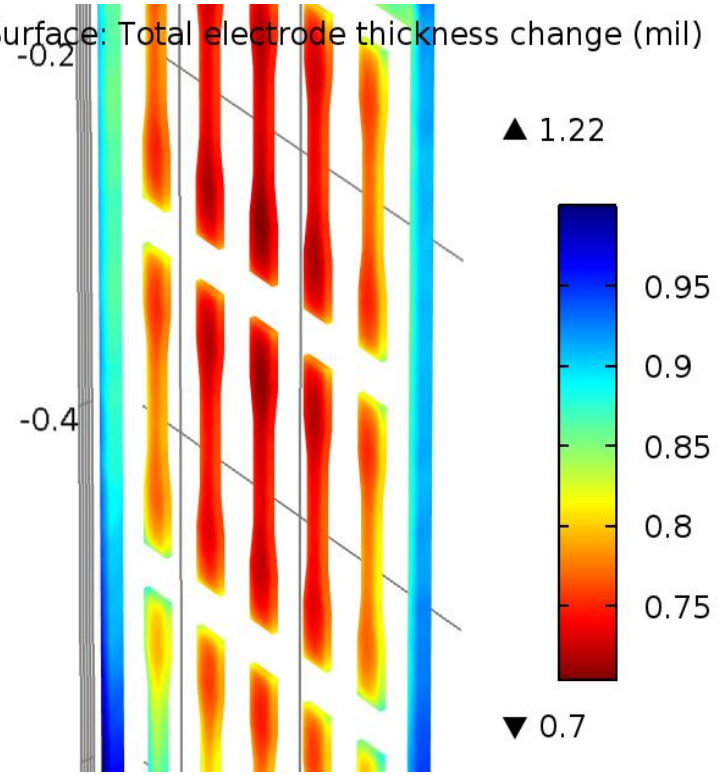
Physics controlled mesh

Copper Electrodeposition Results

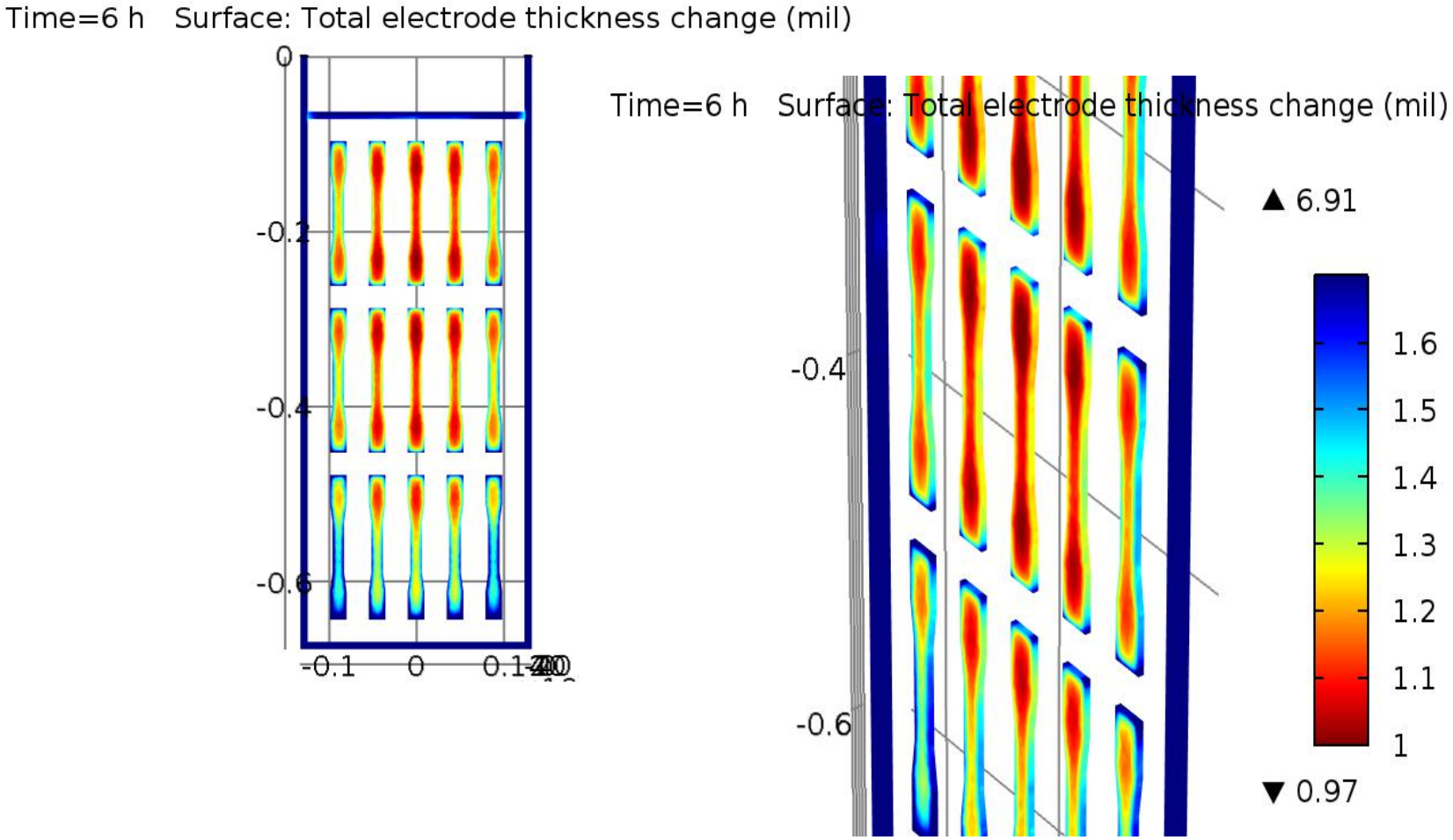
Time=3 h Surface: Total electrode thickness change (mil)



Time=3 h Surface: Total electrode thickness change (mil)



Nickel Electrodeposition Results

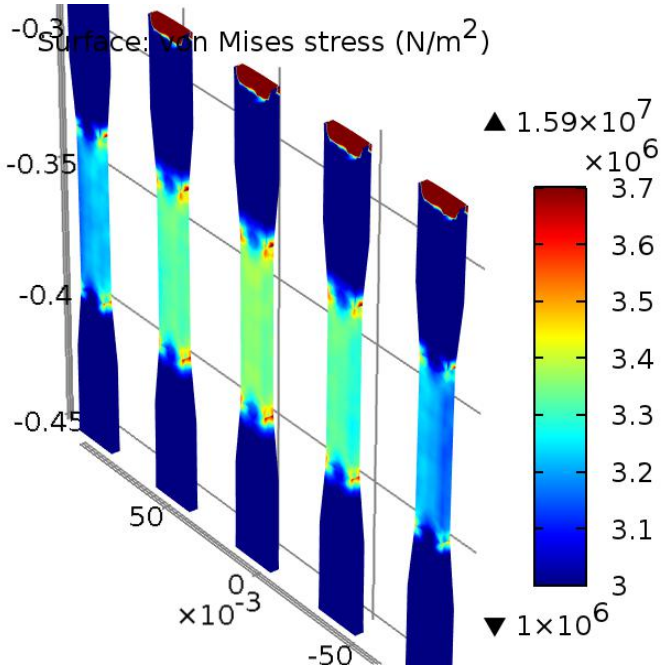


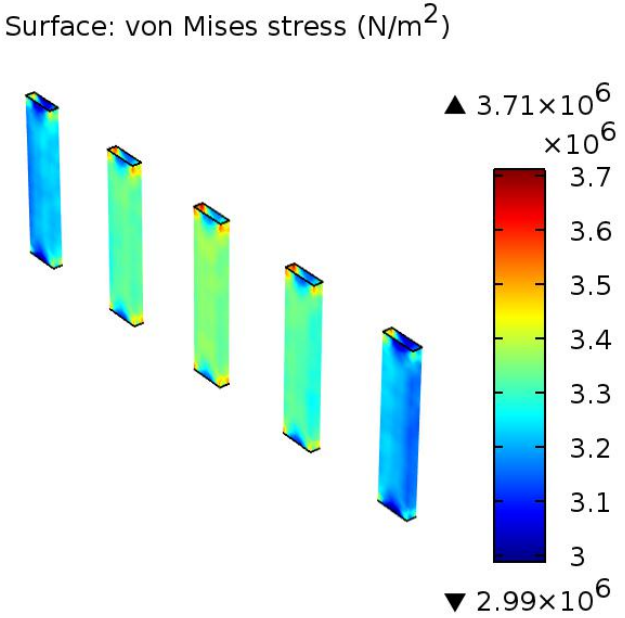
SPAWAR Systems Center ATLANTIC

Electrodeposition Primer

- Copper plates faster and more uniformly than nickel
- Controlling plating uniformity requires controlling plating current distribution with modeling
- Use field control elements
- Last resort for better uniformity – use electroless plating

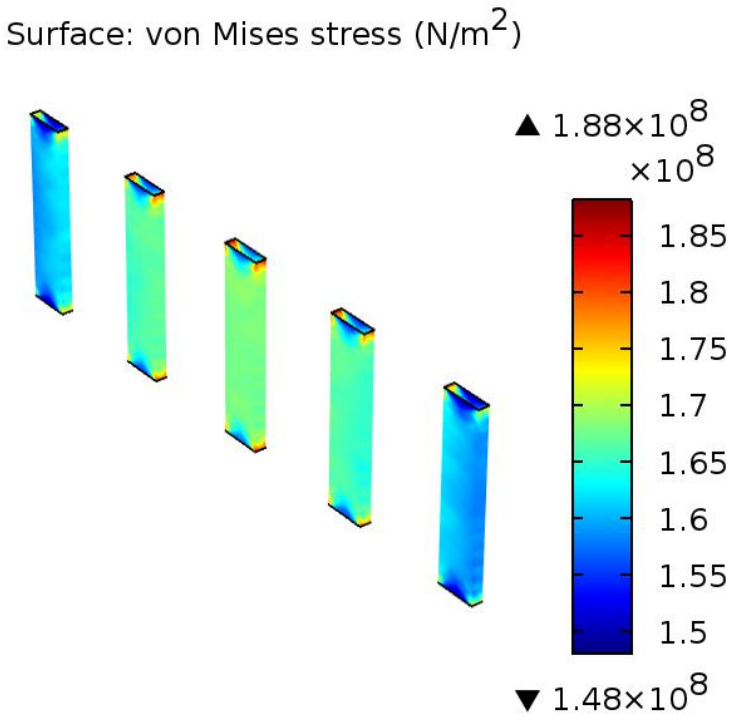
Structural Mechanics Results

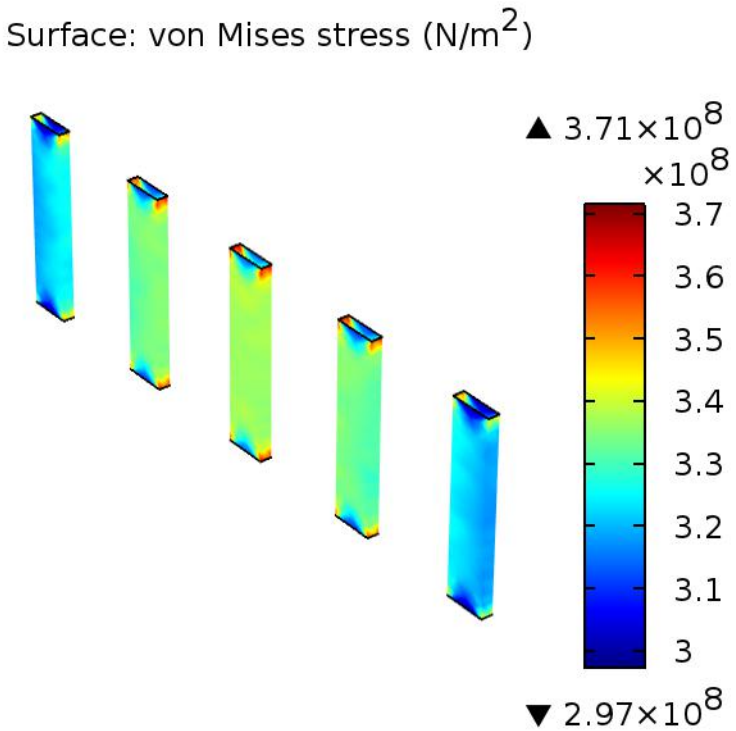




Linear Elastic Model Ultem 9085 Core

Structural Mechanics Results

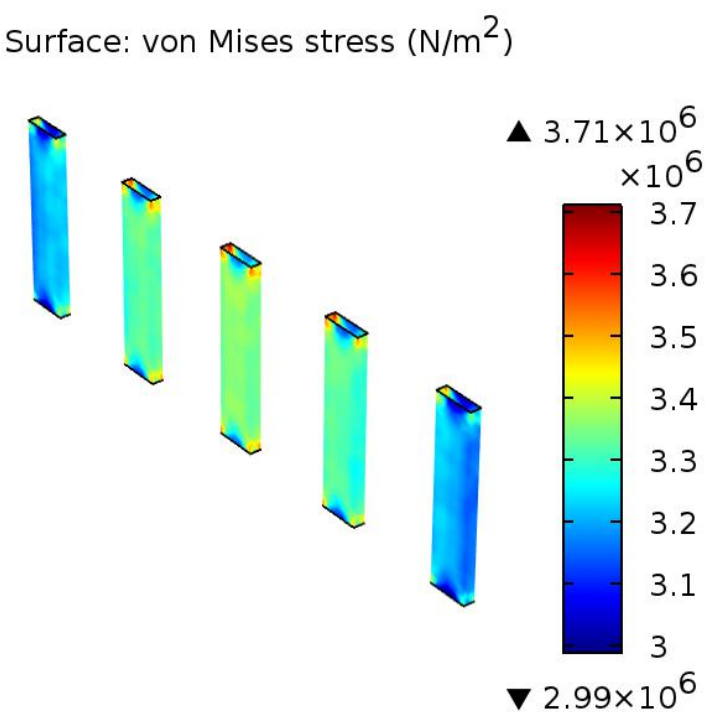


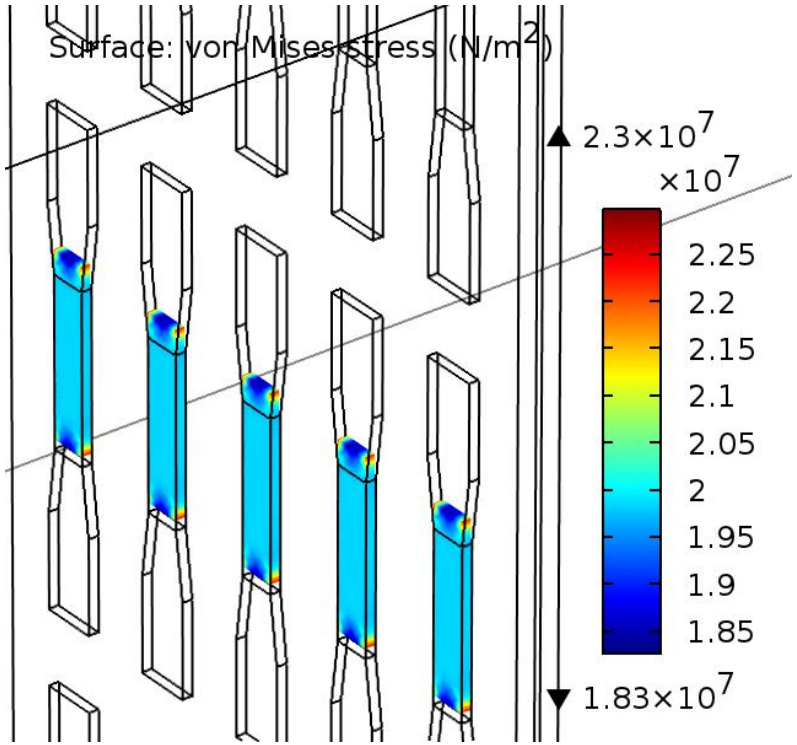


Linear Elastic Model 3 mils Cu Shell

1 mil Ni Shell

Structural Mechanics Results





Linear Elastic Model Ultem Core

Ultem 9085 No Metal Shells

SPAWAR Systems Center ATLANTIC

Structural Mechanics Results

- Stress in the thermoplastic core is 50-100x lower than in the electroplated shells, the shells carry the applied load
- Stress and principal strain are 1/6th the values compared to the unplated thermoplastic FDM material
- Results are limited to the linear elastic range of the materials
- Plating metal shells may mitigate 2:1 anisotropic mechanical properties for FDM material

SPAWAR Systems Center ATLANTIC

Future Work

▼ Validate the linear elastic model thru testing

- Test Ultem 9085 specimens
- Test Cu plated specimens
- Test Cu + Ni plated specimens

▼ Extend the model to non-linear materials

- Use tertiary electrodeposition model
- Use linear material nodes with layers, not shells
- Extend model to non-linear materials