Creep Modeling Using Plate Theory
Shankhadeep Das, Sanjay Mathur and Jayathi Y. Murthy
Purdue University

Objective: To Model Creep in RF MEMS Devices Using Finite Volume Method (FVM) Based Mindlin-Reissner Plate Theory

- Use finite volume method to study creep deformation of RF MEMS devices using Mindlin-Reissner plate theory
- Implement a general non-linear stress-strain rate constitutive law in the FVM plate model to characterize any creep mechanism
- Study creep in fixed-fixed plates for a range of aspect ratios to study the applicability of plate model for RF MEMS
- Compare accuracy and CPU cost for creep modeling with plate model and full 3D FVM structural model
- Study Coble creep in nanocrystalline nickel RF MEMS devices
- Compare numerical result for long-term creep behavior of frogleg device with experimental data

Conclusions
- FVM solver for creep modeling in RF MEMS has been developed
- The solver models RF MEMS device as a thin plate and uses Mindlin-Reissner plate theory
- The plate model accurately predicts creep in thin RF MEMS devices
- The computation advantage with plate model over full 3D FVM structural model increases with an increase in aspect ratio
- The solver has been applied to study Coble creep in frogleg RF MEMS device made of nanocrystalline nickel

References

Plate Model Overview

- Solve for vertical deflections and rotations about x and y axes
- Balance moments about x and y axes and force along the z-axis
- Assume plastic deformation occurs only due to bending
- Completely linearize elastic part of stress tensor
- Model contribution due to creep using an explicit Euler procedure
- Resolve plate thickness to store stress and plastic strains

Creep in Fixed-Fixed Plates
- Plate model accurately predicts creep for thin RF MEMS devices
- The computational advantage with plate model over full 3D FVM structural model increases with an increase in aspect ratio

<table>
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<th>L/h</th>
<th>Percentage Error</th>
<th>Plate Model CPU Time (hrs)</th>
<th>Structural Model CPU Time (hrs)</th>
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Percentage error in creep deformation at time t = 500 hrs

Creep Deformation in the Frogleg Device
- For A = 75x10⁻⁵/hr, simulated plate deflection matches well with experimental data

Stresses in the Frogleg Device
- Stresses mainly carried by the legs of the device
- Stress concentration at the corners
- Simplified beam models insufficient for creep modeling of the device

Future Work
- Extend to PRSIM device creep data
- Extend FVM-based plate model to study deformation of curved RF MEMS devices
- Predict creep in PRISM device for range of voltages

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References