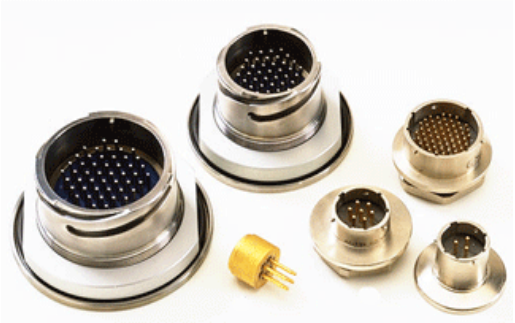
SAND2017-5423C

Assessing sealing glass equivalency based on viscoelastic behavior



Ryan Jamison, Brenton Elisberg, Kevin Troyer, Mark Stavig, & Kevin Ewsuk

Monday, May 22, 2017

PACRIM 12 & GOMD 2017

Waikoloa, HI, May 21-26, 2017

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Equivalent Sealing Glasses

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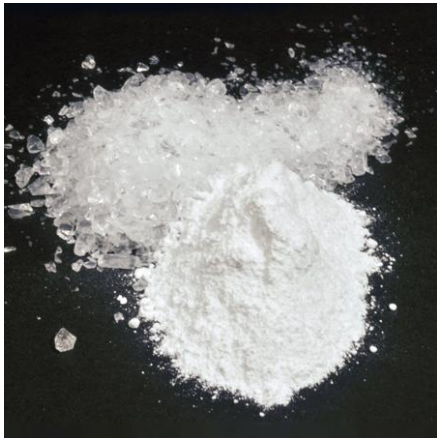
- What is Corning 9013?



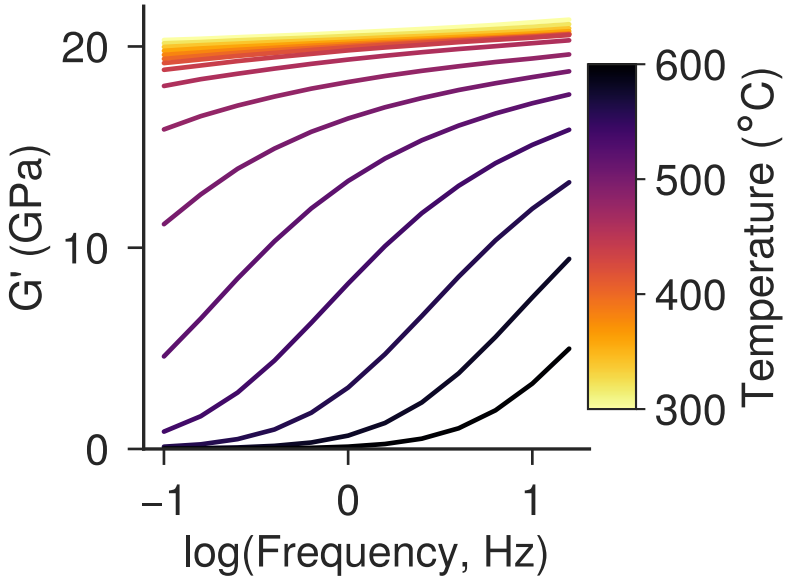
corning.com

- How do we evaluate equivalence?

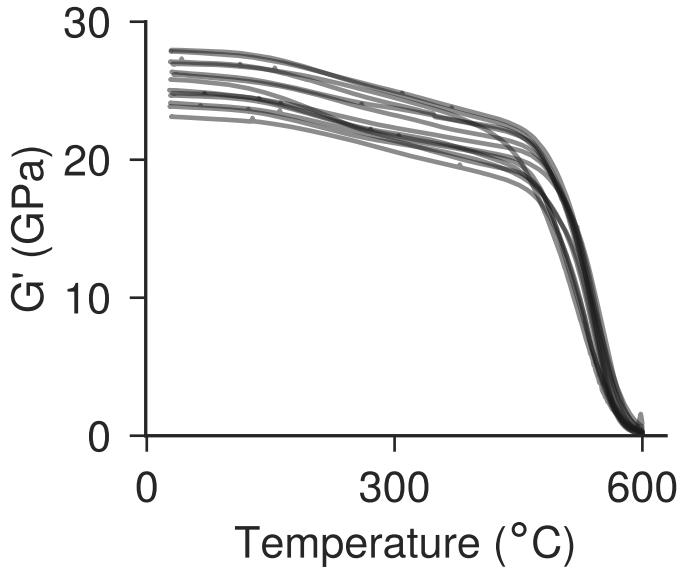
1 - Schott Glass 8061	2 - MRG AB88
3 - Elan 5	4 - Elan 13
5 - Community Glass Produced 8061	6 - Community Glass Produced 930

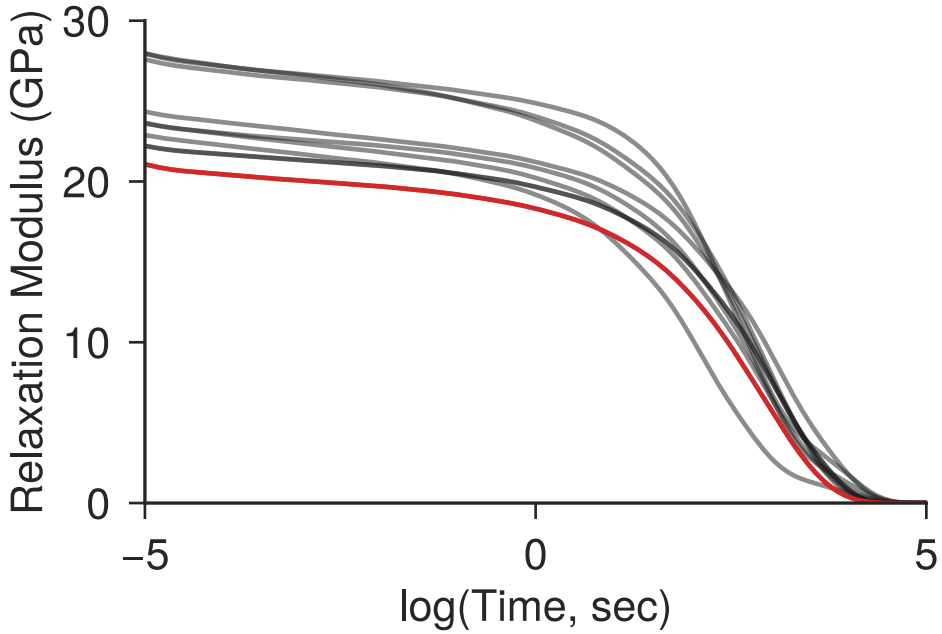
- What about viscoelastic behavior?

Shear Spectrum Characterization

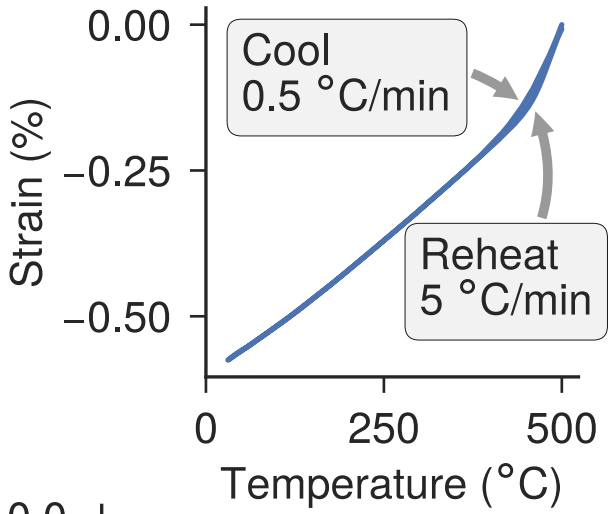


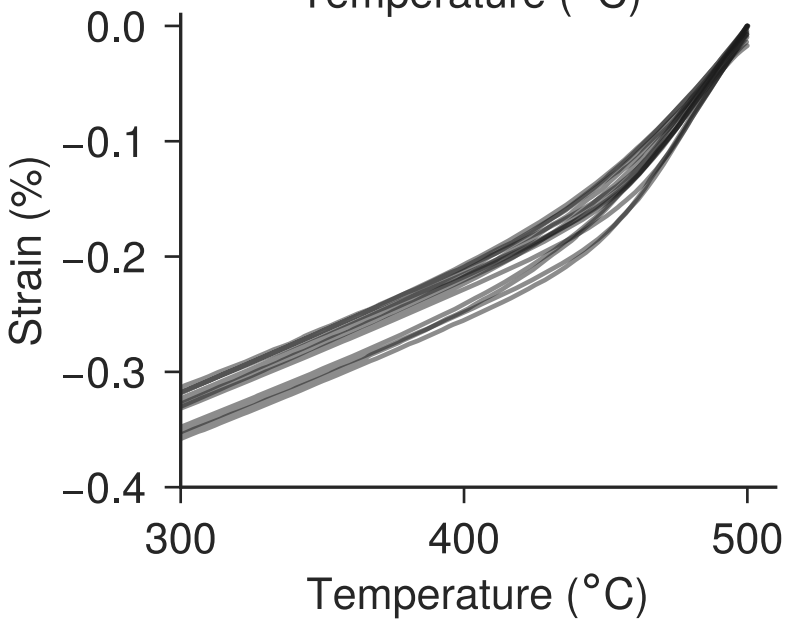
- Isothermal frequency sweeps
- Constant frequency temperature sweeps



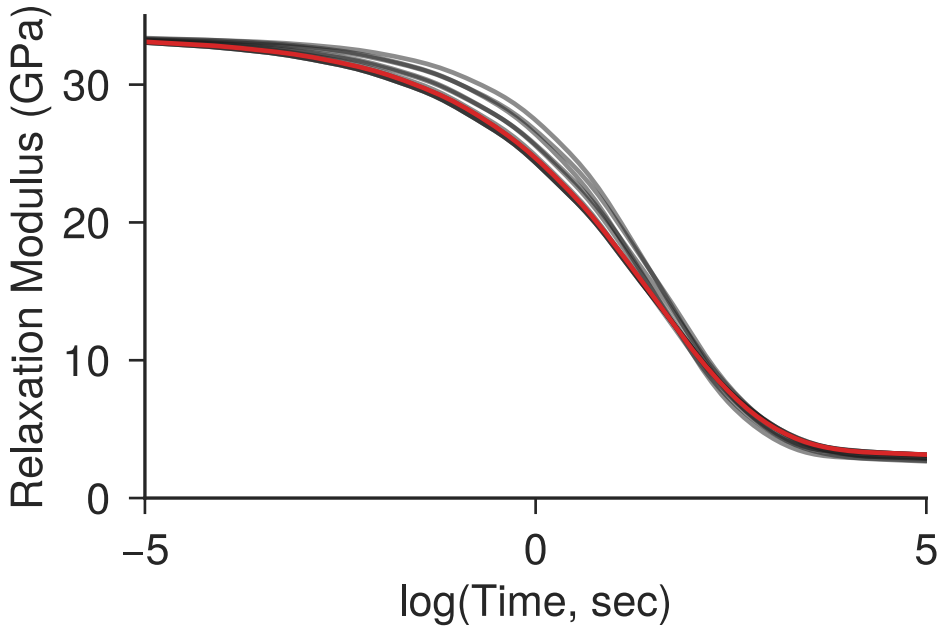


Bulk Spectrum Characterization

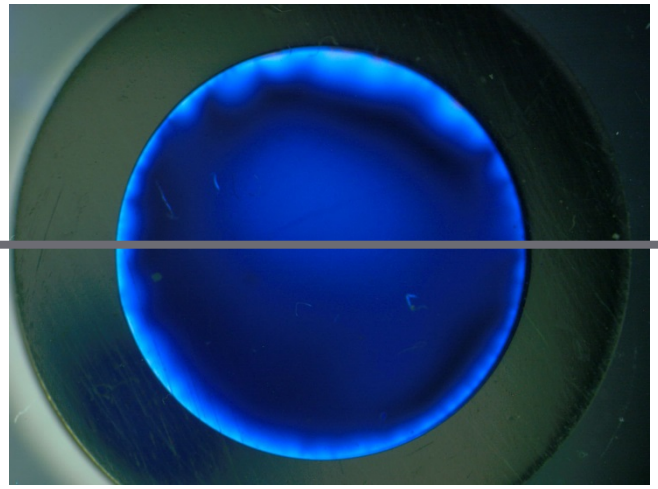




- K_∞ and K_g assumed consistent
- Multiple thermal strain measurements



Model Compression Seal



Concentric seal geometry

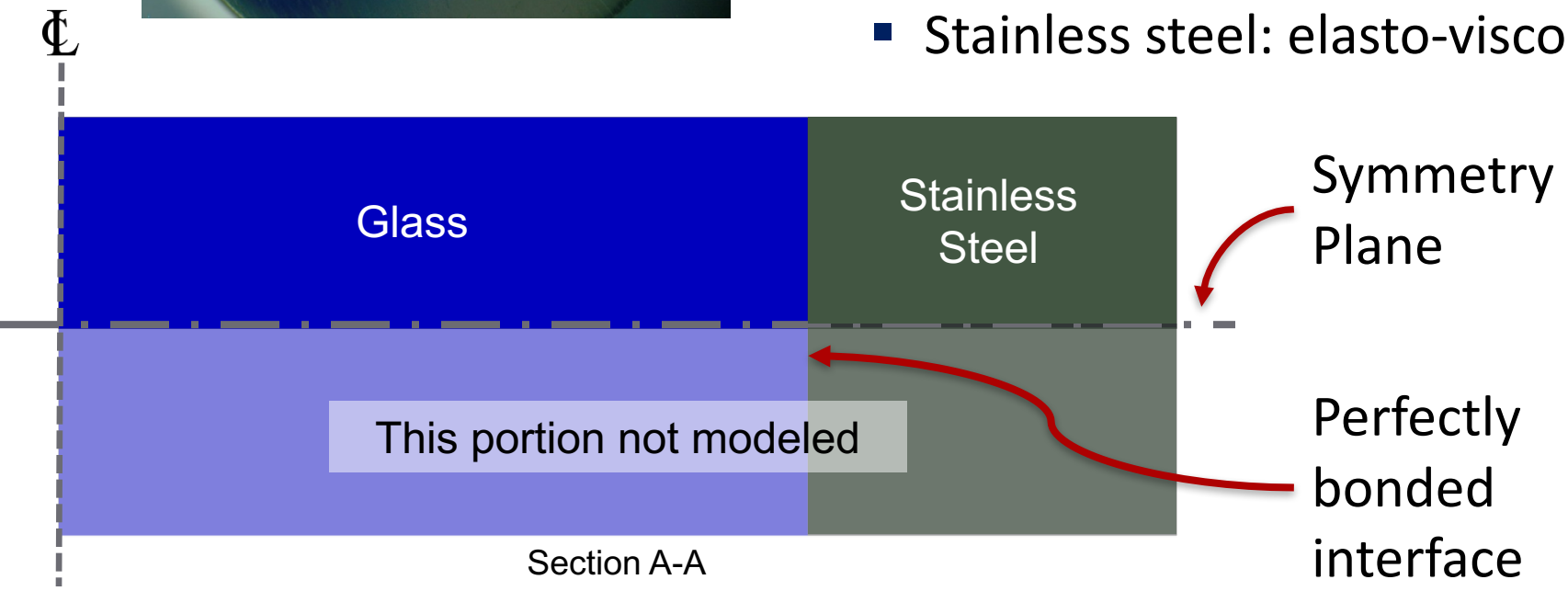
- Shell OD = 16.1 mm, ID = 10.8 mm
- Glass thickness = 3.1 mm

Thermal processing

- Cool from 600 °C to 20 °C

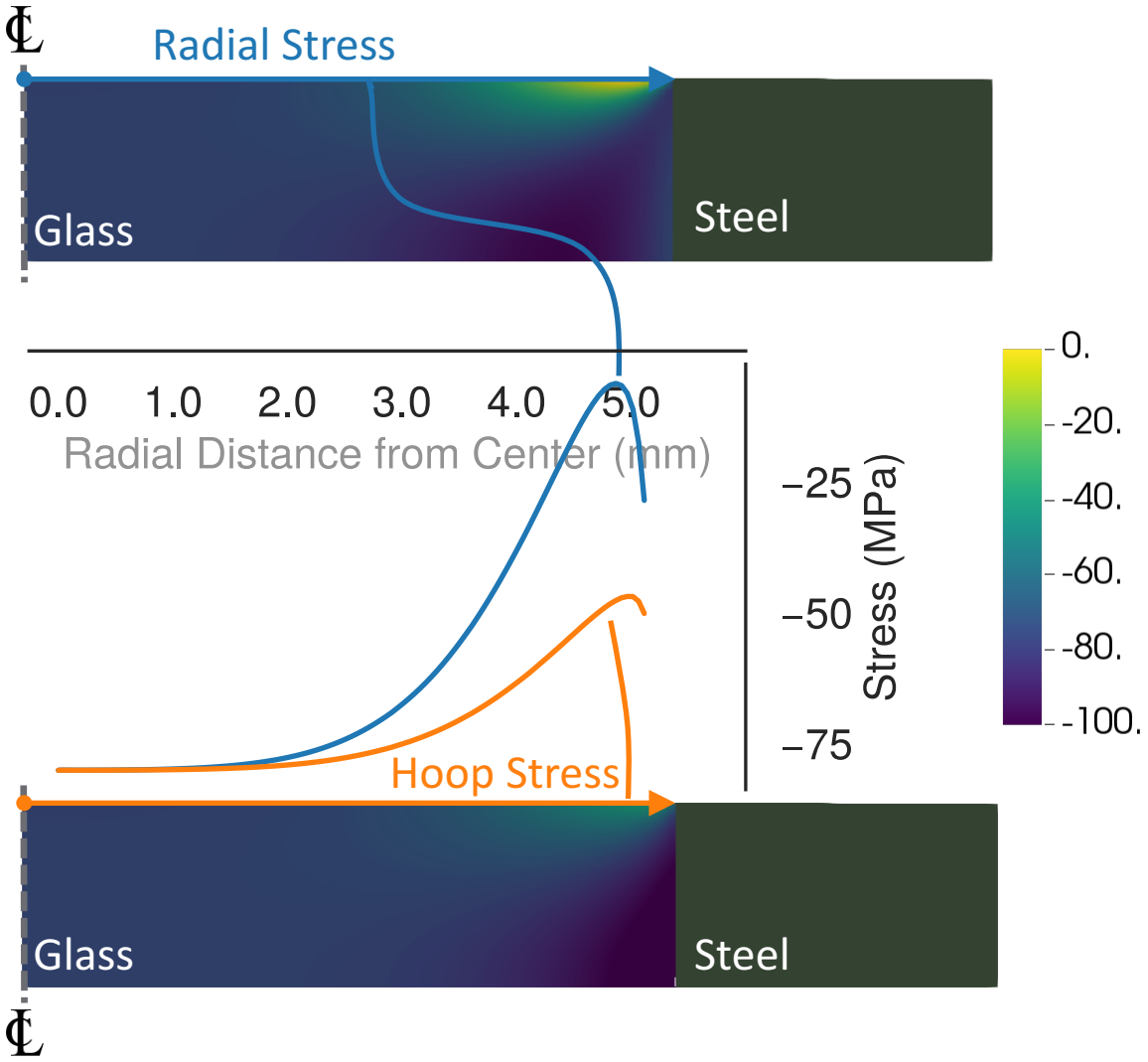
Material models

- Glass: thermo-viscoelastic [1]
- Stainless steel: elasto-viscoplastic



[1] R.S. Chambers, *et al.,* Characterization and calibration of a viscoelastic simplified potential energy clock model for inorganic glasses, *J. Non-Cryst. Solids* (2015)

Baseline Model Response



Radial Stress

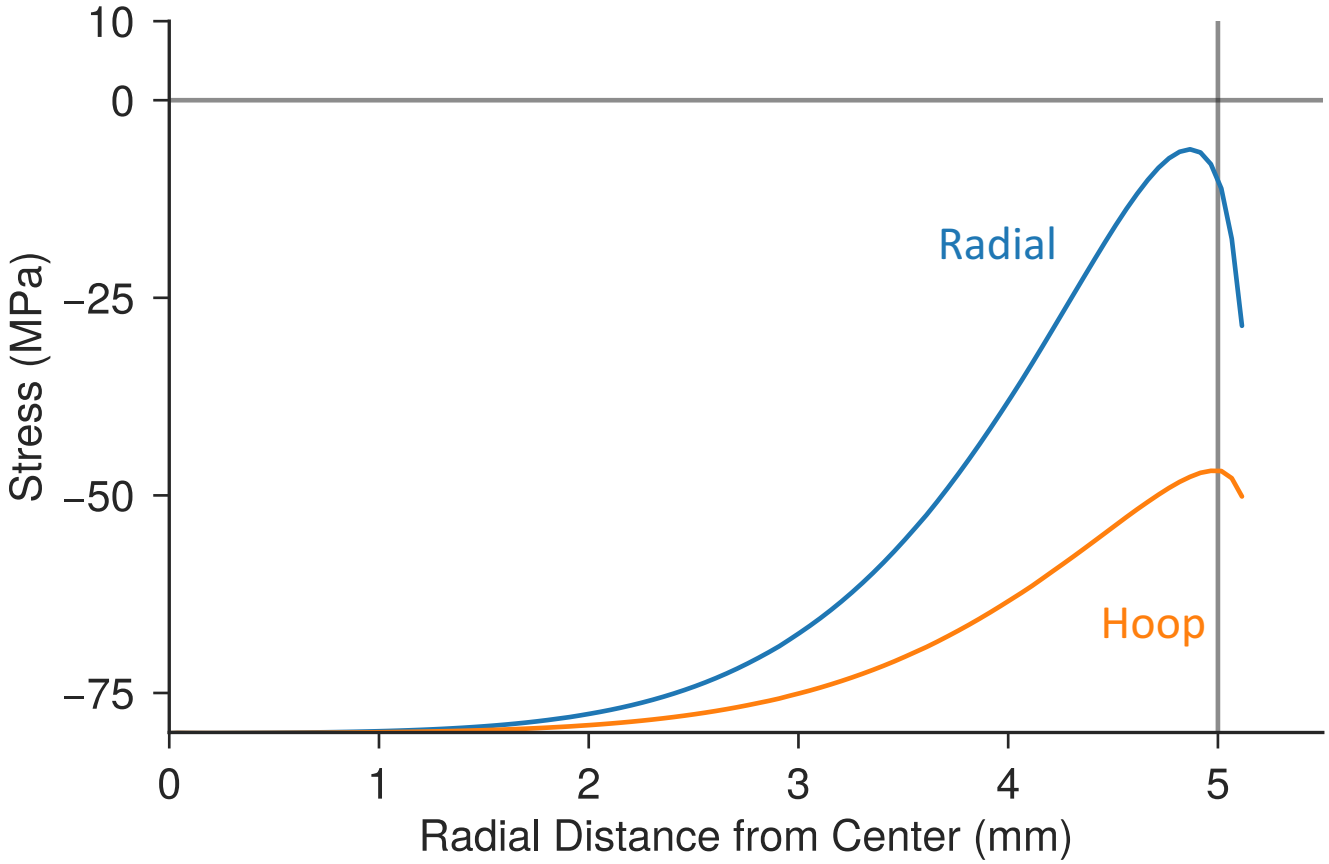
- The glass is in radial compression
- The radial stress on the surface near the shell is the highest

Hoop Stress

- The glass is in hoop compression

Residual Stress After Sealing Cycle

- There is a small variation in the hoop stress
- The largest variation in stress occurs in the radial direction near the shell-glass interface



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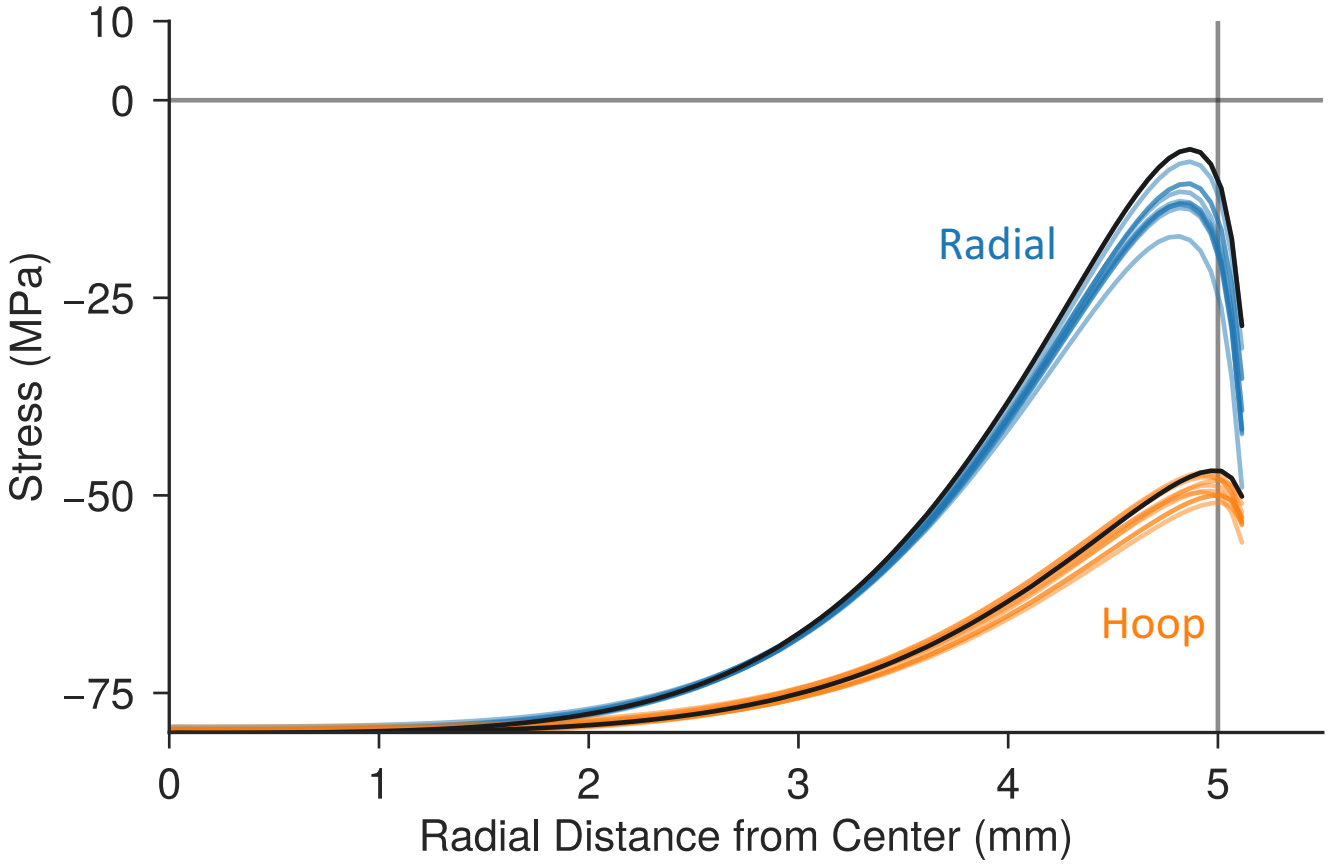

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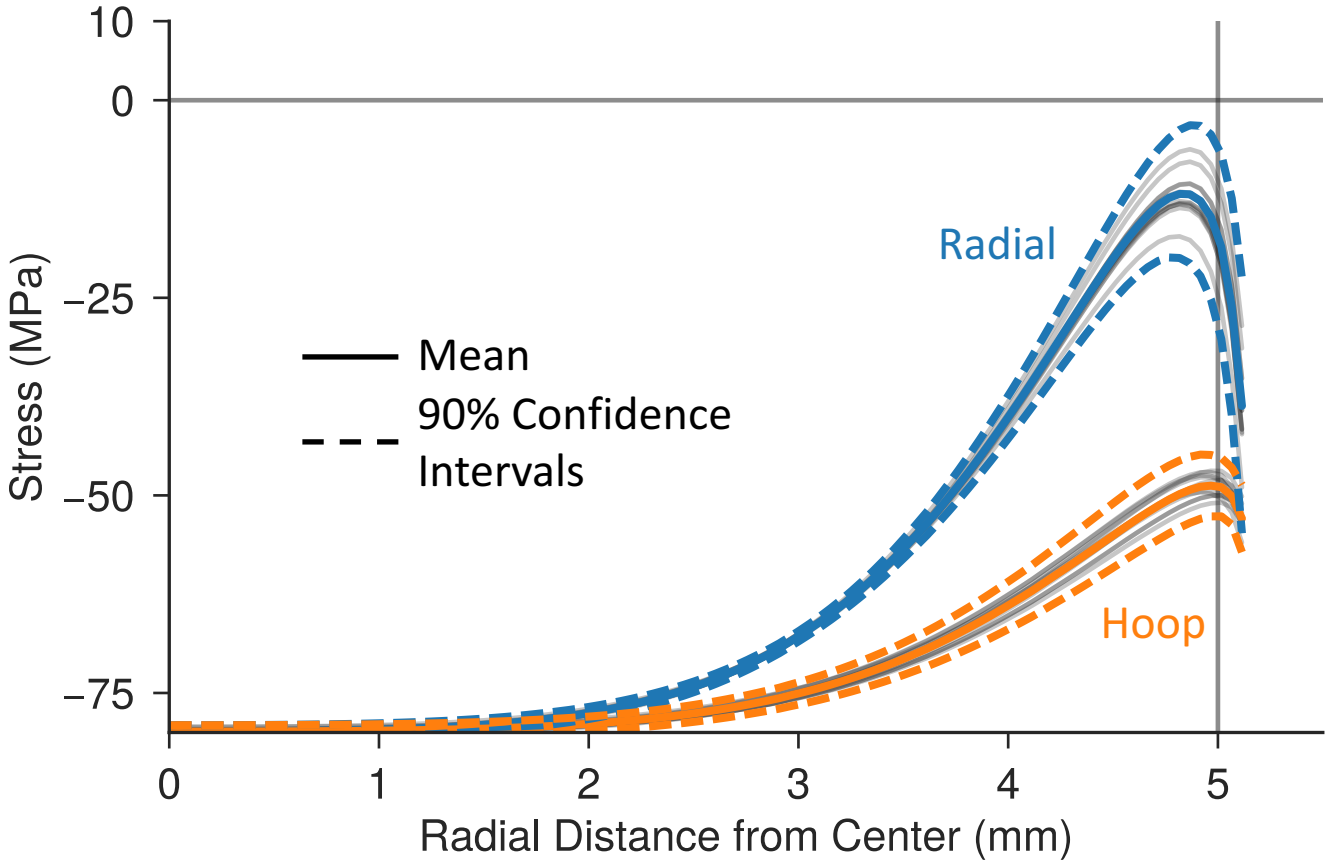

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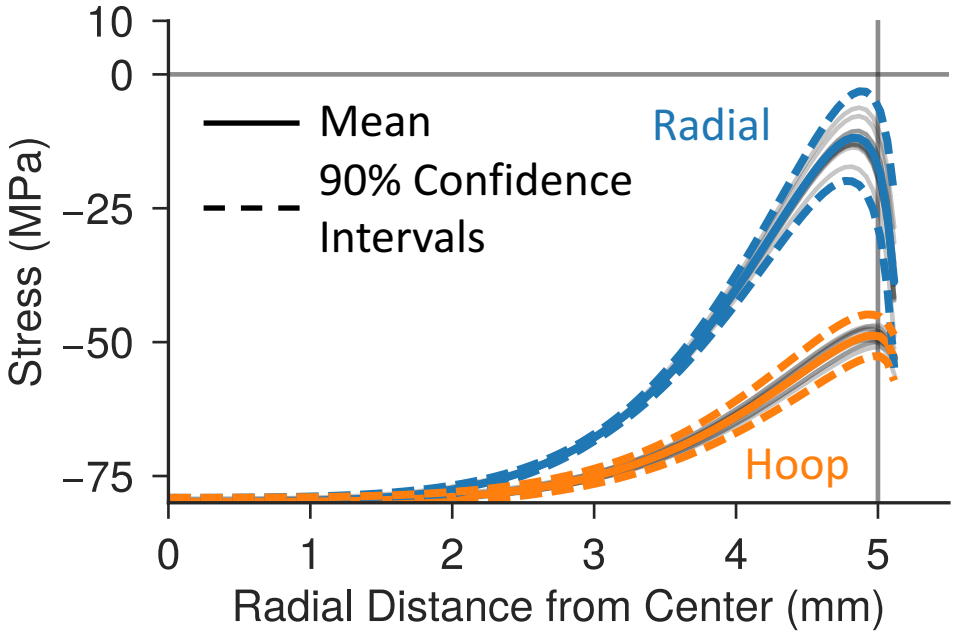
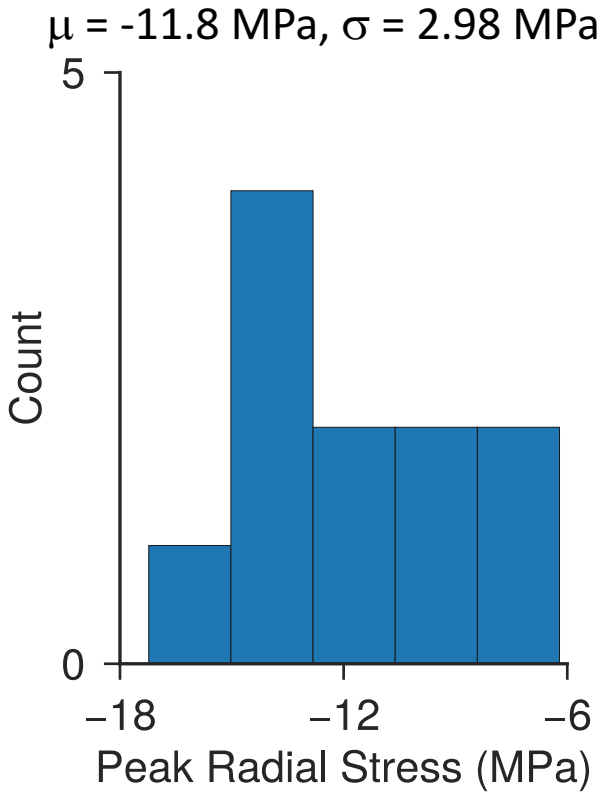
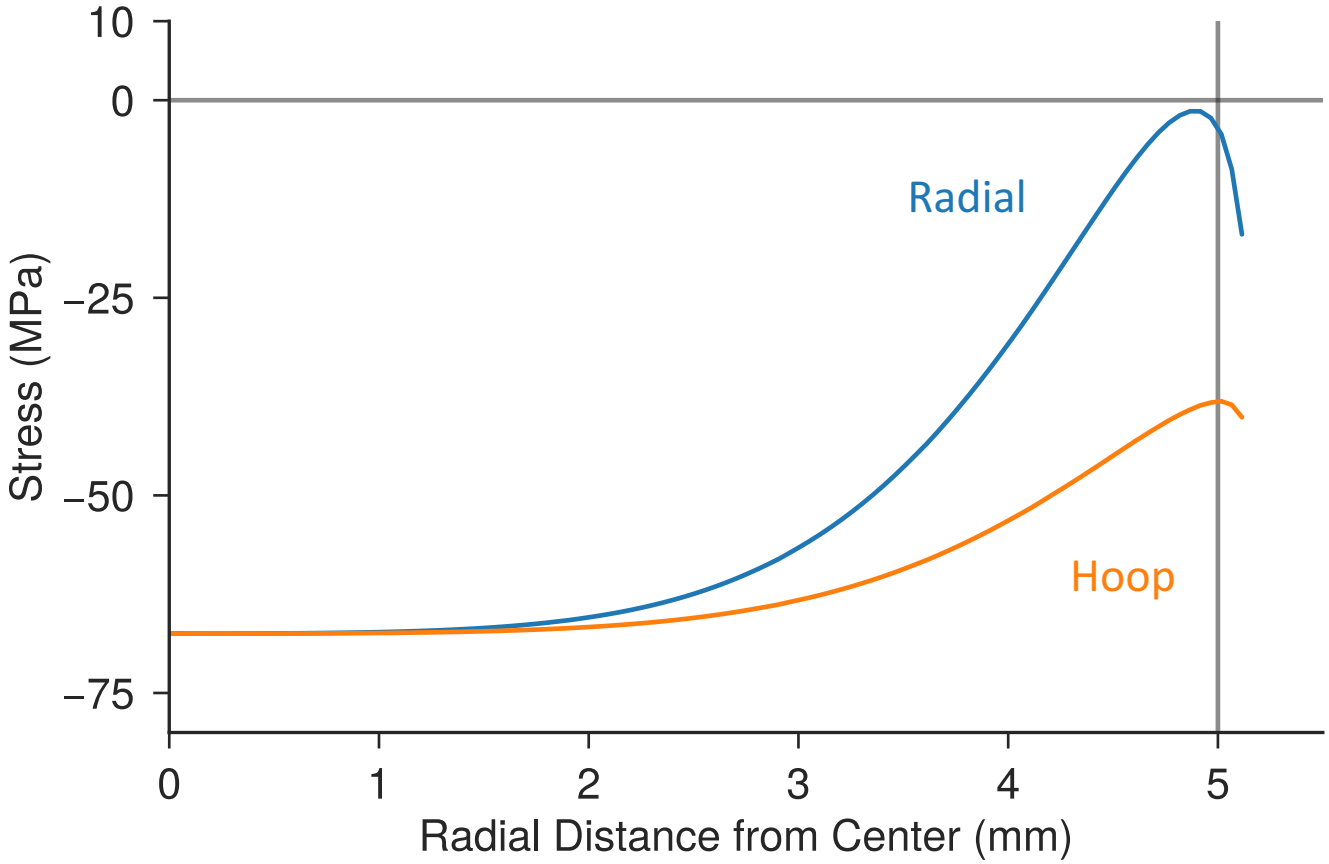




Residual Stress After 1 Year

- Exhibits similar trends to stress state after sealing
- The peak radial stress increases with aging



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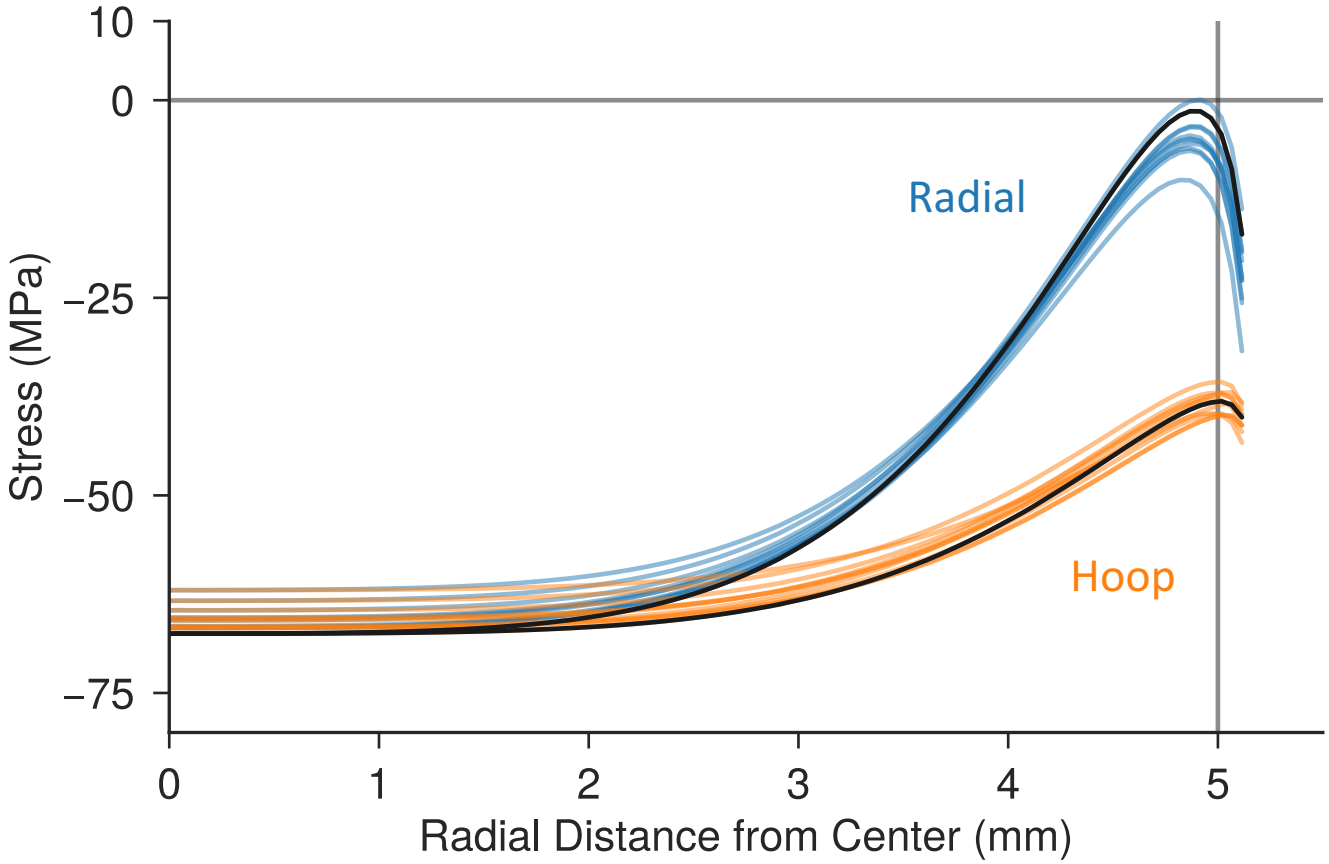

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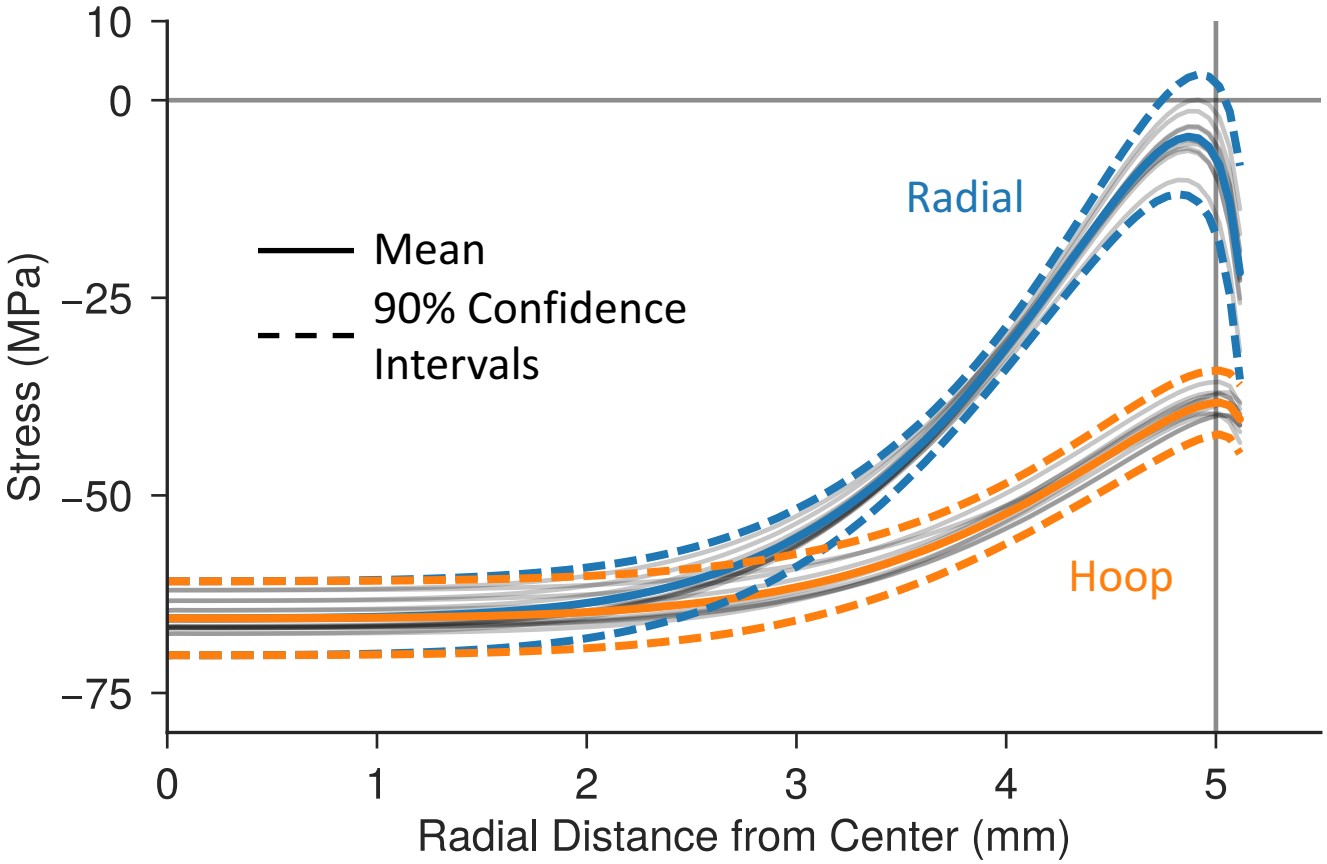
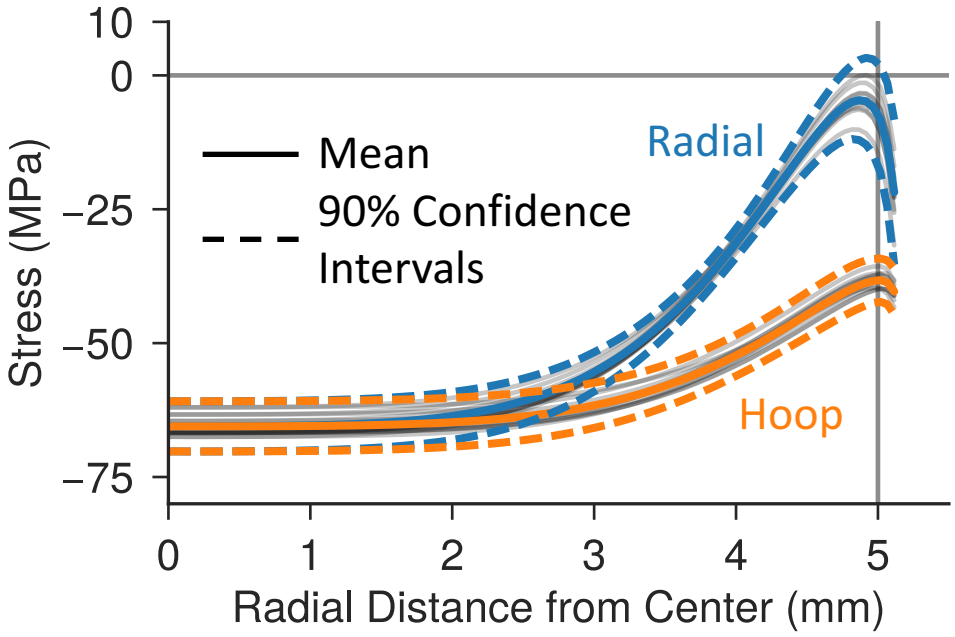
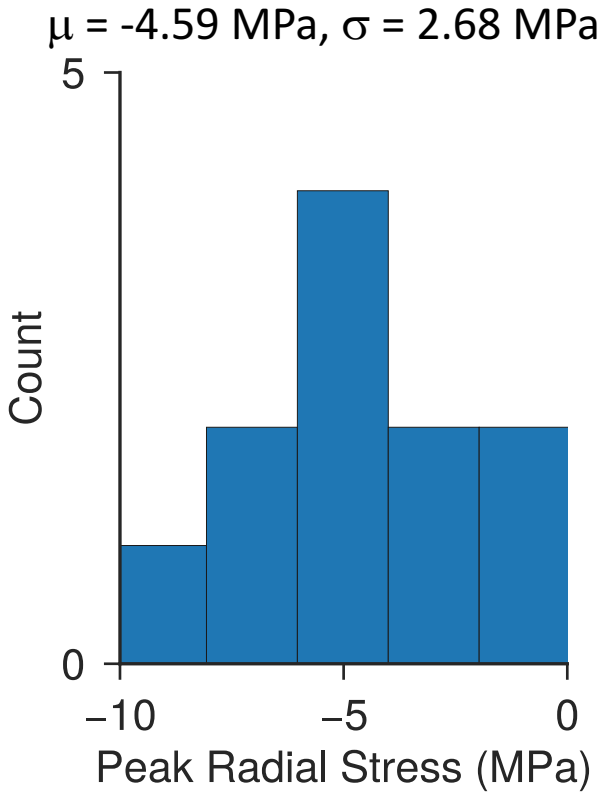


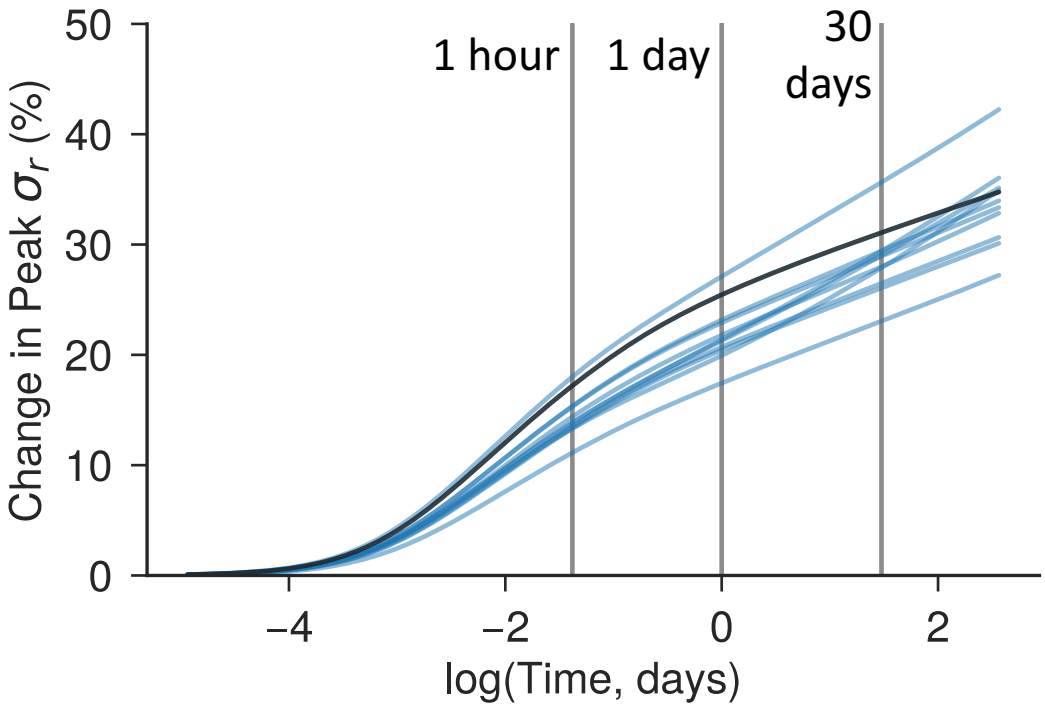
Residual Stress After 1 Year

- Exhibits similar trends to stress state after sealing
- The peak radial stress increases with aging
- The change in the deviation of peak radial stress magnitudes is small





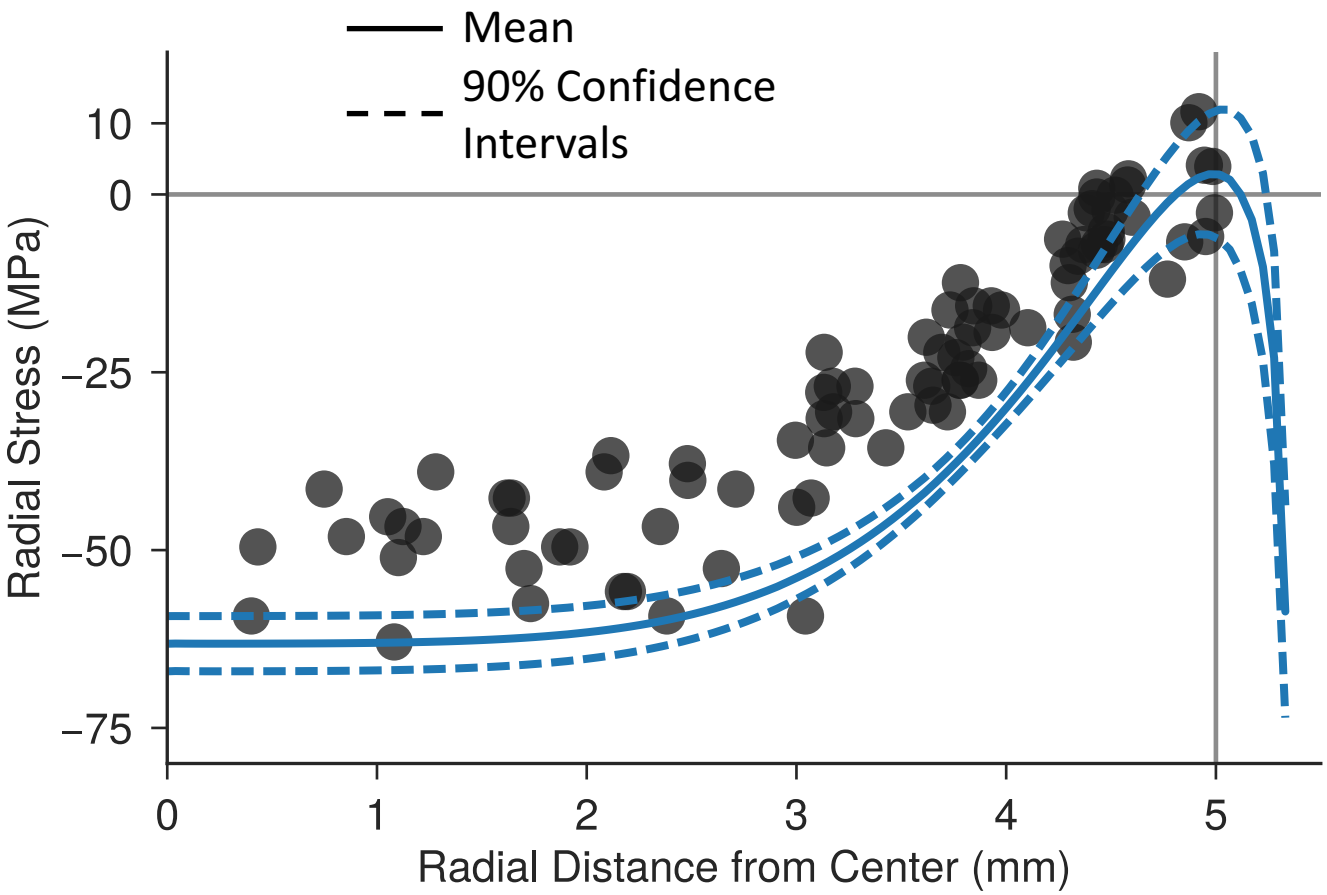
Effects of Aging on Peak Radial Stress



- The peak radial stress increases from -17 MPa to -11 MPa for the baseline case
- The largest change in peak radial stress is greater than 40%

Assessing Equivalency

- Used indentation methods to *infer* residual stress*
- Model variation within experimental variation



*Data from Thomas Buchheit

Conclusions

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- Analyzed the viscoelastic behavior of equivalent glasses
- Shear and bulk relaxation moduli characterized for equivalent glasses
- Material model realizations created and propagated through simple concentric seal model
- The confidence bounds for the surface stress are tight near the center and wider near the shell
- Based off available experimental data, the glasses analyzed could be considered equivalent

References

1. R.S. Chambers, *et al.,* Characterization and calibration of a viscoelastic simplified potential energy clock model for inorganic glasses, *J. Non-Cryst. Solids* (2015), http://dx.doi.org/10.1016/j.jnoncrysol.2015.06.005

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Backup
Slides

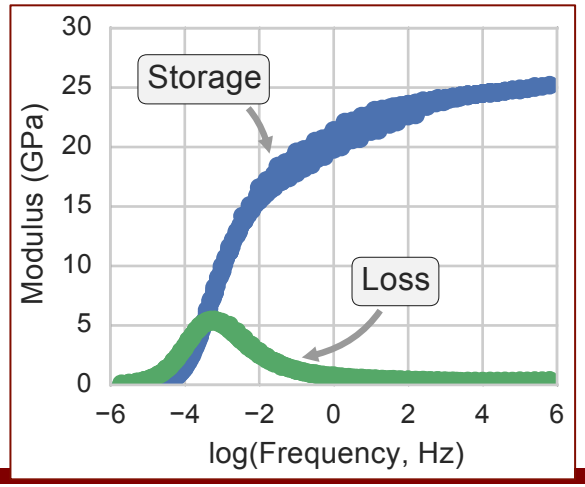
The SPEC Model

The Simplified Potential Energy Clock Model[1] allows for:

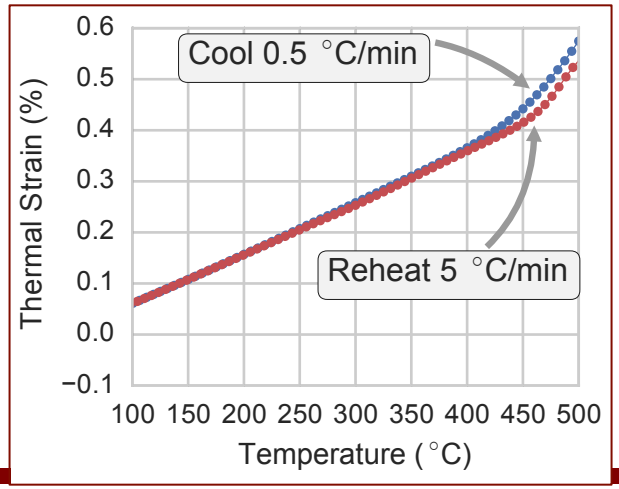
- Stress during cooldown
- Structural relaxation
- Creep

The SPEC model was calibrated for Schott 8061 sealing glass[2]

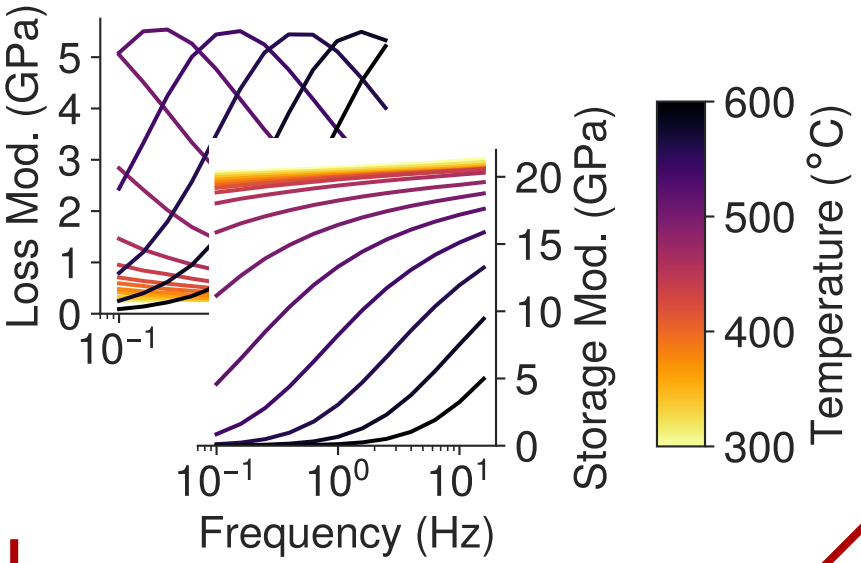
Shear Relaxation Spectrum via Direct Measurement



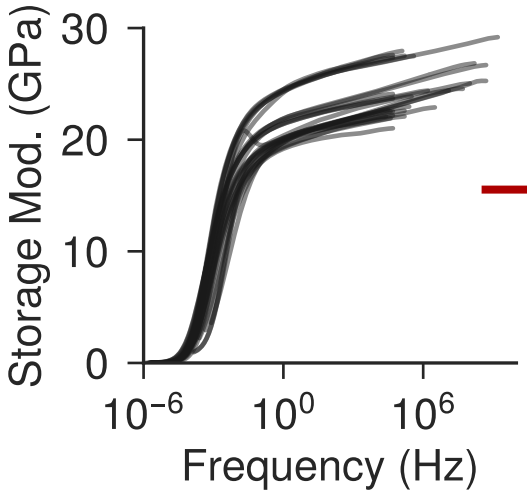
Volumetric Relaxation Spectrum via Thermal Strain

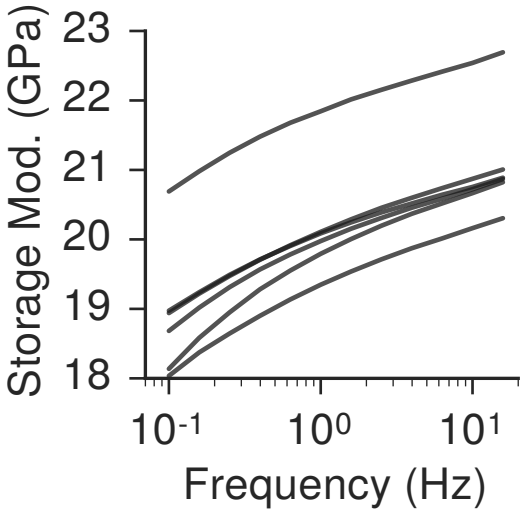


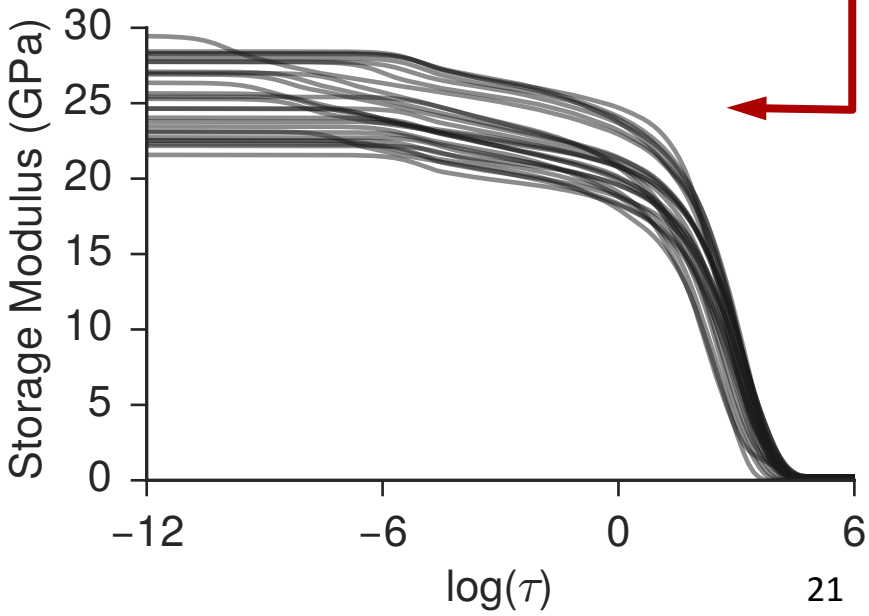
Shear Spectrum Characterization



Analysts
x 3







Bulk Spectrum Characterization