Environmental effects on tent processing and tent stability in NIC targets

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M. Stadermann, J. Fair, S. A. Letts, M. Feit, T. I. Suratwala, T. Biesiada, J. Horner

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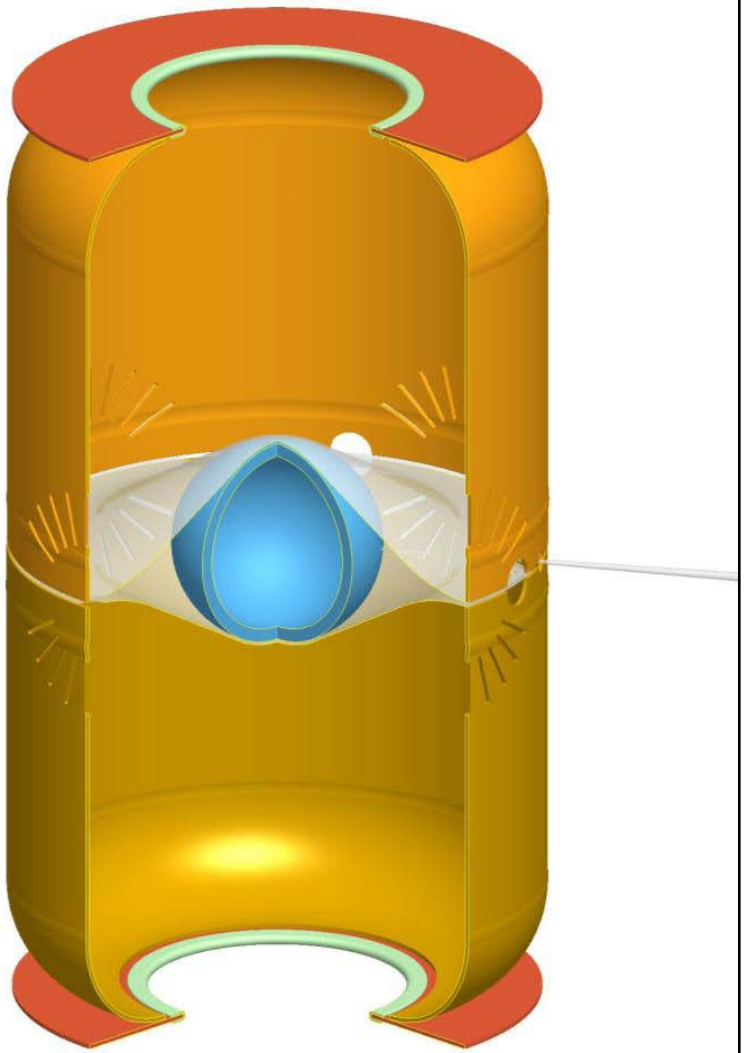
Polymer tents are used to mechanically support the fuel capsule within the hohlraum

Schematic of Hohlraum, capsule & tent

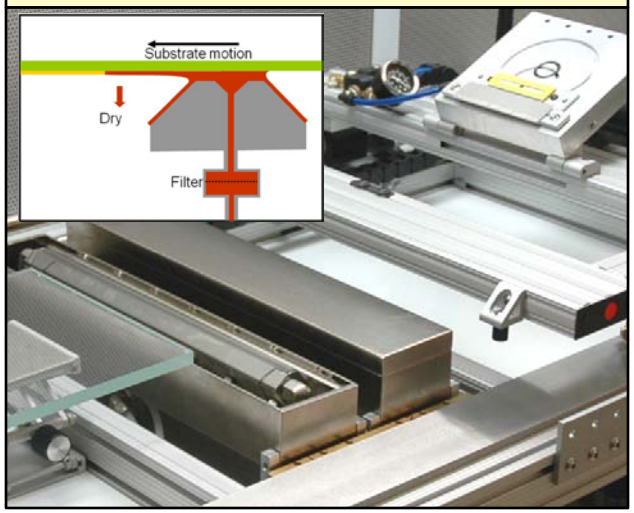


Tents have stringent mechanical and performance specifications

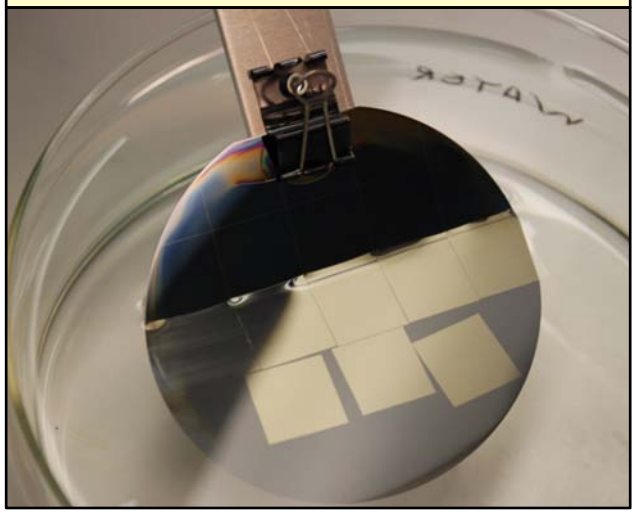
- **Tent deflection without tearing: >1 mm**
- **Typical tent thickness <110 nm low**
- **Capsule centering: –10 µm axial, 12 µm radial**
- **Low mass, and low Z material**
- **Holes (for gas equilibration) – size/location vary with target type**

Tent Fabrication Process

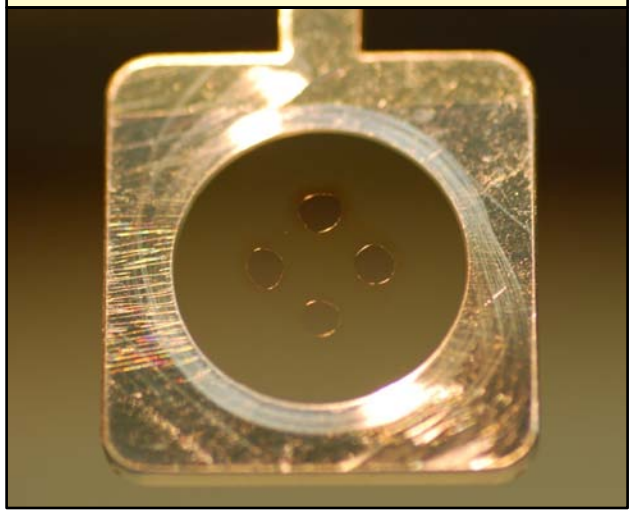
1. Meniscus Coating



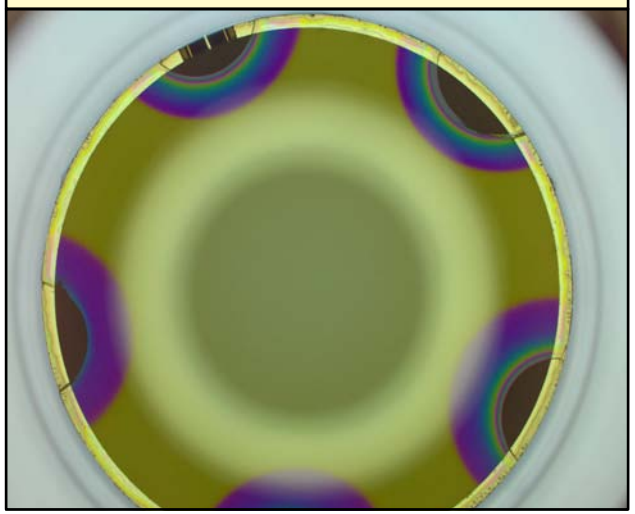
2. Liftoff



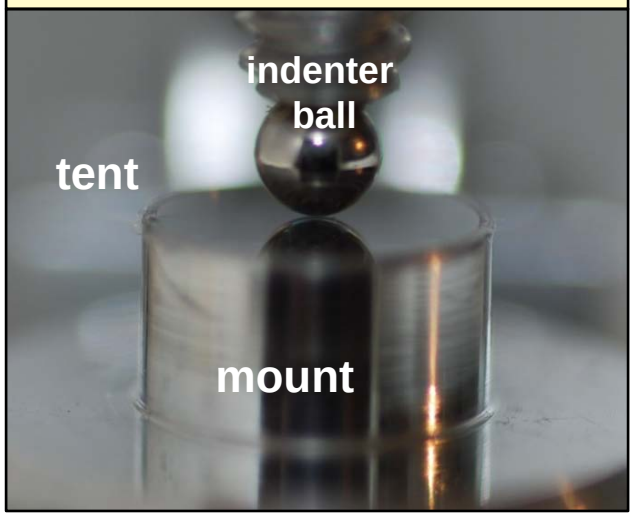
3. Mount & Hole burn



4. Glue on Hohlraum

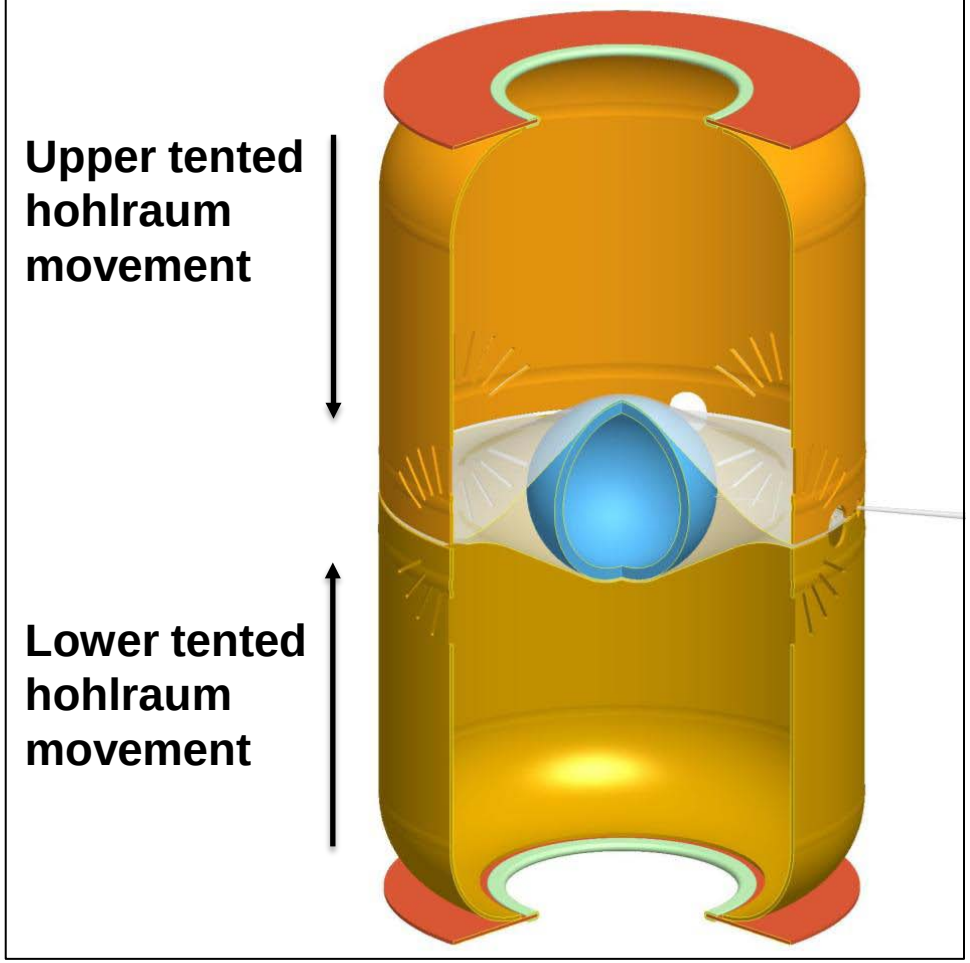


Offline QC tent strength

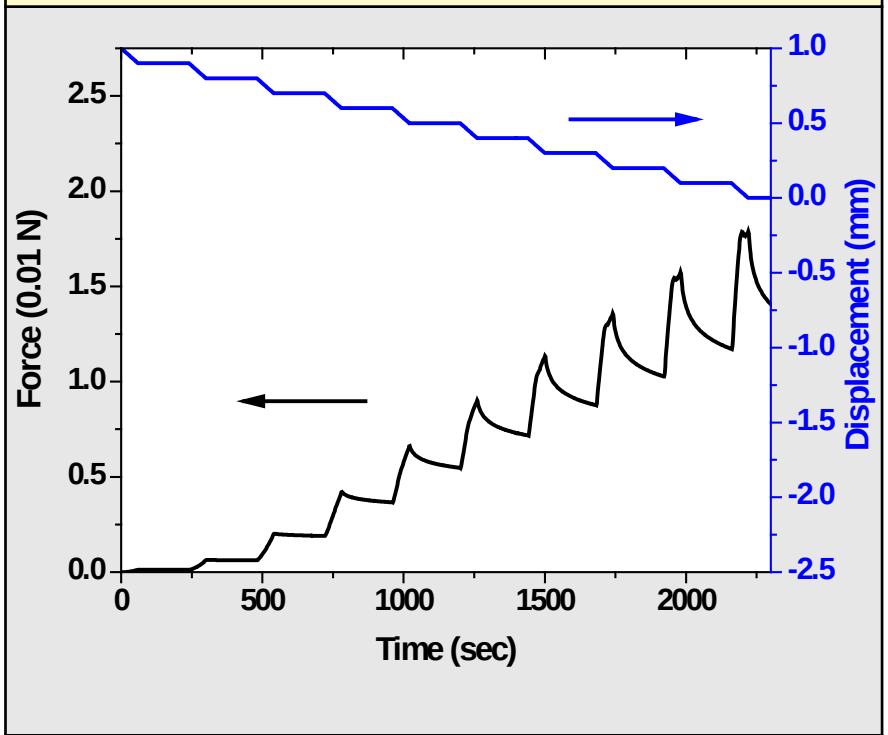


Two tented Hohlraums sandwich the capsule during assembly; the tent has time-dependent mechanical response

Stationary capsule is sandwiched between tented hohlraums



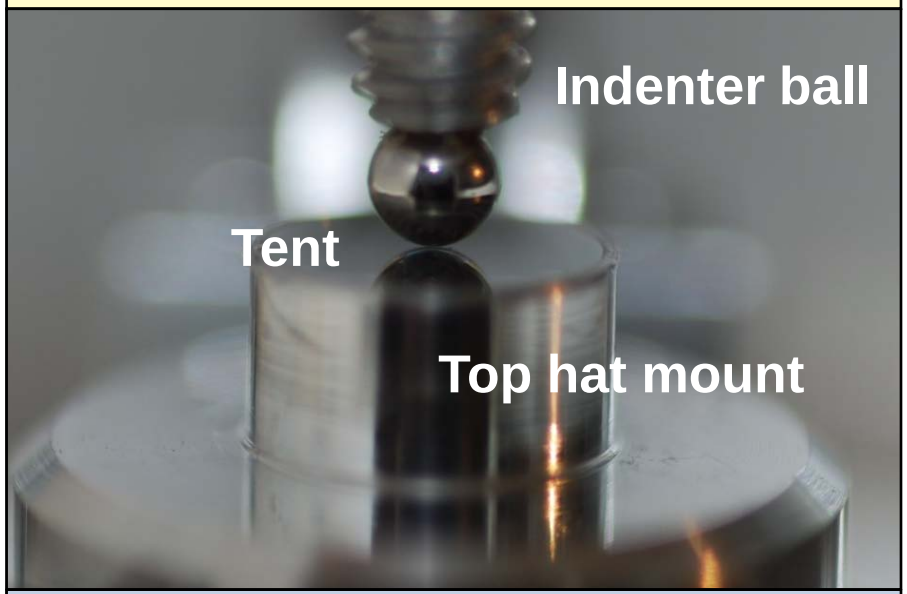
Tent force and displacement during assembly



- Tent is displaced in 100 μm increments with 180 sec pause
- Force on tent relaxes viscoelastically and viscoplastically

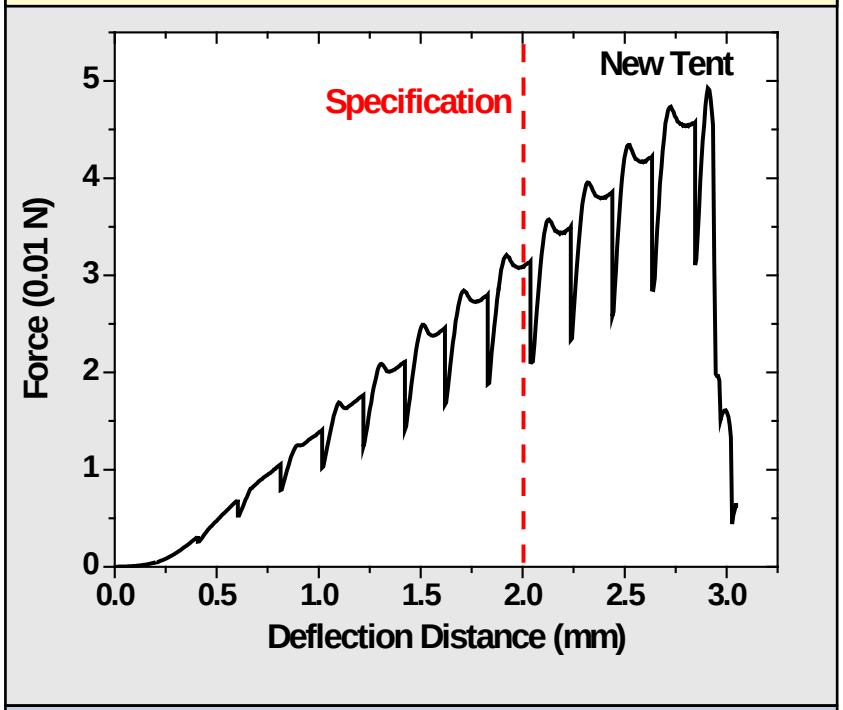
Offline mechanical testing using ball indentation serves as an important diagnostic of tent material strength

Tent load testing: Ball over mounted film



Test measures deflection at failure as well as modulus, viscoelasticity, and strength as function of time and environment

Typical indenter output



Typical test applies defined ball displacement (100 μm increments, 100 μm/min, 180 sec lag) recording force as function of time and deflection

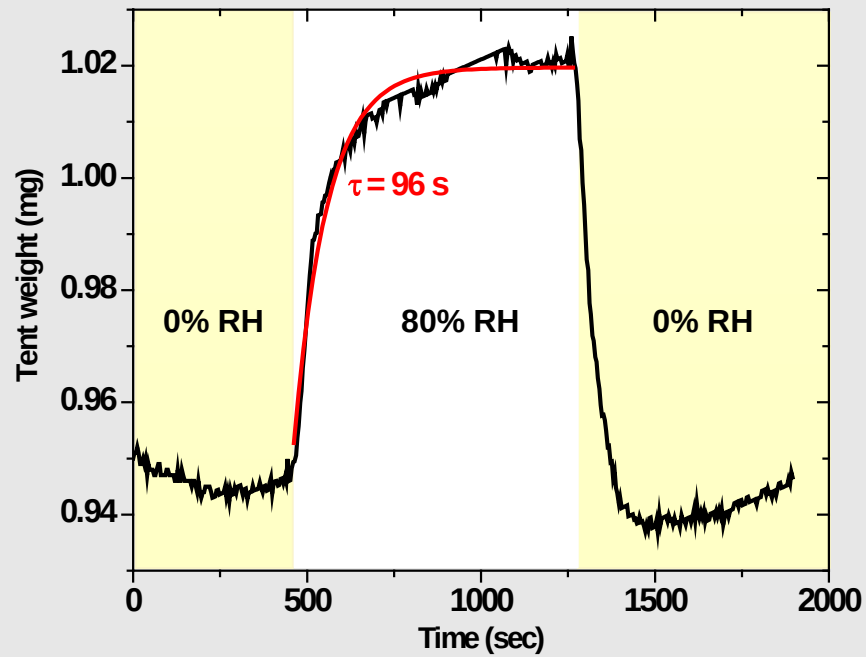
Tent performance is governed by intrinsic properties and extrinsic use conditions

Intrinsic Properties	Extrinsic use conditions
1. Molecular weight distribution 2. Solution degradation through pump shear and reaction with water	1. Water vapor influence on tent dimensions and stress 2. Glue vapor influence on mechanical properties 3. Affect of hohlraum asperities

1:40 Monday PM1-2 **The Influence of Chemical and Mechanical Effects on the Stability and Strength of Formvar Tents**

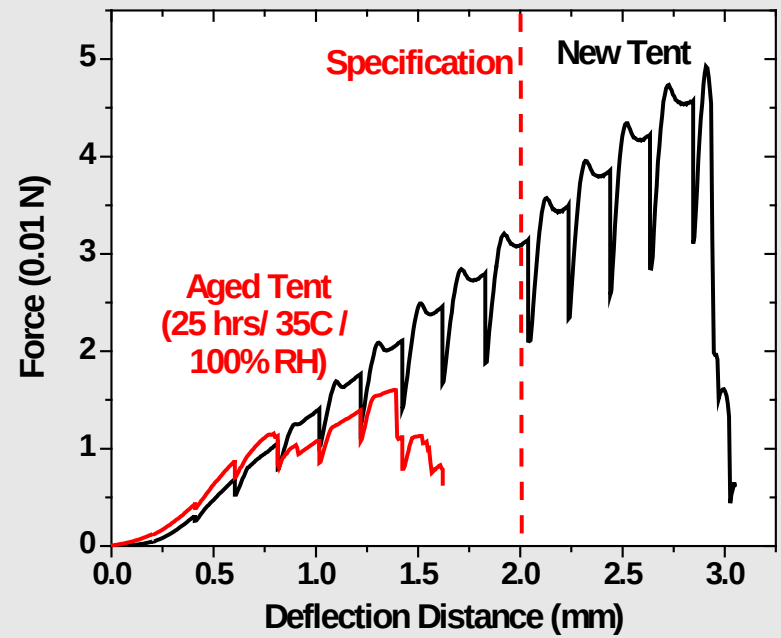
Formvar films readily absorbs & desorb water; High humidity exposure reduces tent strength

H_2O abs/desorb kinetics



Majority of H_2O abs/desorb kinetics takes <100 s

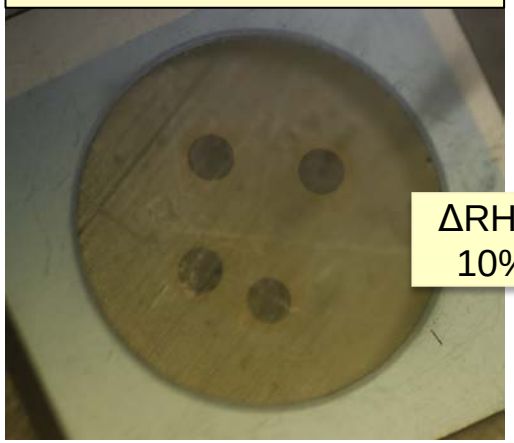
Effect of high H_2O exposure on tent strength



Accelerated H_2O exposure reduces tent failure strain

Increasing humidity causes tents to wrinkle

No wrinkling

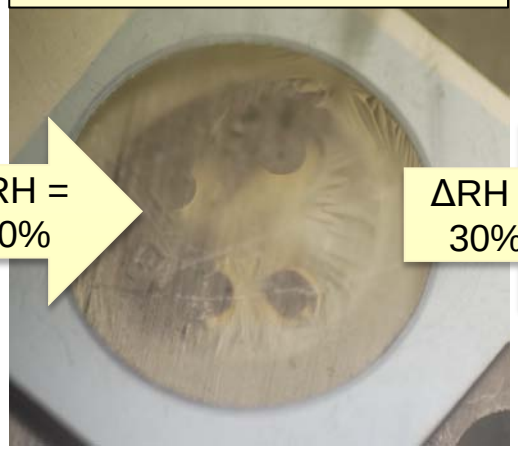


ΔRH = 10%

Wrinkling around burn holes interferes with tent inspection

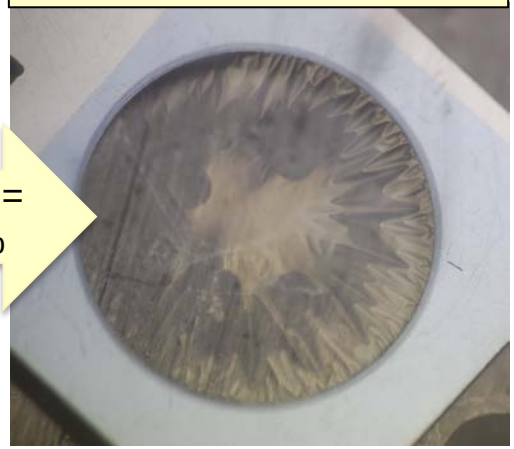
ΔRH = 20%

Wrinkling in burn hole area interferes with assembly

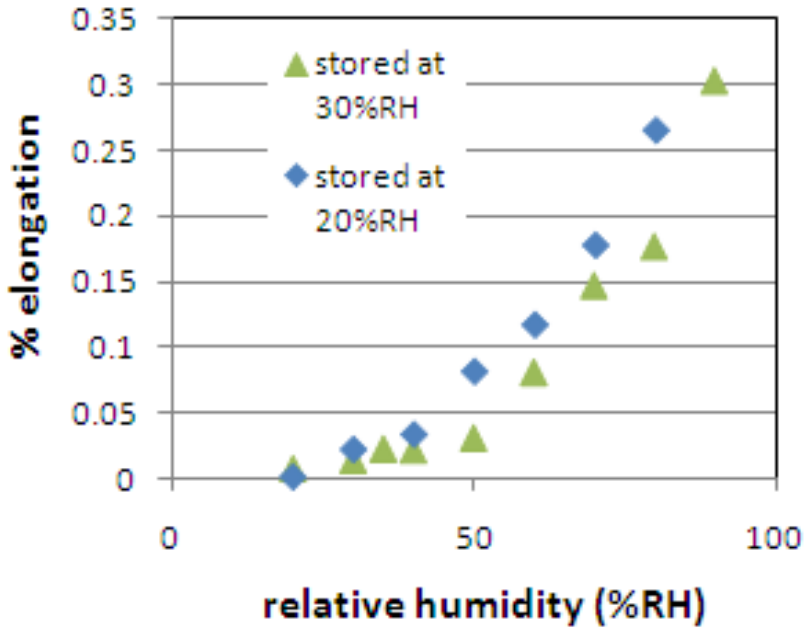


ΔRH = 30%

Wrinkling of entire tent

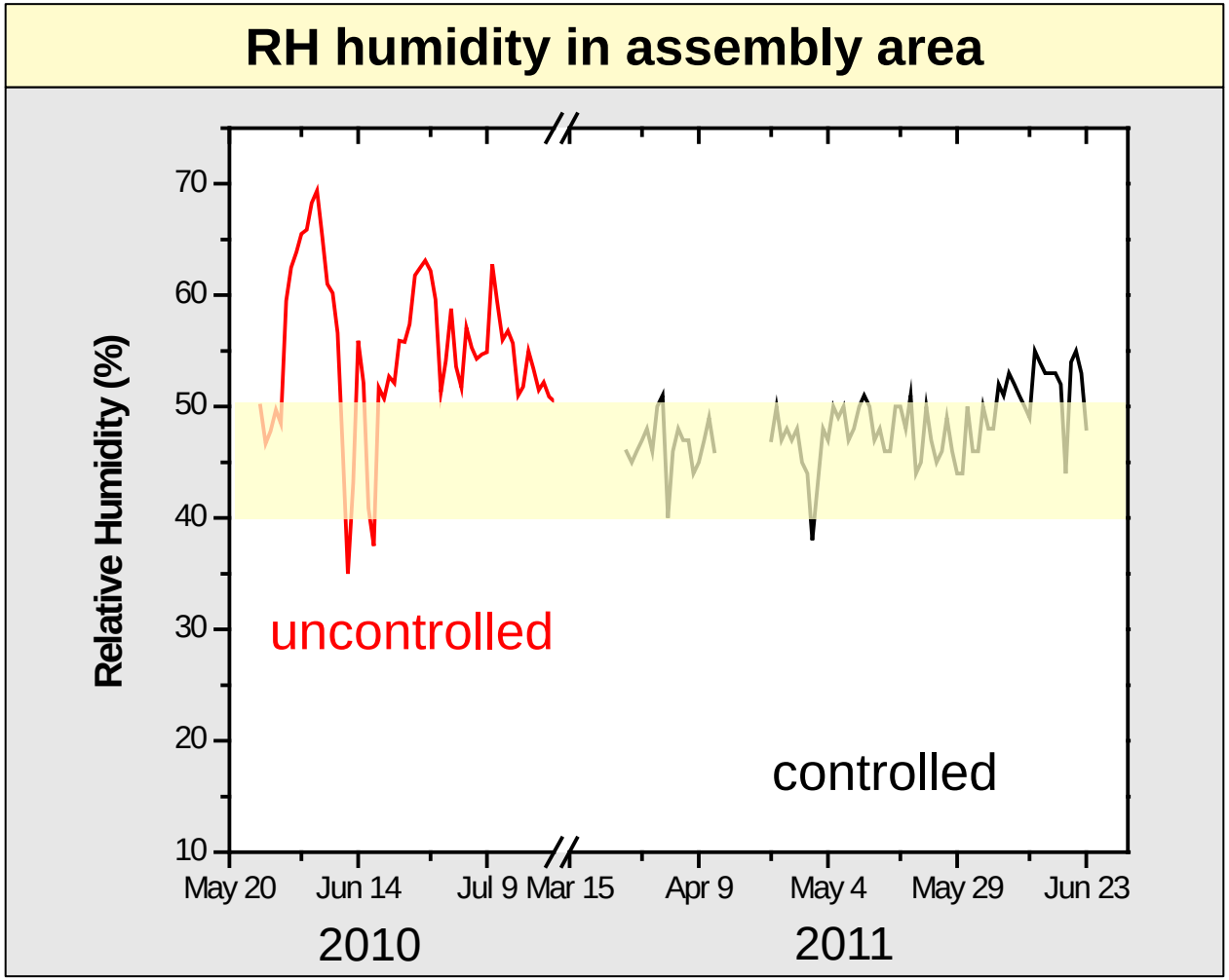


Tent elongation with humidity increase depends on how tent was stored



During drying, the water-swollen tent shrinks and is stretched plastically due to edge constraints.

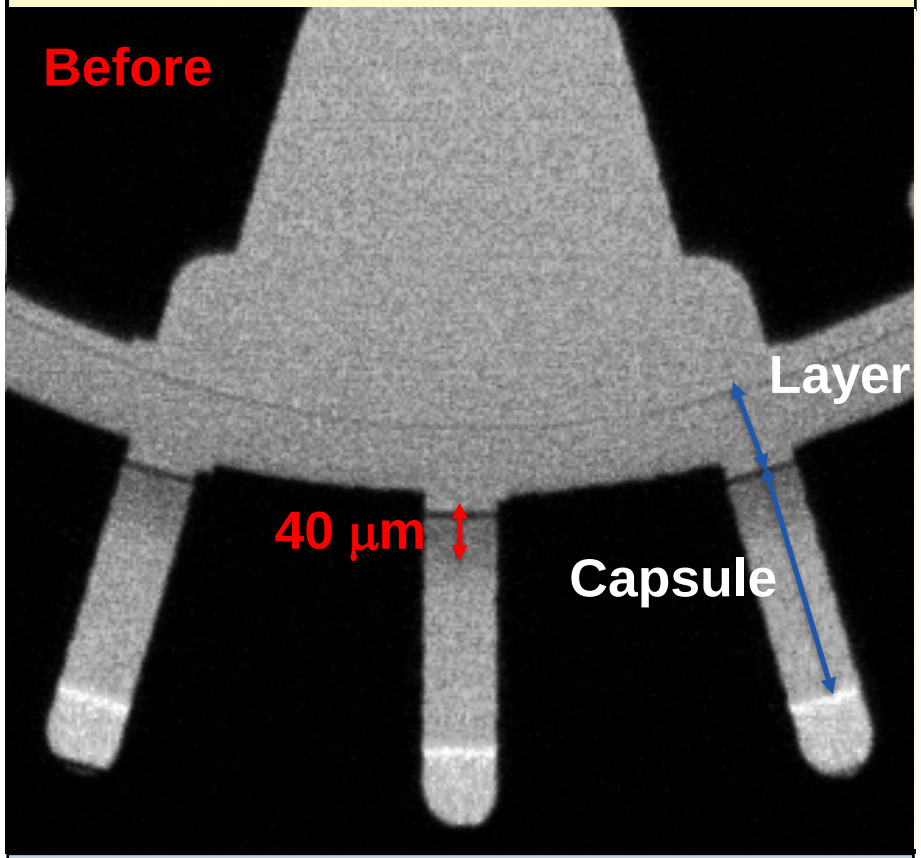
Humidity in assembly environment must be controlled to enable processing of tents



Cleanroom humidity control (45±5%) and 2 week tent lifetime have been implemented to minimize wrinkling, capsule offset, and strength degradation

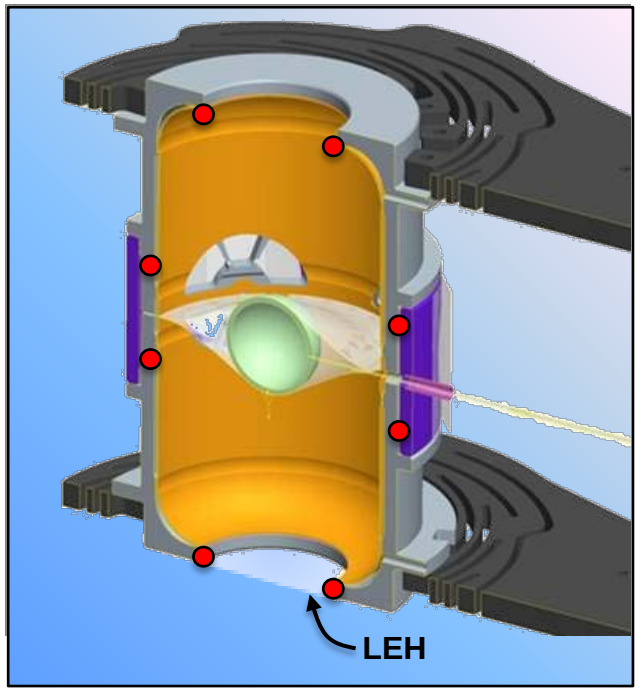
Vapor from the glue used to bond components causes the capsule to sag from its intended position

X-ray view of capsule location from starburst



Capsule dropped about 40 μm after closing last LEH window (specification is 10 μm)

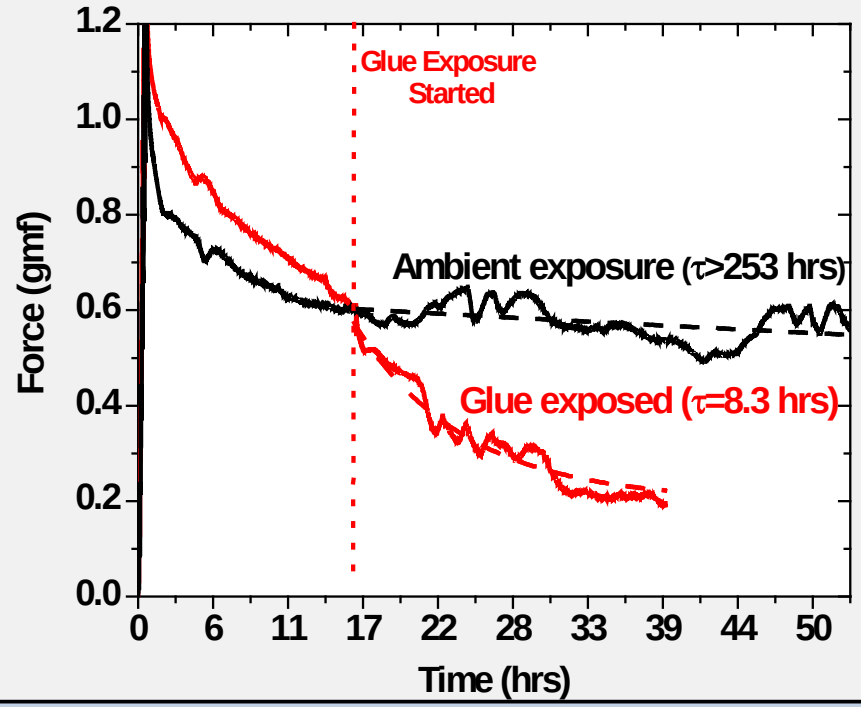
Glue in multiple locations may not be fully cured



Uncured glue can saturate the vapor phase of the gas-tight target vapor quickly

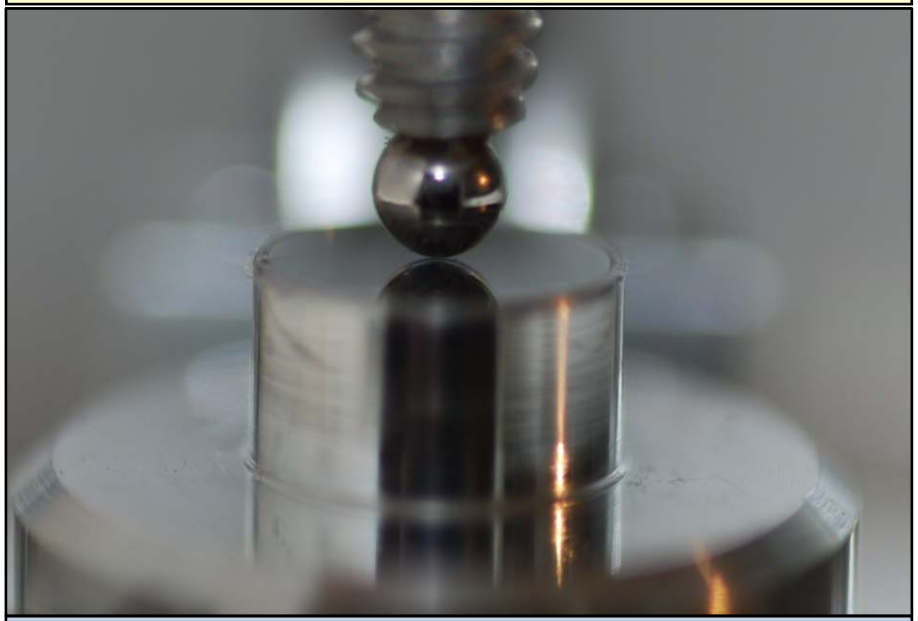
Vapor from the glue used to bond components causes the tent to viscoelastically relax faster, resulting in capsule sag

Tent force at constant displacement w & w/o glue vapor exposure



Offline testing showed glue vapor exposure causes tent to visco-elastically relax faster (τ_s=8.3 hrs)

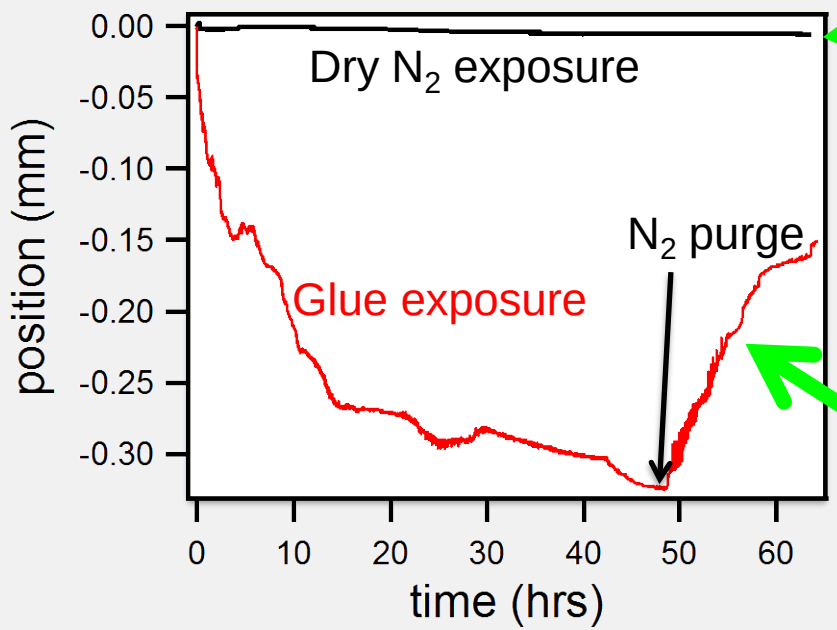
Constant displacement measurement provides force response



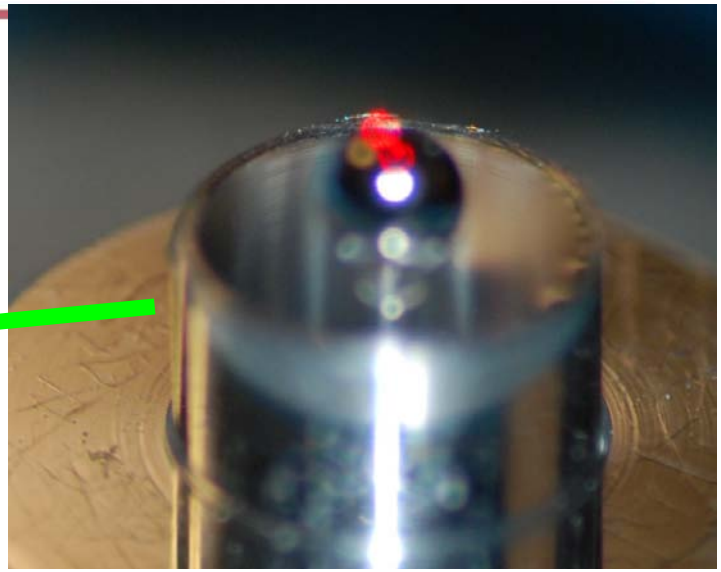
Glue is placed into balance and sealed at the start of the exposure

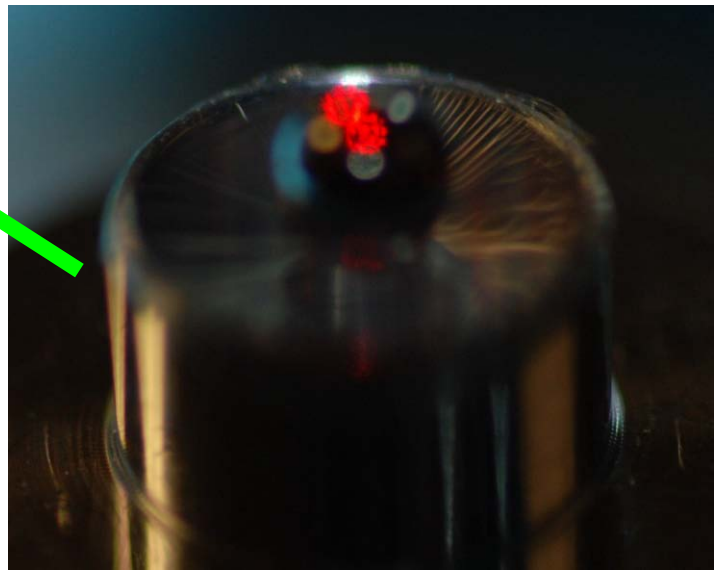
Constant force measurement of the sag shows partial reversibility when glue is purged

Tent displacement at constant force w & w/o glue vapor exposure



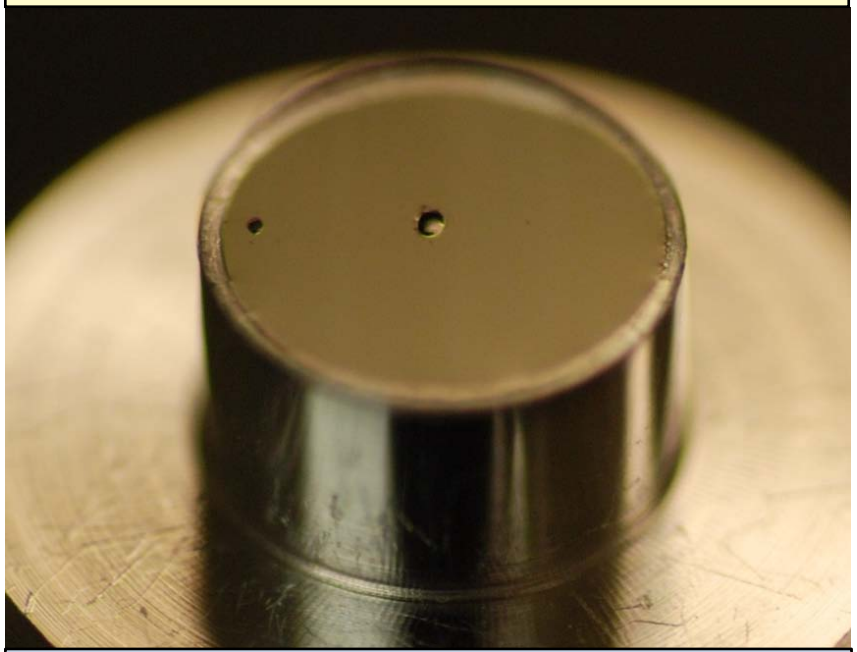
Glue-exposed tent relaxes significantly more; part of the relaxation is reversible





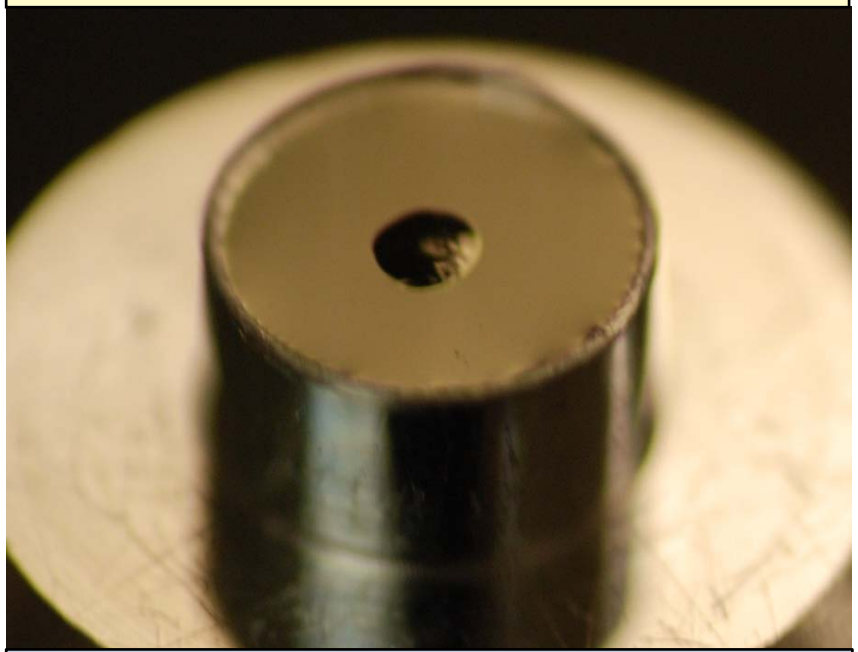
Plastic deformation caused by weight is visible after weight removal

No glue exposure



After 6 days, the irreversible deformation is 25-30 µm deep

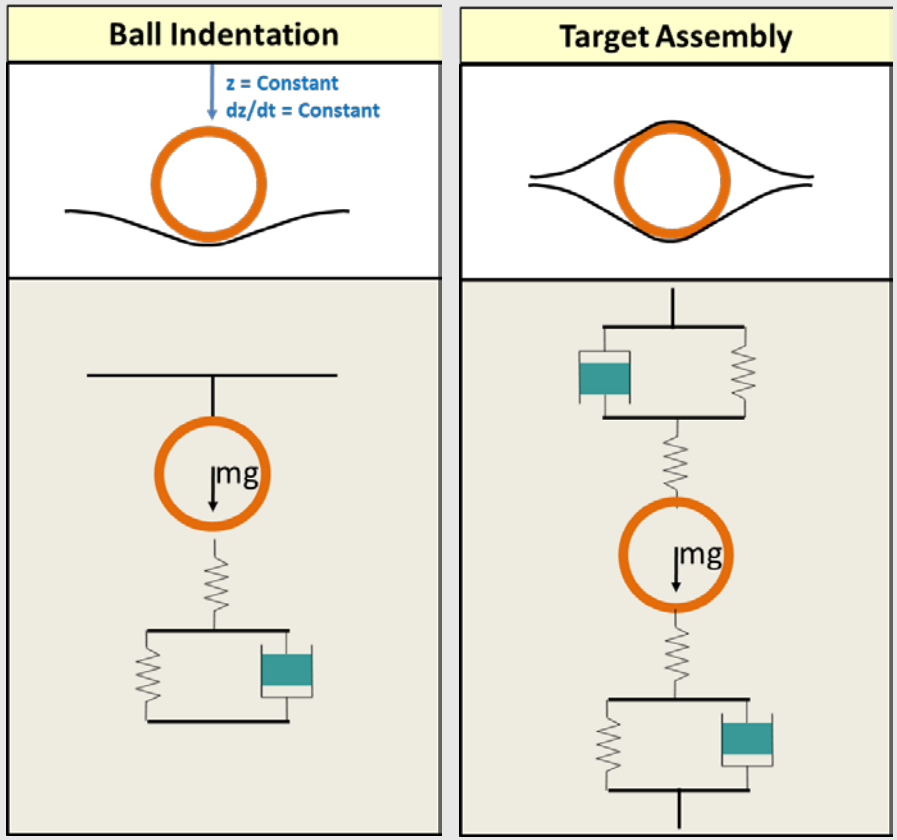
Glue-saturated gas phase



After 2.5 days, the irreversible deformation is 80 µm deep

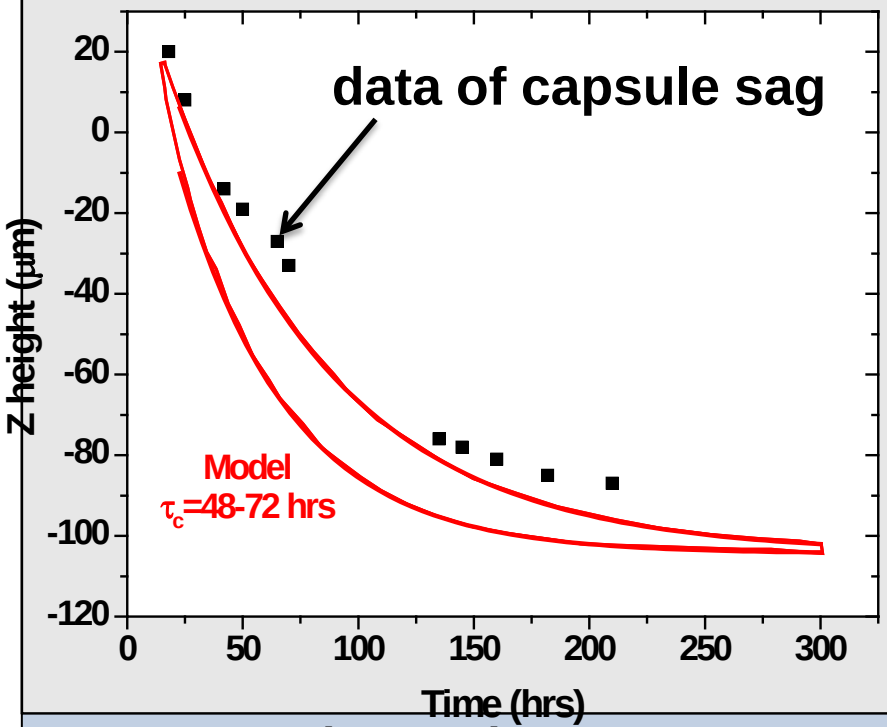
The rate of sag has been approximated using delayed elasticity model, consistent with observed sag rate

Hookian spring element view of viscoelastic model



Single time constant delayed elasticity model was used to simulate ball indentation test and target assembly

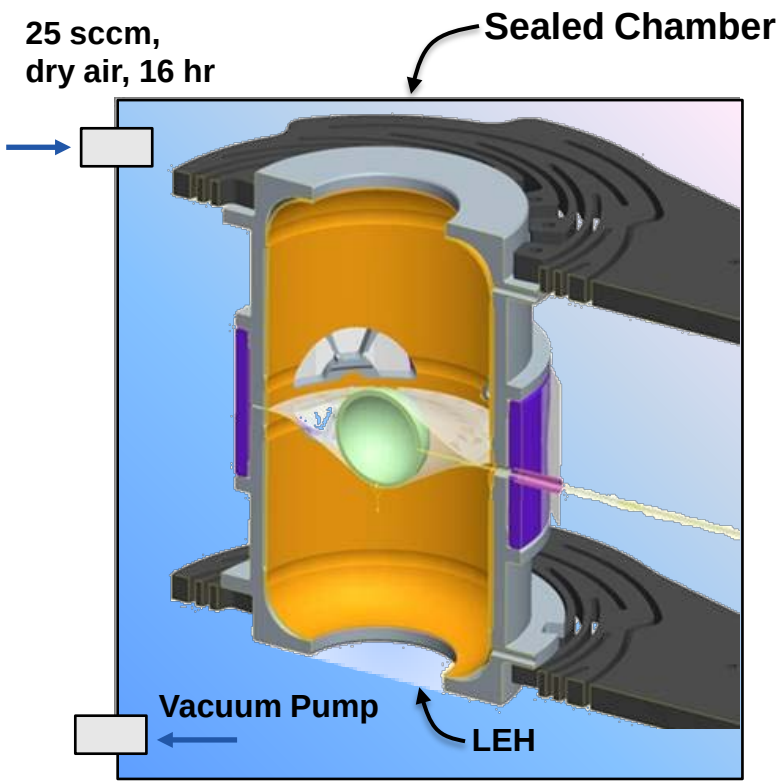
Measured vs calculated capsule movement



Measured capsule movement was exponential (τ_c= 87 hrs); Calculated time constant using model & ball indentation measurements is τ_c=48-72 hrs

A gas purge of Hohlraum before putting on last LEH window is being used as a mitigation for capsule sag

Schematic of gas purge mitigation



Target assembly (with all components glued except top LEH window) is purged with air to reduce volatiles from all glue joint

- Data on 4 THD targets show capsule sag has been noticeably reduced using purge

Target ID	Capsule Sag
27870003	-13.3 μm
27850003	-9.6 μm
27850005	-8.4 μm
27850007	-10.1 μm

- Capsule sag observed before purge mitigation ranged from 25-80 μm

Conclusions

- The effects on tents of vapors common two target fabrication, adhesive and water, where characterized
- Both vapors are detrimental to target performance if uncontrolled
- Mitigations and controls were implemented to reduce the impact of glue and water vapor

NIC

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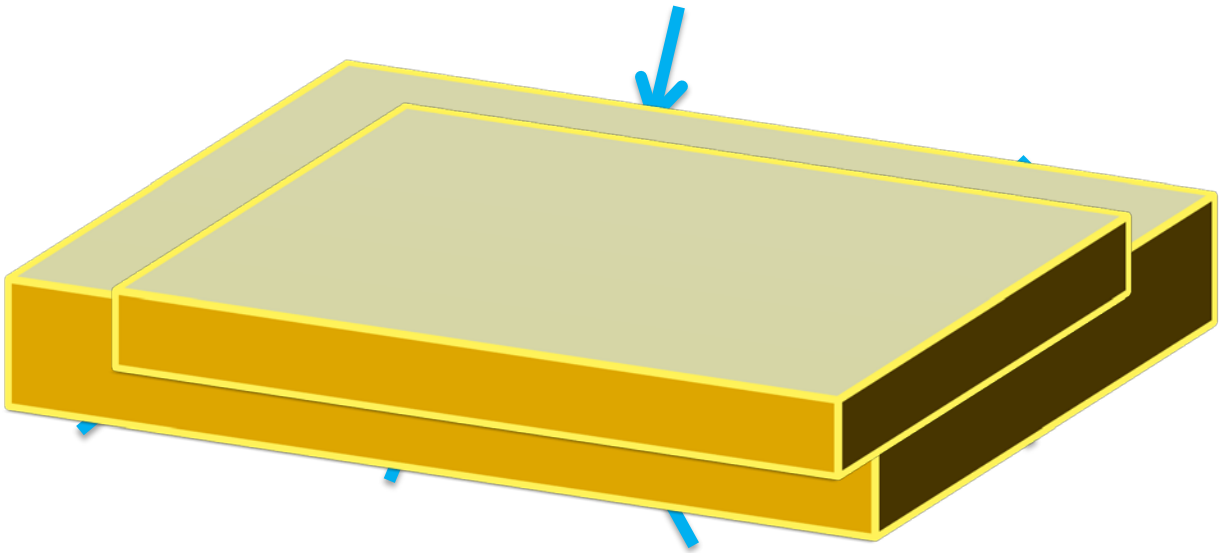
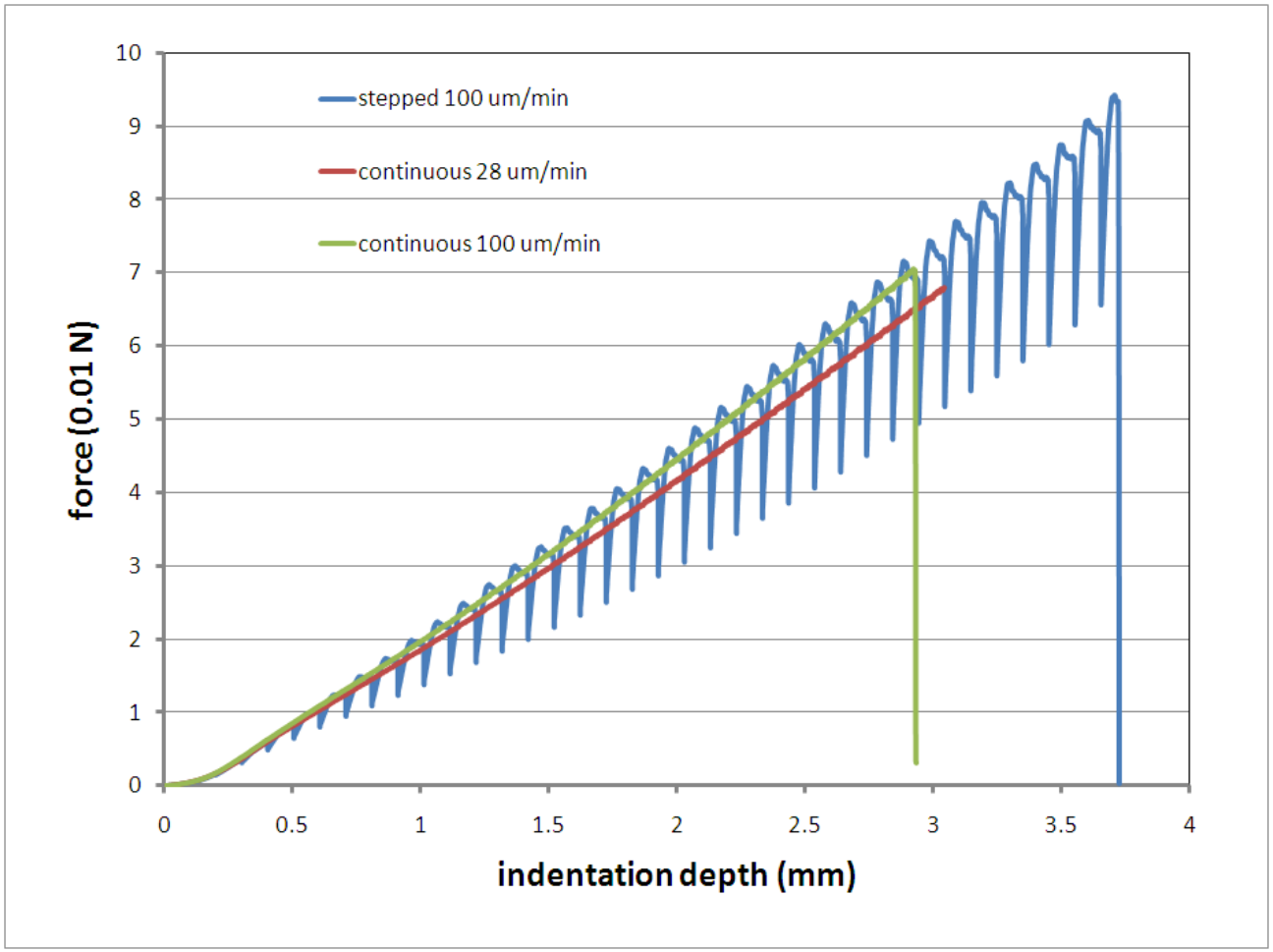
Jeff Horner
Michael Feit

Surrounding vapor can change physical, chemical and mechanical properties of a tent



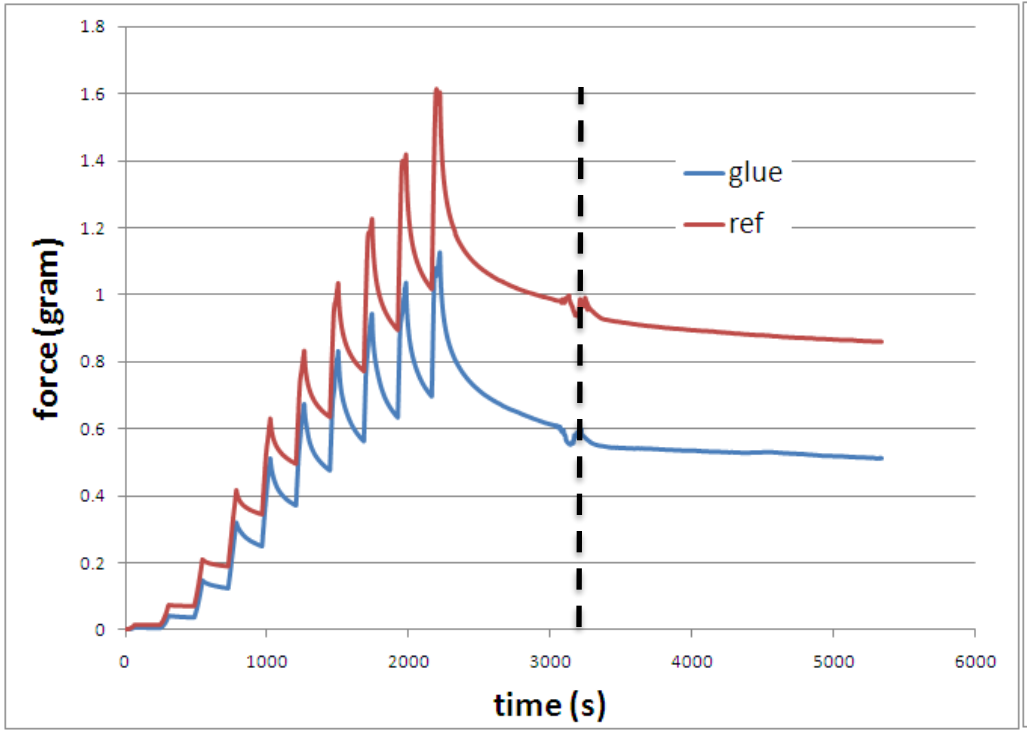
Vapor uptake changes the size and mass of the tents

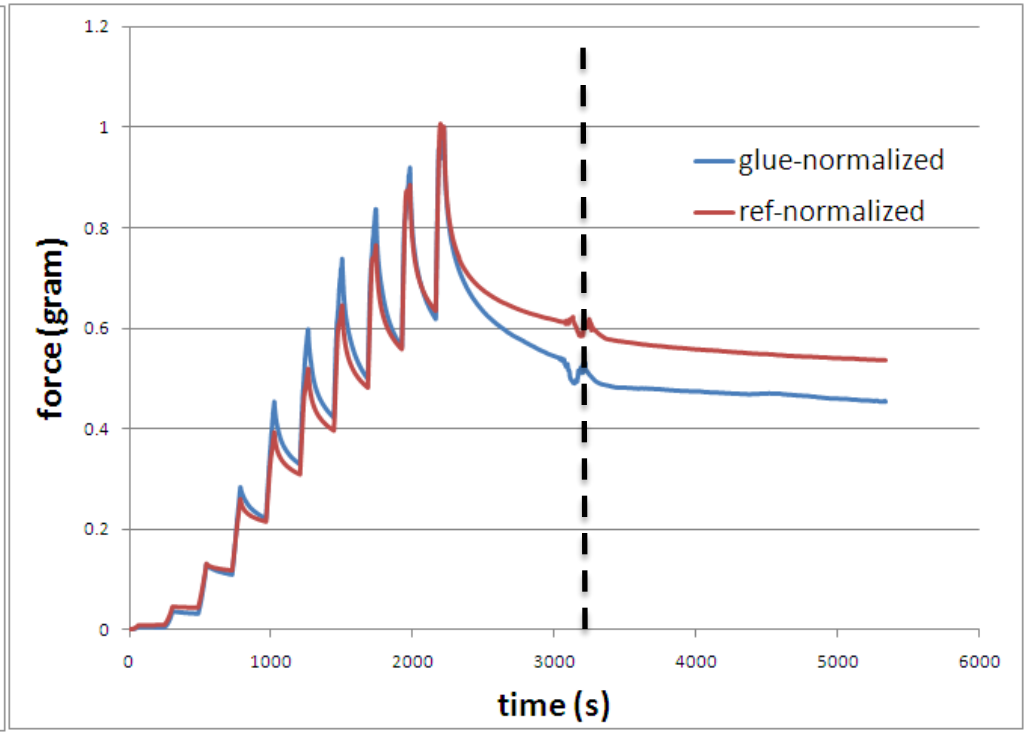
Stress as a function of different indentation rates and methods



- the stepped test consists of indenting at the listed rate for 1 min, then pausing for 3 mins
- continuous tests are indented at the given rate without breaks until the tent fails

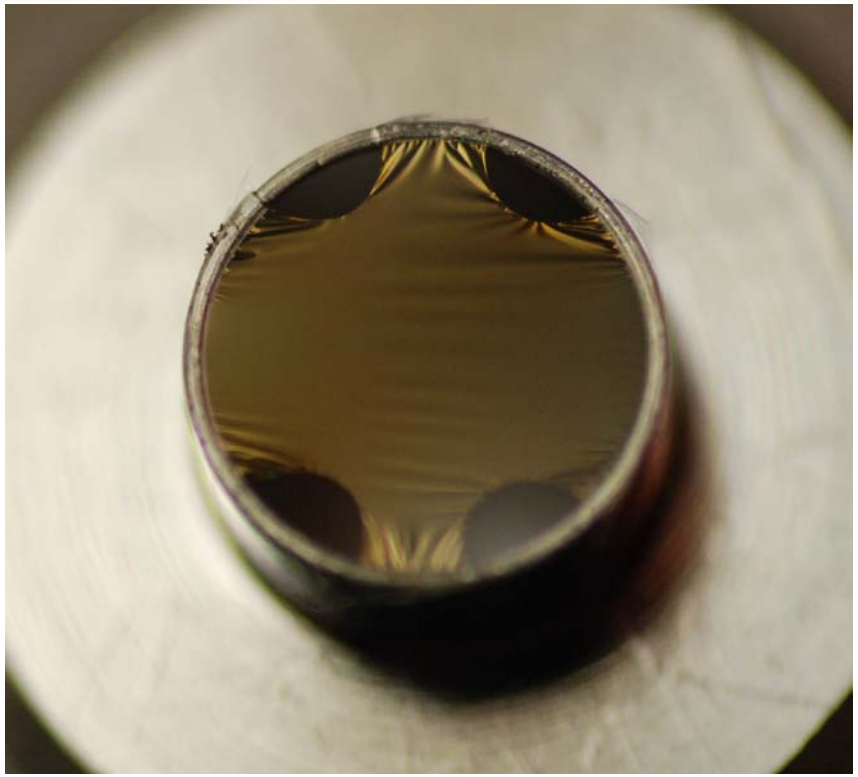
Exposing tents to adhesive and UV

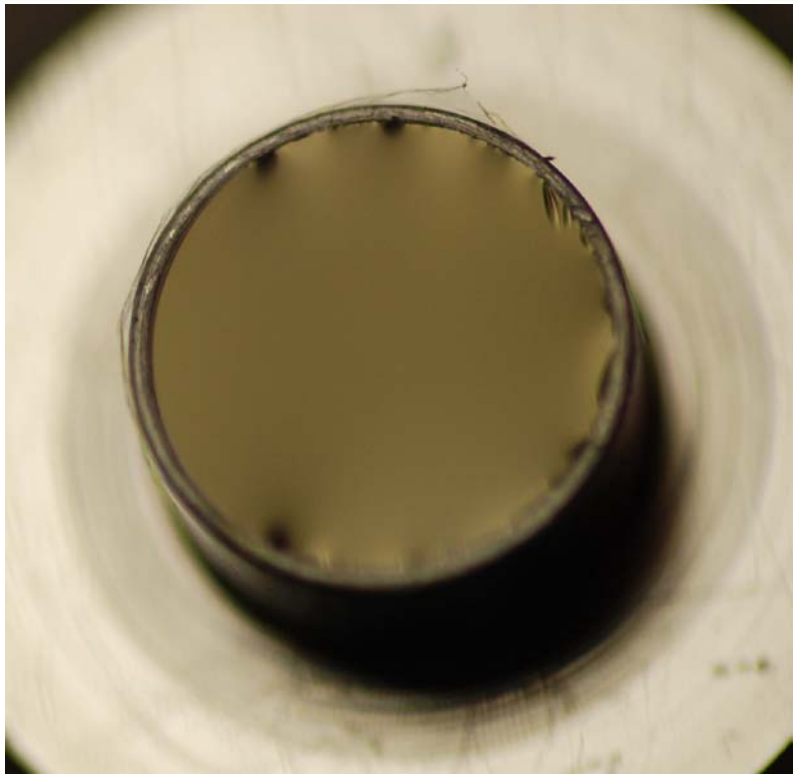




- reference tent was indented normally, balance chamber opened at 3100 s, exposure at 3160 s
- glue sample was indented in the presence of glue; open and expose as reference
- relaxation behavior of the glue sample changes slightly after exposure to UV
- the modulus of the exposed tent is almost 50% lower than that of the reference

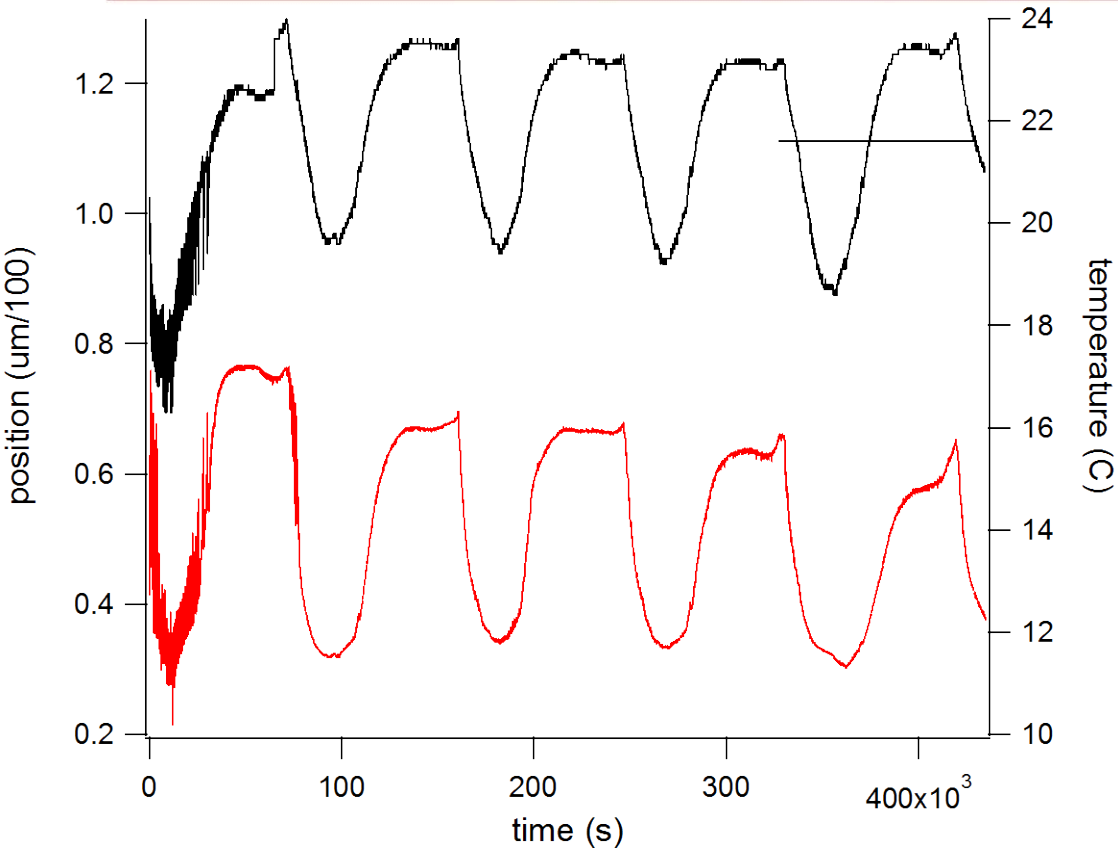
Wrinkling of tents exposed to glue





- both tents were enclosed in a small container with a drop of glue in the top hat for ~60 mins
- only the burned tent shows wrinkles; the wrinkles were present before curing
- the direction of the wrinkles is the same as observed before with respect to the burn holes and likely a result of the burn pattern

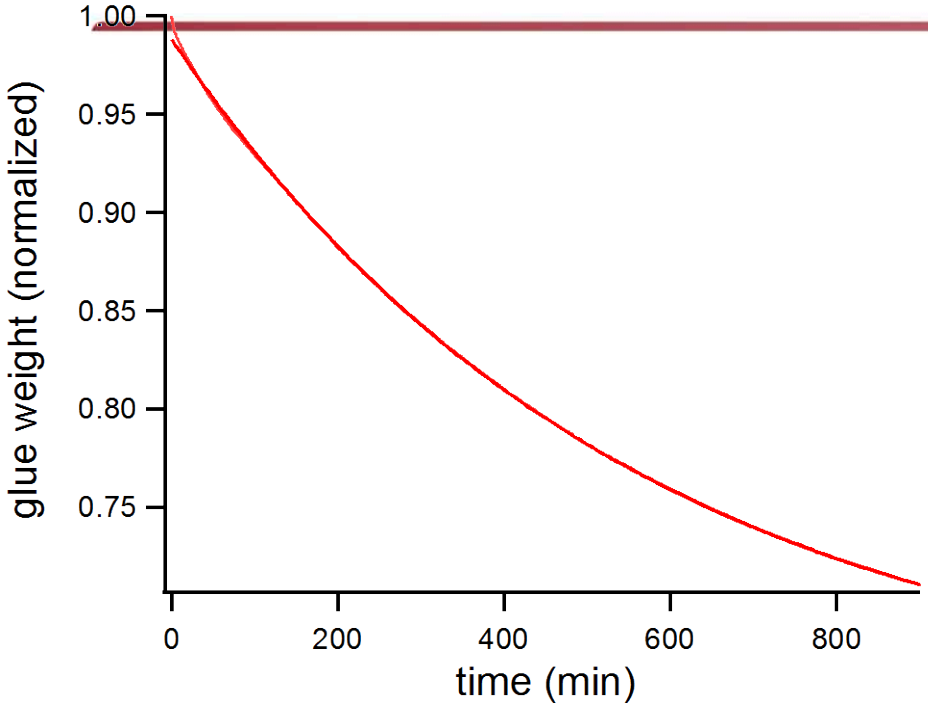
Tent sag



Tent is exposed to ambient up to ~60k seconds, then is sealed airtight to a large block of aluminum

- position is strongly correlated to temperature
- movement is likely cause by humidity (low T is about 50% RH, high T is estimated to be ~40% RH)

Glue evaporation TGA data



UV-Mix, uncured

temperature: ambient

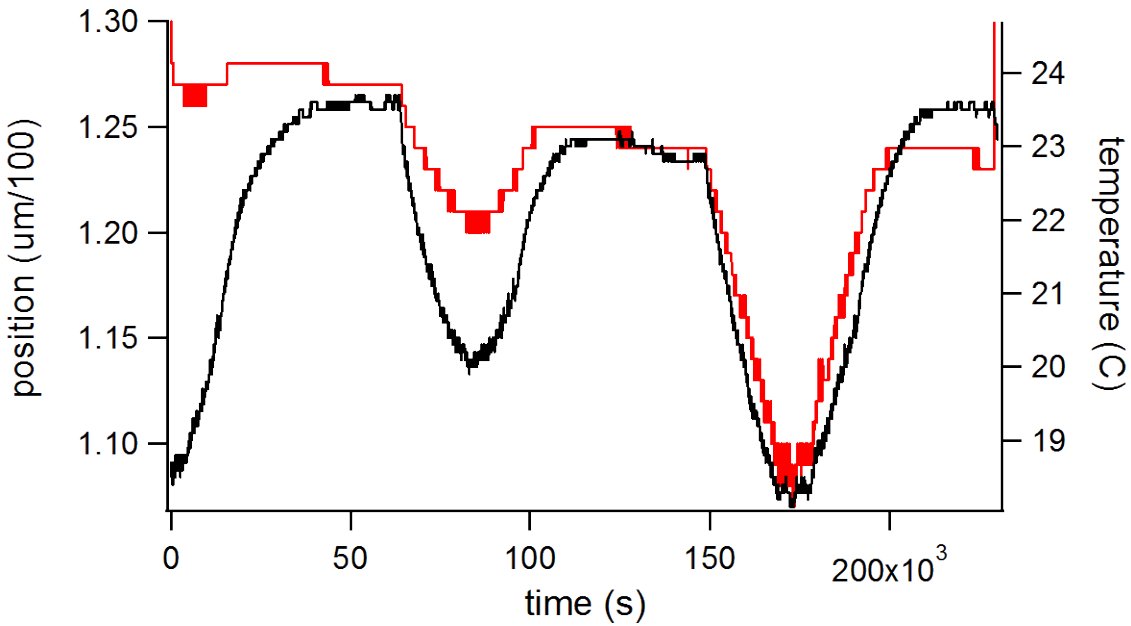
gas flow rate: 20 sccm

surface area: 28 mm^2 (pan size)

fits exponential with

τ = 540 min and y_0 = 64%

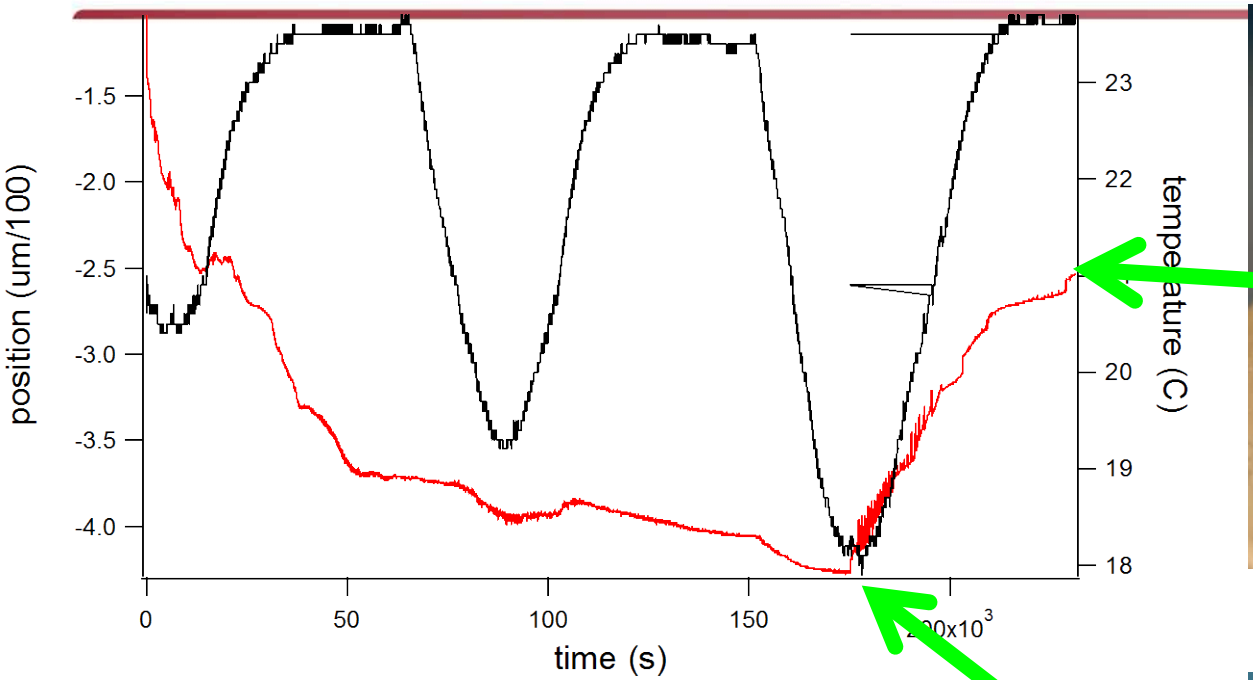
Capsule sag in dry N_2 purge

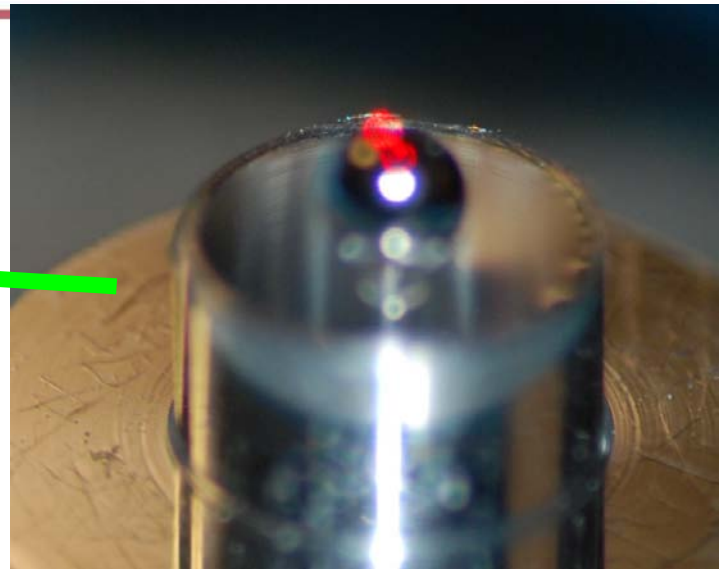


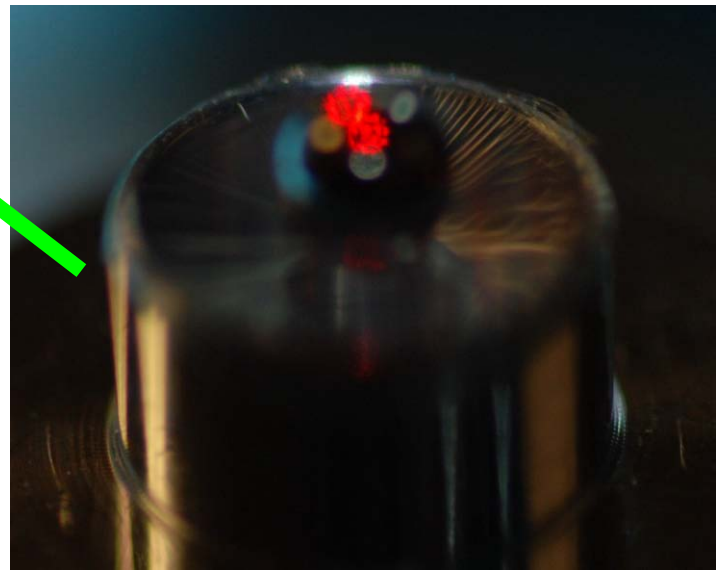
Tent is covered with a petri dish which is purged with a constant flow of 250 sccm of dry N_2

- capsule movement with temperature change increases with time
- tent position does not change after temperature passes a certain threshold; maybe tent is in its most taut state beyond that threshold

Creep of tents with glue







UV-Mix, uncured

First part fits double exponential with τ1 = 290 mins and τ2 = 1525 mins

Tent stretches back out, recovers sag after glue is removed (~170k seconds)