SAMS meeting (14/02/2018)
Update on compression-fit mirror

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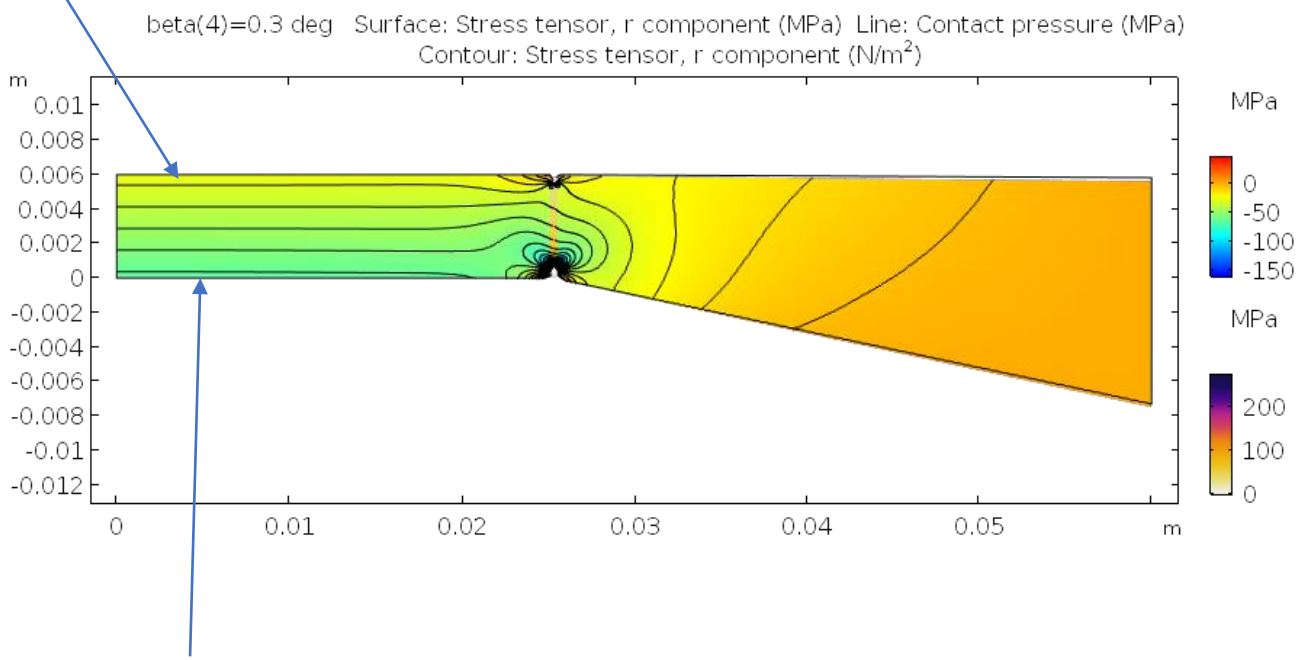
Stress limit of fused silica

- Tensile strength is the main limitation: c.a. 50 MPa
- From Minkyun's talk: bending + compression allows wide range of spherical power
- **Figure of merit: Ratio between spherical power and average tensile stress along front surface (back surface mainly see compression stress) needs maximized**
- Min spherical power required: 150 mD
- Max allowed tensile stress: 50MPa/3 = 17 MPa

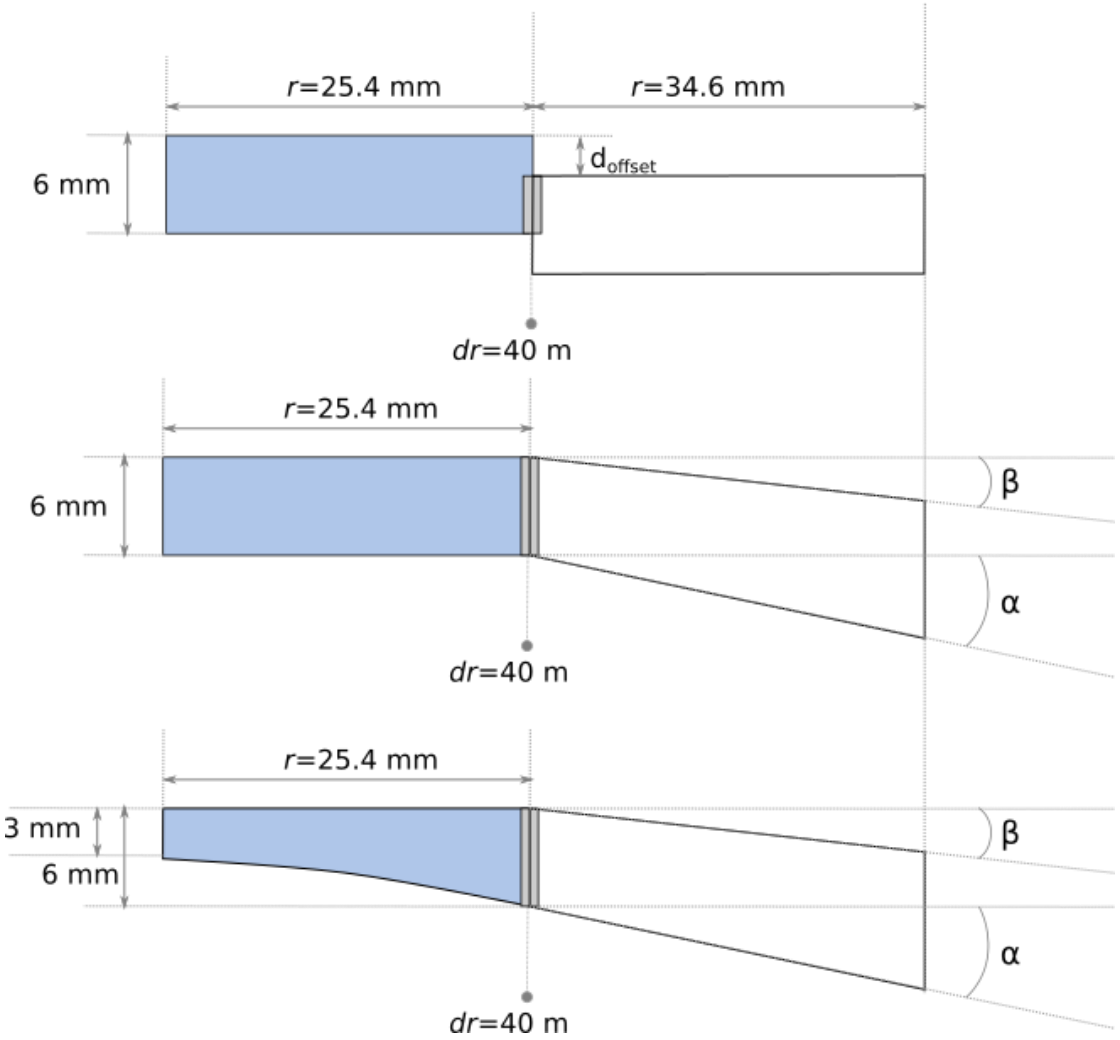
→ $S/P_{T,max} \geq 8.8$ mD/MPa

Tensile stress at front surface (+ve radial stress component)



Compressive stress at front surface (-ve radial stress component)

Geometries comparison

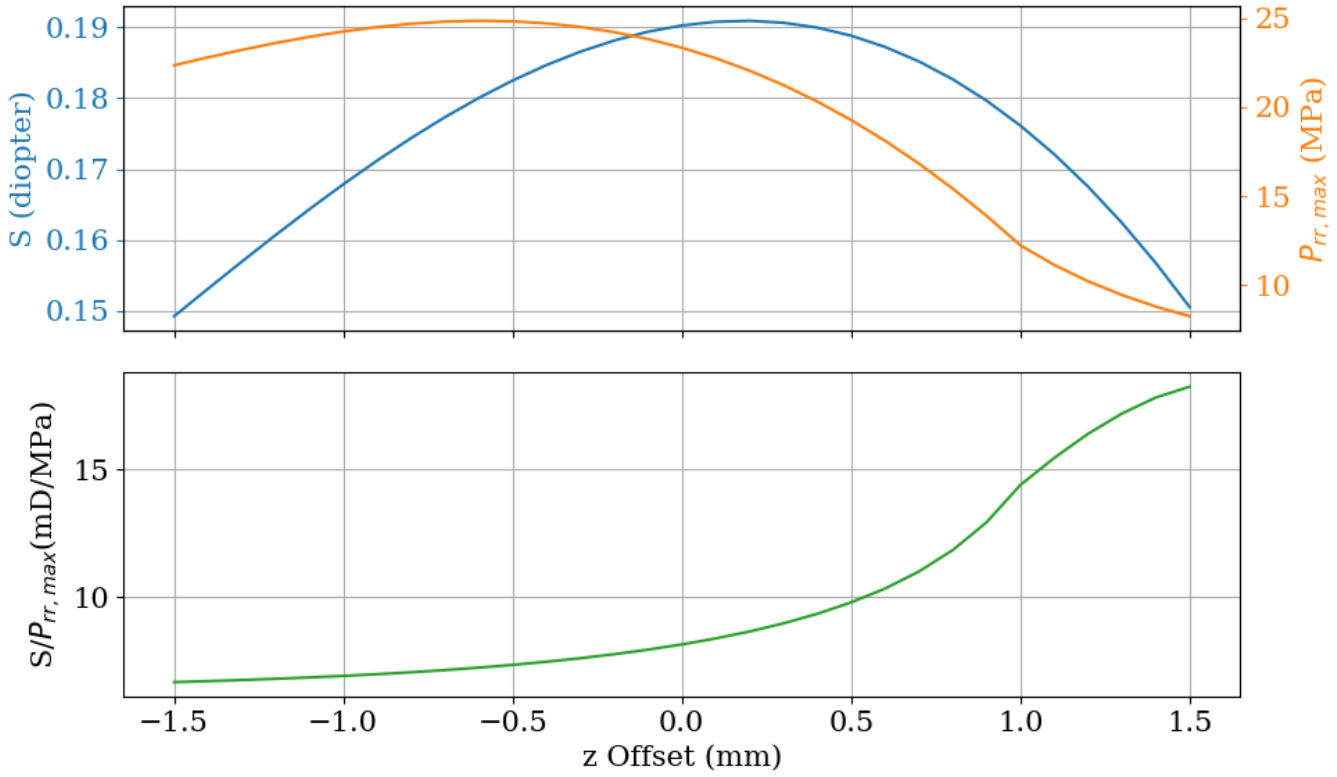


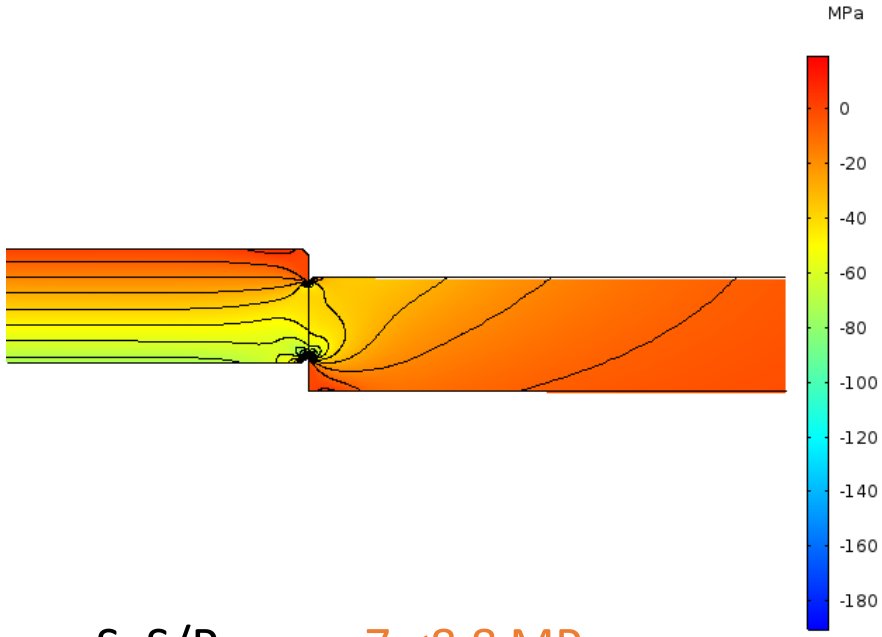
a) Offset ring	*Variable*: offset distance d_{offset}
b) Chamfer ring + flat mirror	*Variable*: Upper and lower chamfer angle (β and α)
c) Chamfer ring + planoconcave mirror	*Variable*: Upper and lower chamfer angle (β and α) Edge thickness: 12 mm or 6mm Central thickness: 6 mm or 3mm

COMSOL FEA simulation

- Use 2D Axisymmetric model
- B.C: Rigid motion suppression
- Cold state difference in mirror radius and Al ring inner radius (interference) *dr*: 40 microns - corresponding to T=100°C assembly
- Adaptive meshing with finer mesh near contact surface between mirror and Al ring
- Positive radial component of stress tensor (σ_{rr}) gives tensile stress P_T

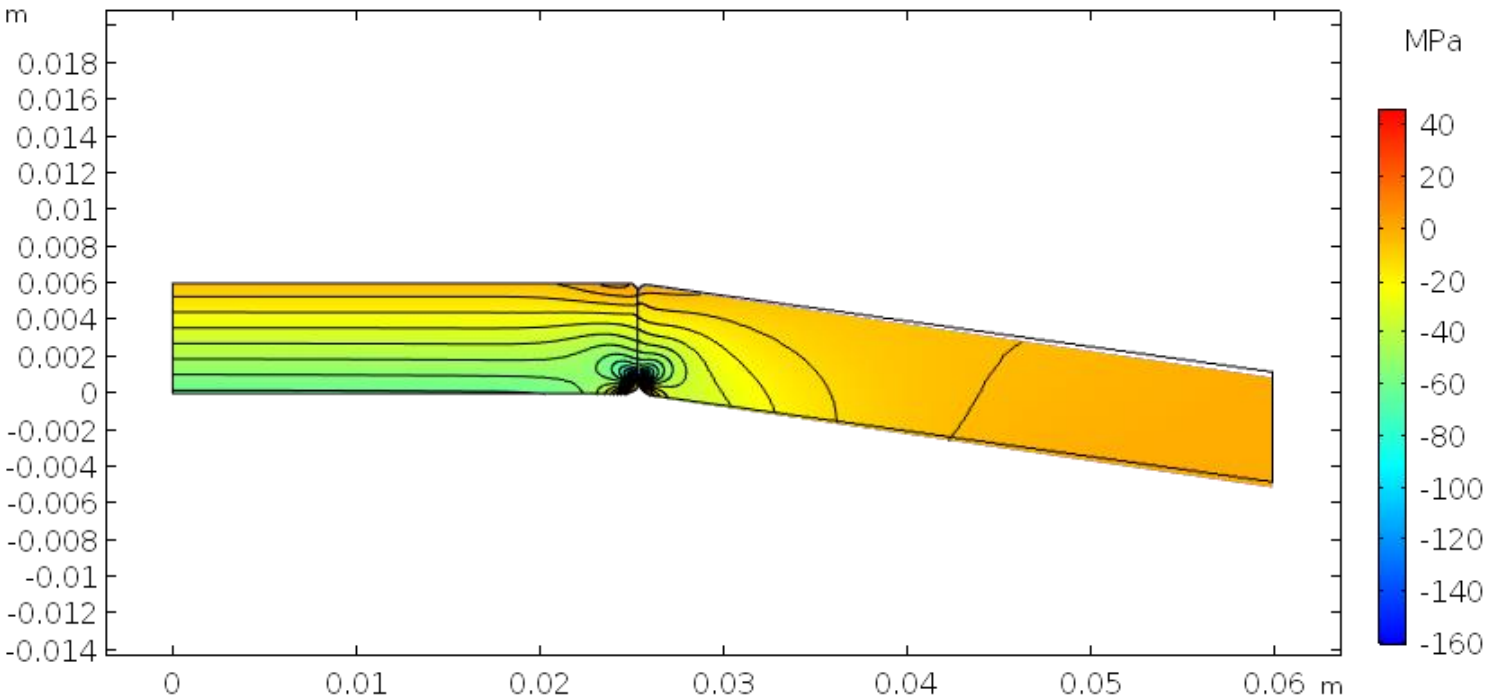
Offset compression fit mirror





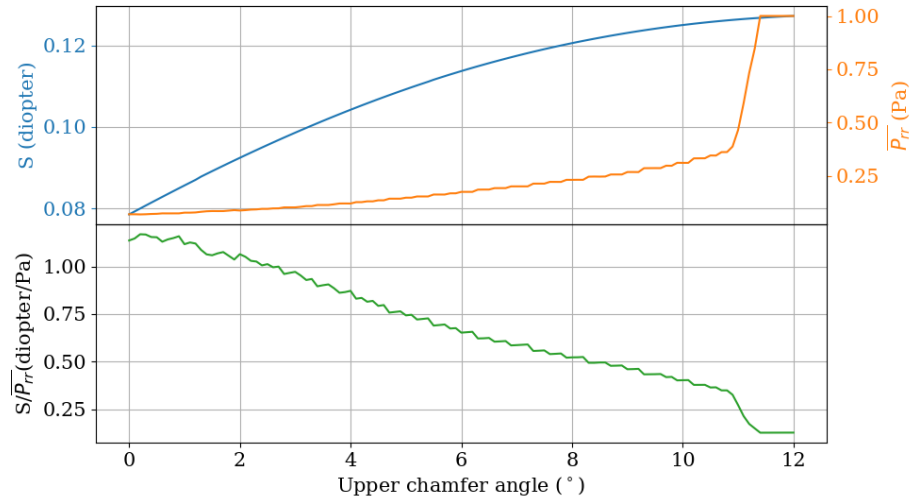
- At max S, $S/P_{T,max}$ = 7 <8.8 MPa
- Shift offset → reduce $P_{T,max}$ to 17 Mpa
- S→ 165 mD,
- $S/P_{T,max}$ = 17 mD/MPa

Chamfer CFM - flat mirror

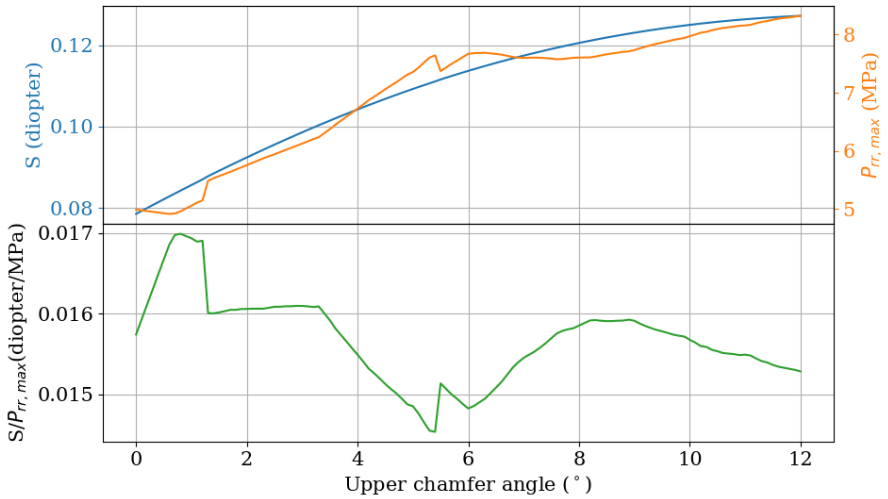


Radial component of stress tensor in a flat mirror with chamfer ring

Chamfer CFM - flat mirror – variable β



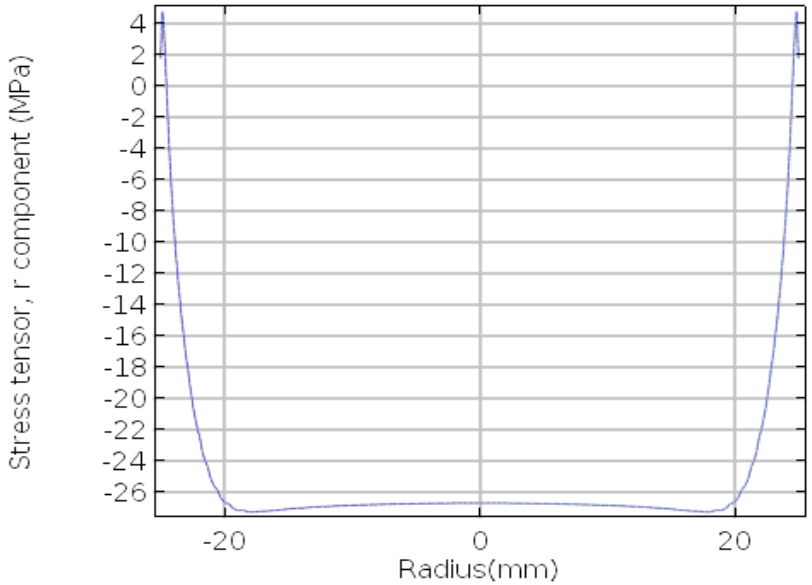
Average tensile stress along front surface



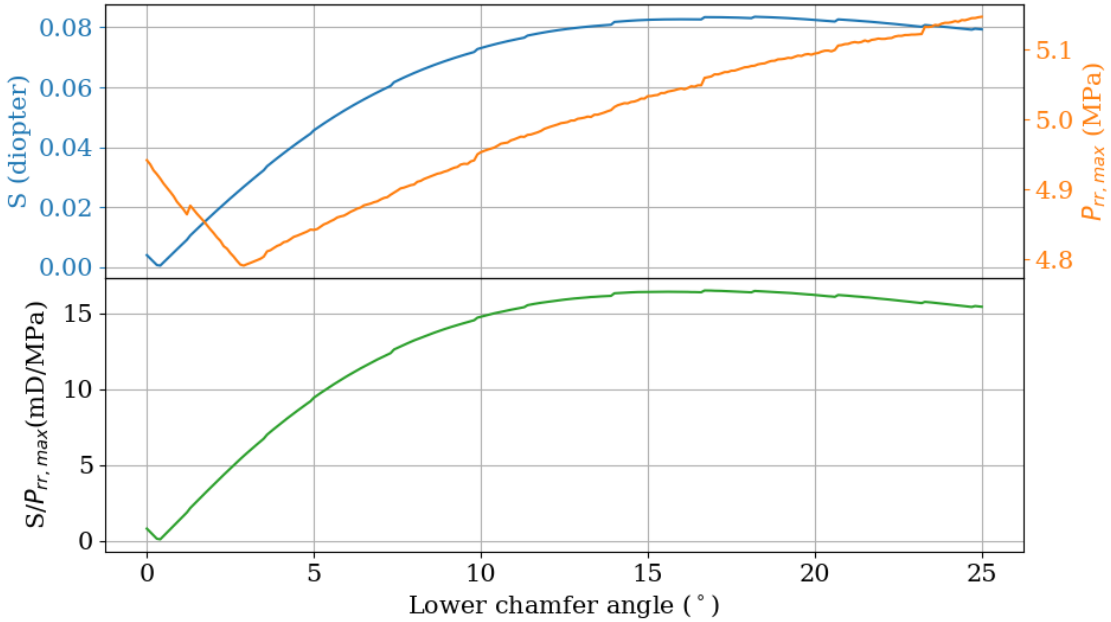
Max tensile stress along front surface

- α = 12°
- Both average and maximum tensile along the front surface of the compression fit mirror increases linearly with β
- Max tensile stress near corner along mirror – ring interface: c.a. 5 MPa (bottom figure)
- Average tensile stress: c.a. 0.08 Pa across the entire surface
- $S/P_{T,max}$ = **16 mD/MPa**, $S/(P_T)_{ave}$ = **8e7 - 1e9 mD/MPa**

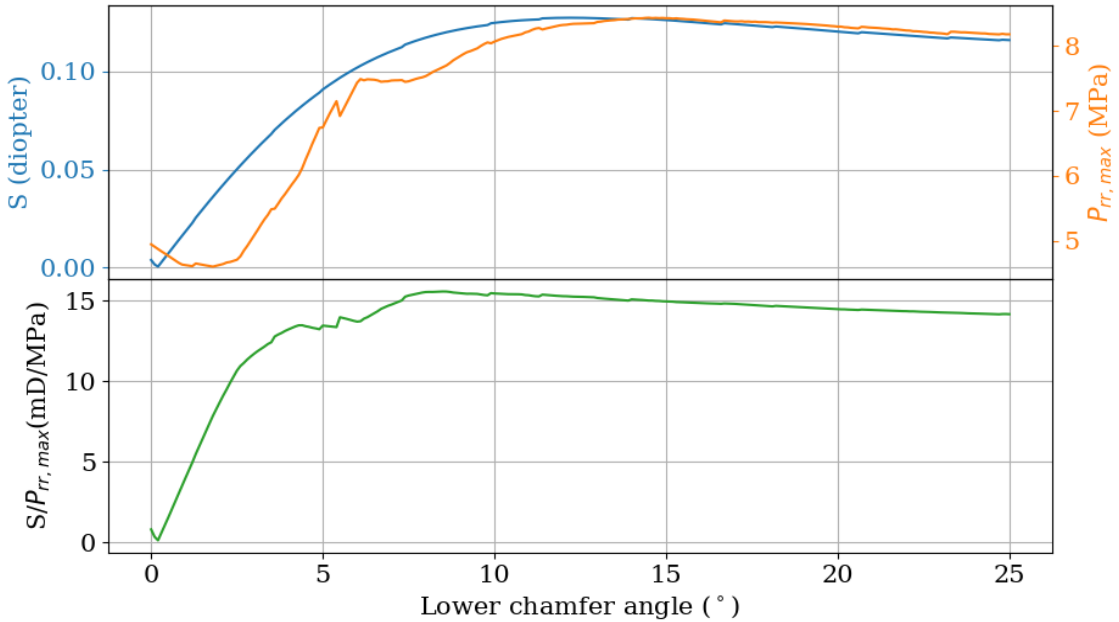
→ $\beta = 0$ minimises average tensile stress, but tensile stress is not limiting factor



Chamfer CFM - flat mirror – variable α



Upper chamfer angle stay constants at 0



Increasing upper chamfer angle (same as lower angle) to increase S

- *β* kept constant 0°
- S/Prr,max ratio proportional to distortion.

→ Optimal S/Prr,max = **17.4 mD/MPa** at *α= 17°*

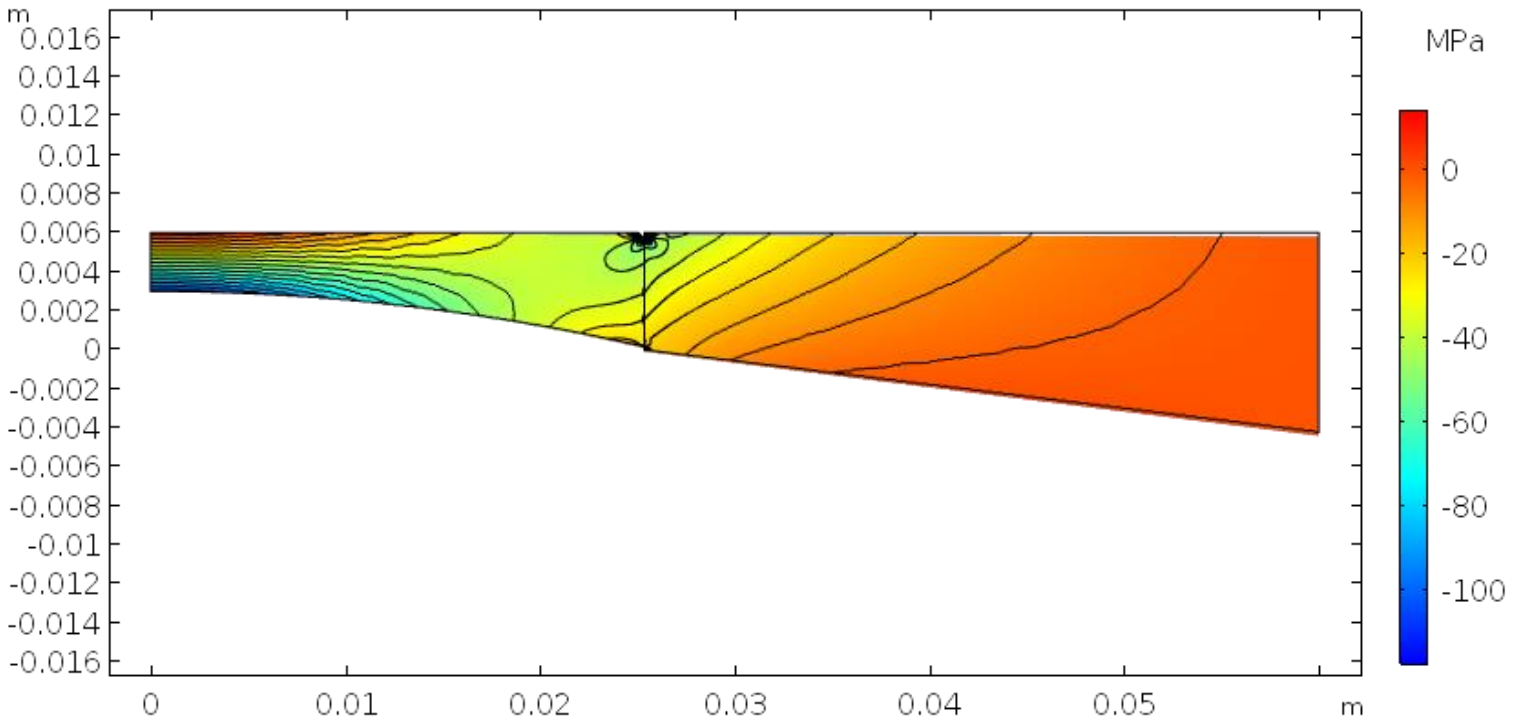
- Limitation: small S (80 mD)

- *Max tensile is almost independent of β*

→ *β = α*

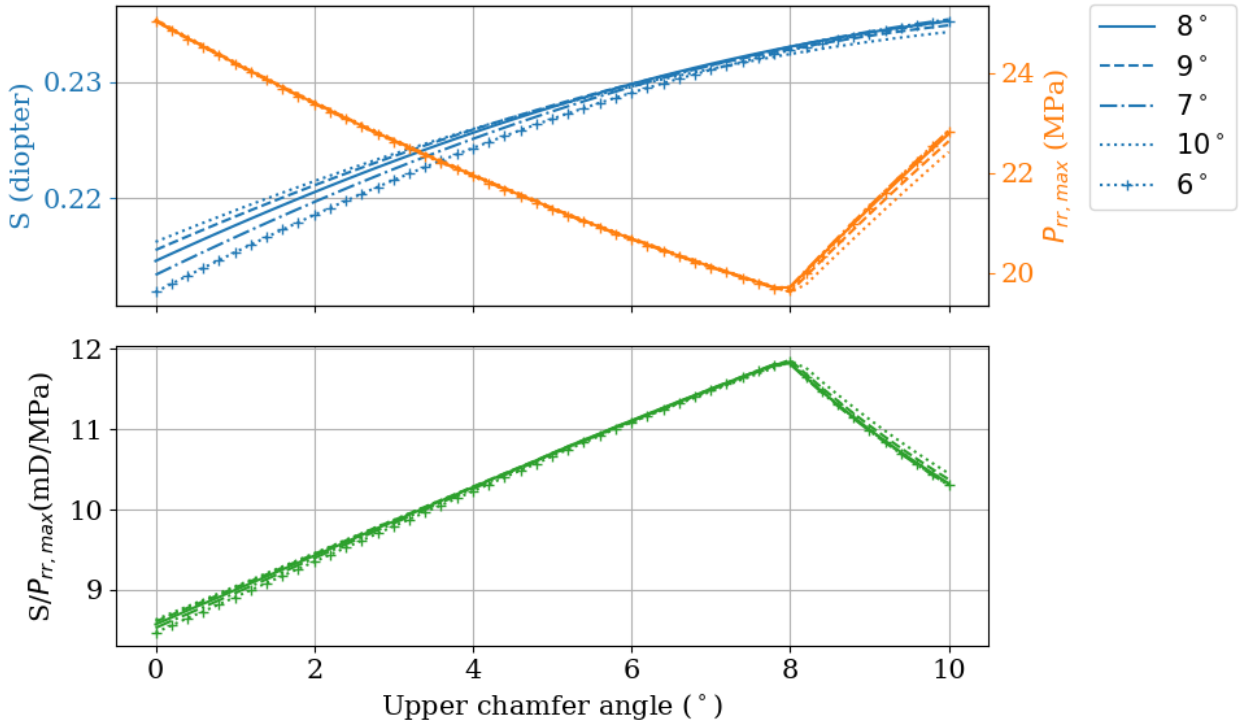
- Optimal S/Prr,max = **15.7 mD/MPa** at *α= 8°*
- S increases to 120 mD
- Harder to assemble

Chamfer CFM – concave mirror



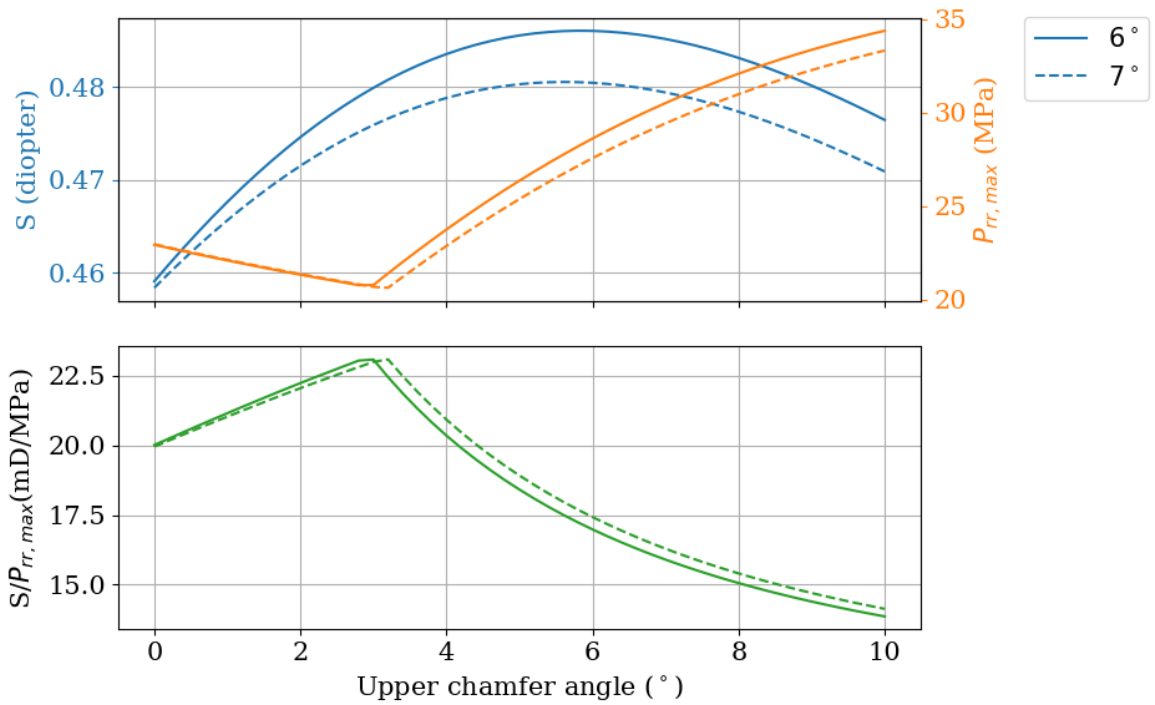
Radial component of stress tensor in a concave mirror with chamfer ring

Chamfer CFM – concave mirror



12mm edge mirror

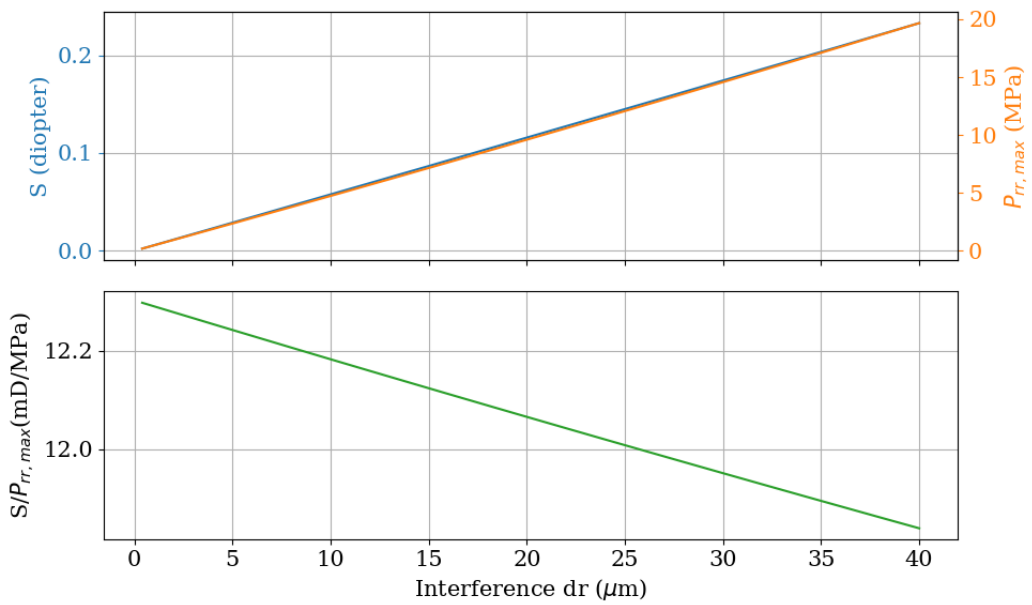
- Edge thickness: 12 mm, central thickness: 6mm, R= 56 mm
- Ratio insensitive to variation in α
- → Optimal S/Prr,max = **11.8 mD/MPa** at $\beta = 8^o$
- Distortion exceed requirements (233 mD)
- High tensile stress (can reduce interference)



6mm edge mirror

- Edge thickness: 6 mm, central thickness: 3 mm, R = 115 mm
- → Optimal S/Prr,max = **22.5 mD/MPa** at $\beta = 3^o$
- Very high *S* (450 mD)
- Similar tensile stress at optimal configuration (can reduce interference even further)

Chamfer CFM – concave mirror-lower stress

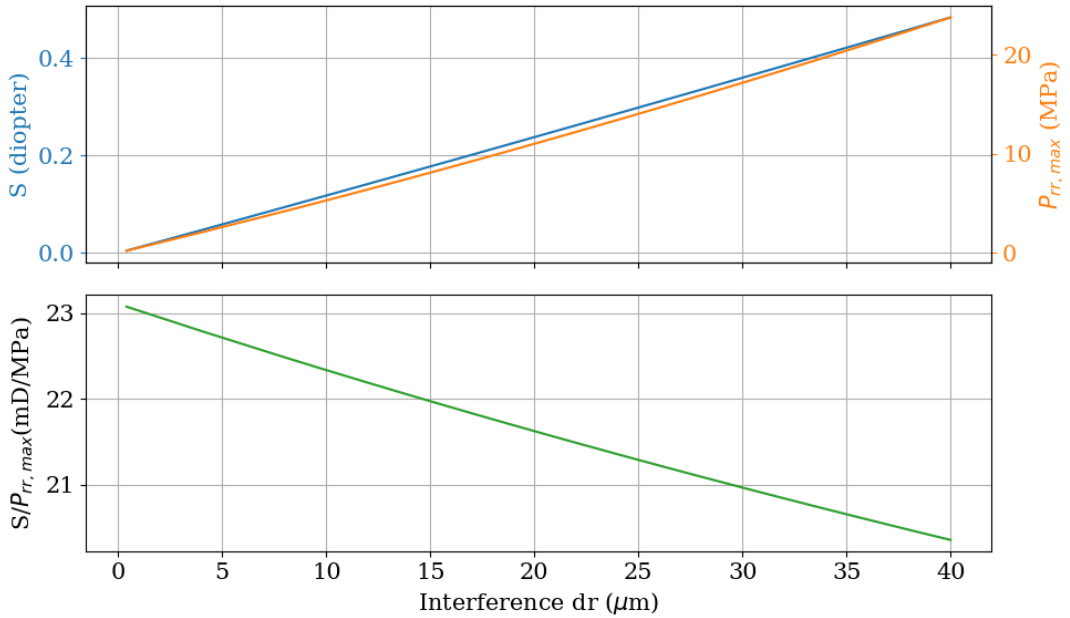


12mm edge mirror, varying interference

- Edge thickness: 12 mm, central thickness: 6mm
- $\alpha = 8^o$, $\beta = 8^o$
- Drop interference to 33 micron, assembly T approx. 82°C

→ → $P_{T,max}$ = 15 MPa, $S/P_{T,max}$ = 12.1 mD/MPa

- S = 200 mD



6mm edge mirror, varying interference

- Edge thickness: 6 mm, central thickness: 3 mm
- $\alpha = 6^o$, $\beta = 3^o$
- Drop interference to 25 micron,assembly T approx. 72°C

→ $P_{T,max}$ = 15 MPa, $S/P_{T,max}$ = 21.5 mD/MPa

- S = 300 mD

Summary

Geometry	Optimal parameter	$S/P_{T,max}$ (mD/MPa)	S/dr (mD/µm)
Offset CFM Thickness: 6mm	*dz* = 1.3 mm	17	4.12
Chamfer CFM, flat mirror Thickness: 6mm	$\alpha = 8^o$ $\beta = 8^o$	15.7	3.0
Chamfer CFM, plano-concave mirror, Edge: 12 mm Center: 6mm	$\alpha = 8^o$ $\beta = 8^o$ *dr = 33µm*	12.1	5.0
Chamfer CFM, plano-concave mirror, Edge: 6 mm Center: 3mm	$\alpha = 6^o$ $\beta = 3^o$ *dr = 25µm*	21.5	7.5