**Adaptive Liquid Filled Membrane Lens**

**Introduction**

Liquid filled membrane lens is made by using elastomeric membrane, this membrane is made using polydimethylsiloxane (PDMS). When volume of lens is changed or redistributed, the shape of lens surface can be changed accordingly. As a result, the reshaping of the lens surface causes the focal length of the lens to change without physical motion.

**Properties Circular PDMS membrane**

- Diameter: 15mm
- Thickness: 0.5mm
- Refractive index: 1.5
- Tensile strength: 2.24MPa
- Young’s Modulus: 360-370MPa
- Poisson Ratio: 0.5
- Transmission: 400-900nm (100um thick)

**Equations**

The model is solved using solid mechanics module in Comsol Multiphysics.

Displacement and velocity field is zero at initial condition, fixed constrains were applied at the and edge at the top, bottom (u=0) and face. Differential pressure P (shown in Figure 2) is applied across the two faces.

\[
\frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial z}{\partial r} \right) = -\left( \frac{P - P_o}{S} \right) \left( \frac{r}{S} \right) \frac{\partial z}{\partial r} = \frac{P - P_o}{4S} (r^2 - r^3)
\]

\[
z = -\frac{P - P_o}{4S} \left( \frac{r}{6} - \frac{r^3}{3 \rho} \right) + k\left( y^2 - 2ax \right)
\]

\[k = \frac{P_o + \frac{2S}{R}}{2\rho ga}, \quad k > 30,
\]

Gravity effect may be neglected

\[k = \frac{P_o + \frac{2S}{R}}{2\rho ga}
\]

Knollman’s analysis, the maximum error in displacement is

\[\Delta z_{\text{max}} < k\left( \frac{h}{2a} \right), \quad h << 2a
\]

For small aperture if displacement is such that \(z_{\text{max}} < 1\mu m\) (Very small value within the tolerance of surface roughness of conventional spherical glass lens).

**Results**

Surface: Total displacement (mm)

**Figure 1:** Deflection in lens at 0 Pa(left) 450Pa (middle) 900Pa (right).

**Figure 2:** Deflection in PDMS membrane.

**Figure 3:** Comparison in spherical glass and membrane lens (112.5Pa).

**Figure 4:** IR Transmittance of PDMS membrane (thickness 100um).

**References**