Research Topic : **Effect of Residual Stress on Structure Stability of Microscale Membranes**
Duration : **2006-Present**
Sponsor(s) : **Infotonics and CAMP/Clarkson University**
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Synopsis of Research and Sponsored Project

During fabrication, large deformations are observed in very high-aspect ratio free-standing micro-scale membranes. Axi-symmetric and full three dimensional membrane models of a 1.6 μm thick, 6 mm diameter membrane were developed to study the structural stability of these membranes with substantial residual stresses.

The shape of the model was determined from fabricated membranes found with depressed centers of 150 μm with rippled edges creating an apparent "cupcake" shape (Fig. 1). By applying a pressure of 101.3 kPa to the surface of the membrane while applying residual stresses within the FE models, 234.7 μm and 259.5 μm displacements were calculated for the axi-symmetric and three dimensional membrane cases, respectively. Although 100 μm larger than the 150 μm displacements expected, the difference is easily attributable to the lack of accurate material properties and residual stresses for the membranes.

The three dimensional membrane models were created as a single layer of SiO_2 with a residual stress of 50 MPa compressive stress rather than the alternating layers with residual stresses of 60 MPa compressive (SiO_2) and 190 MPa tensile (TiO_2) used in the axi-symmetric case. This is the cause of the deflection difference between the two models.

As part of these simulations, the effects of residual stresses and external forces on the membrane shape were investigated. Modifying the residual stresses had little effect on the membrane displacement. The simulations showed that the deflection of the membranes is attributable to an out-of-plane force rather than residual stress. The "cupcake" shape was not successfully calculated in ABAQUS, but the levels of in-plane stress are of magnitude (compared to the yield stresses for materials published) to cause yielding of the material. If the material properties and stresses were more accurately measured from the fabricated membranes, more accurate models could be developed and it is conceivable that the "cupcake" shape could be output. These more accurate models would also directly lead to better comparison between the measured displacement of the fabricated membranes and the calculated displacement by the simulation.

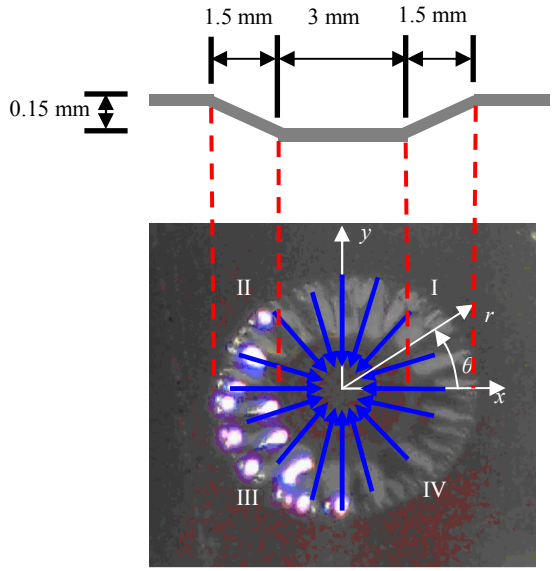

Fig. 1. The observed profile and top view of the fabricated thin film membrane exhibiting the "cupcake" depression shape.

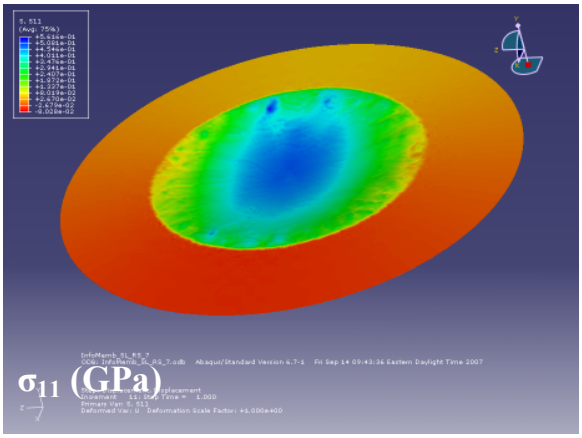

Fig. 2. Stress field for the σ_{11} case of the three dimensional membrane.

Recent Publications

J. Ricci, C. Cetinkaya, *Effect of Residual Stress on Structural Stability of Microscale Membranes*, In preparation for publication in Review of Scientific Instruments, 2007.