
# Virtual Research Presentation Conference

## Stretchable Optical Lightguides for Sensing Deformation During Parachute Deployment

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RPC-277

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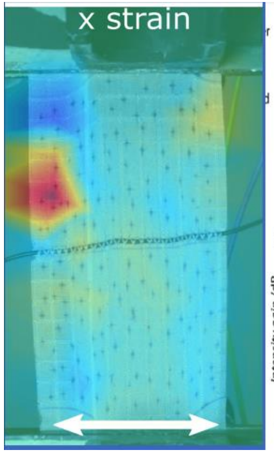
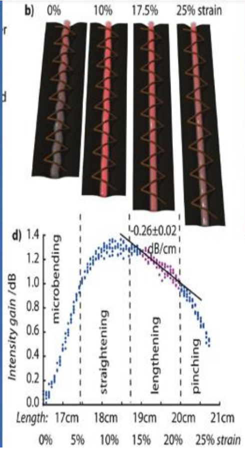
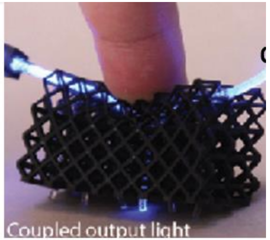
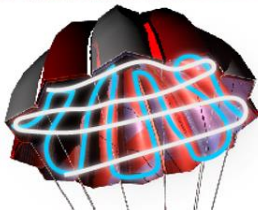
### Abstract

The *Advanced Supersonic Parachute Inflation Research Experiment* (ASPIRE), tested its last parachute experiment on September 7th 2018 and deployed a parachute at Mach 1.8: “in less than 0.5 seconds, 200 lbs of Nylon, Kevlar, Technora go from a drum sized bag the density of wood to an inflated parachute with the volume of an inflated house. Generating nearly 70,000 lbs of drag.” Without knowledge of how the structural arrangement of F-111 nylon fabrics composed of these fibers rearrange and stretch during the >1,500 mph winds experienced in parachute inflation, it is not possible to accurately model the fluid-structure interactions (FSI) in hypersonic parachute inflation. To bridge this knowledge gap, our goal is to embed stretchable optical lightguides within parachute gores in order to map the local strains experienced by hypersonic parachutes during deployment.

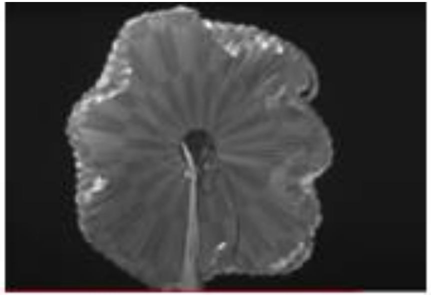



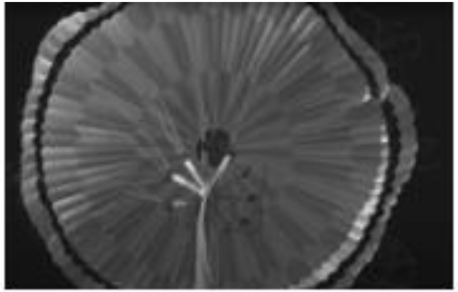
# Problem Description

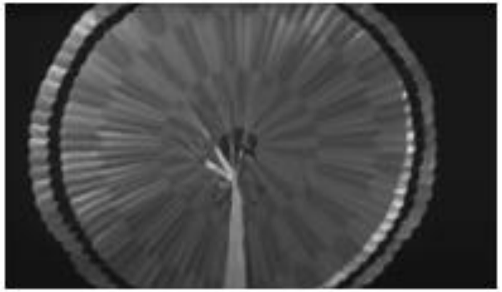
a) Parachute failures are single points of failures for missions, and can cost years of effort and possibly billions of dollars. Co-I Shepherd and Parks have recently been developing fabrics capable of self sensing their own strain. We hypothesize that they can be embedded in parachutes for high resolution strain mapping during deployment.

b) The sensing fabrics are composed of rubber fibers with <1 MPa elastic modulus, and use optical communication to indicate strain. High compliance materials and structures should have low impact on the mechanics of the parachute, and the optical data communication should allow high data rate sampling during hypersonic inflation.

c) ASPIRE parachute testing has been valuable and successful; however, the use of high speed videography to observe parachute inflation dynamics is susceptible to errors from occlusion. Additionally, the resolution of imaging is not capable of localizing the strain differentials in the fabric itself.





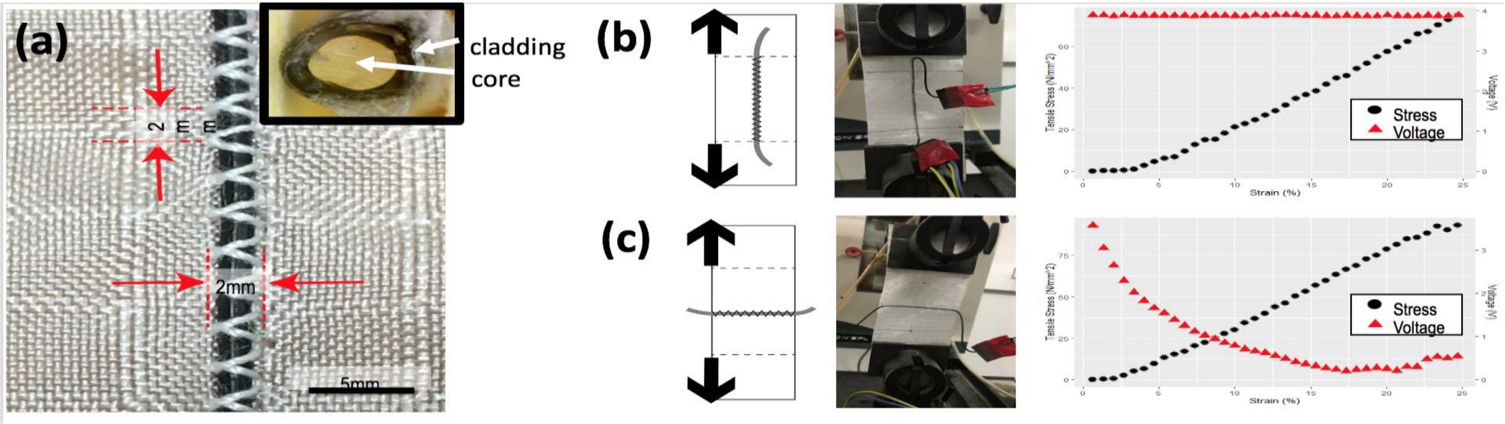


# Methodology

a) Stitching stretchable fiberoptics into F-111 fabric and measuring the attenuation of propagating light in tension

b) Structure-Optics coupled modeling of deformation and light propagation

c) Elucidate the relationship between optical response to fabric deformation

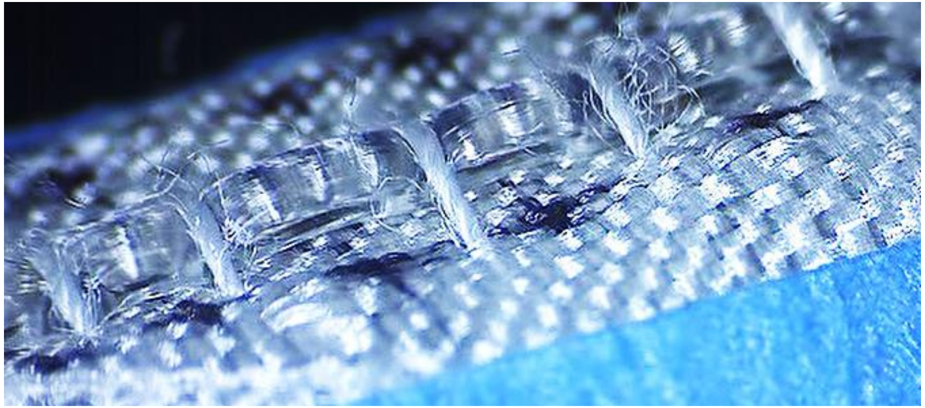


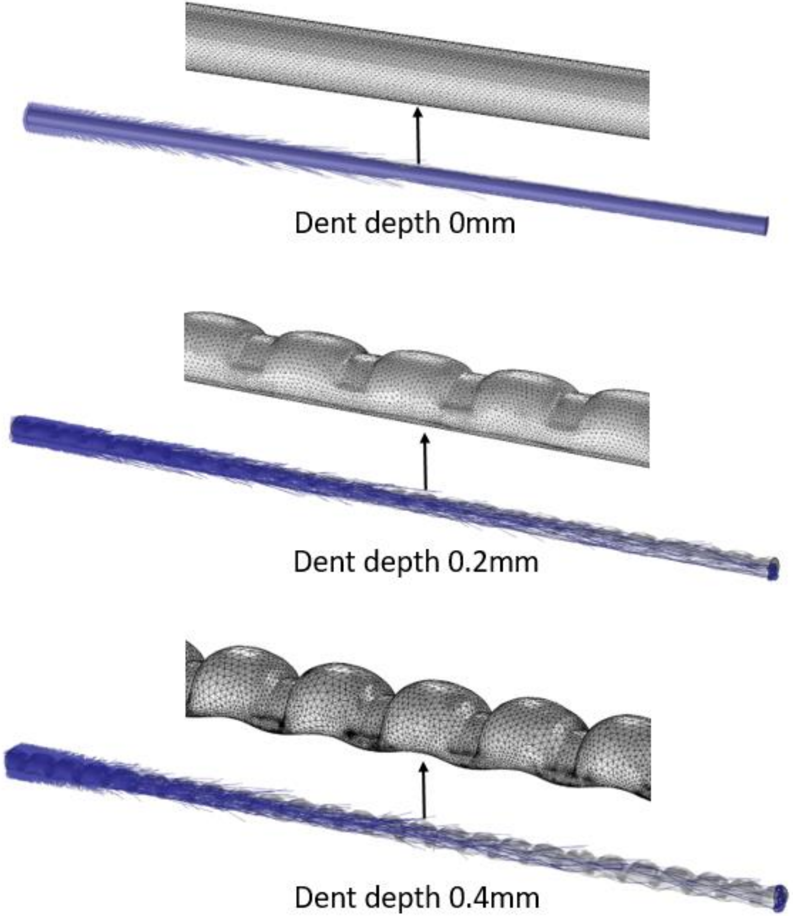

# Results

a) Predictive models of sensor output upon tensile loading achieved

b) Reasonable expectations that sensors could predict strain fields in hypersonic inflation

c) Gather sensor data and ground truth from multiple fibers to gauge error for our predictions.





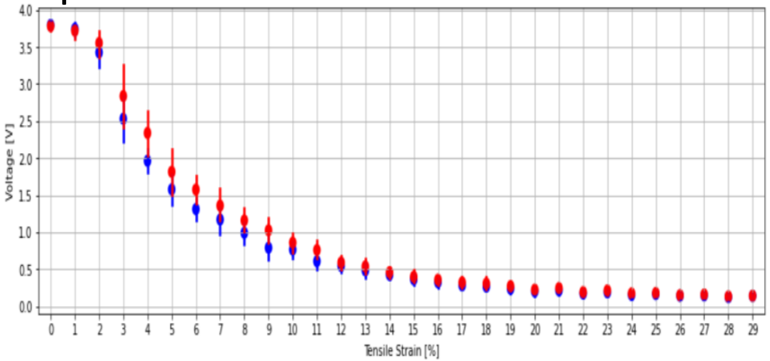
# Results

a) We have achieved a low variance correlation between tensile strain on an F-111 fabric coupon and voltage change from a phototransistor connected to our stretchable optical waveguides.

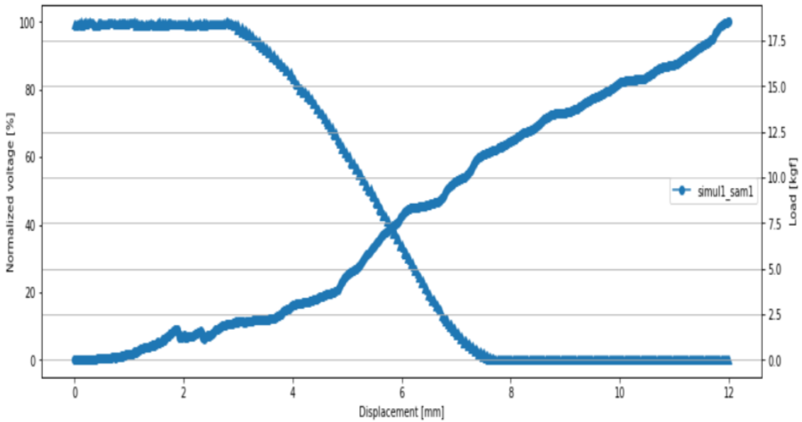
b) Additionally, we have identified the major contributing factors to the change in power output from these waveguides upon stretching and validated this assumption via structure-optical couple simulations.

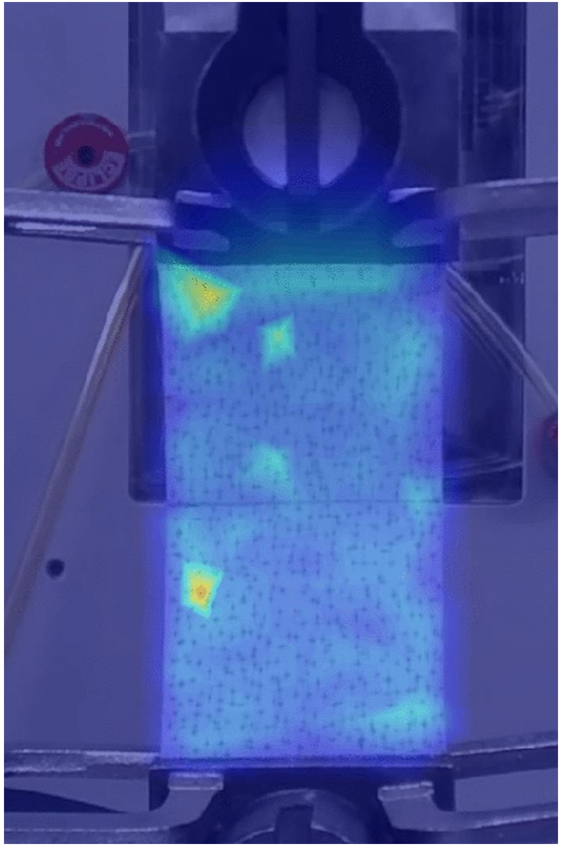
c) With a little more tuning, we can begin to make predictions from tensile loading of gores with multiple fibers. We will then compare our prediction of strain fields to that of the DIC data (Right animated Gif).

experiment




simulation



# Publications and References

Jeo et al., Stretchable Optical Lightguides for Strain Mapping of High Tensile Modulus Fabrics (in preparation)