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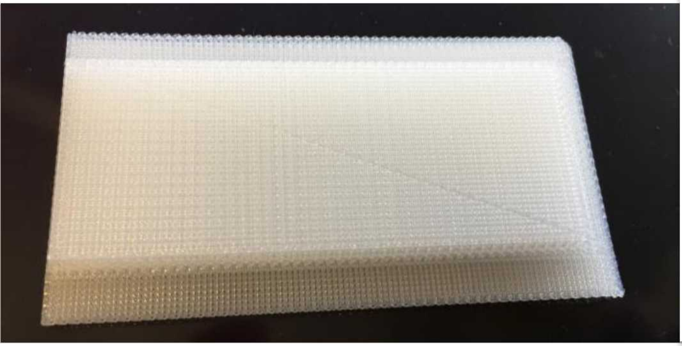

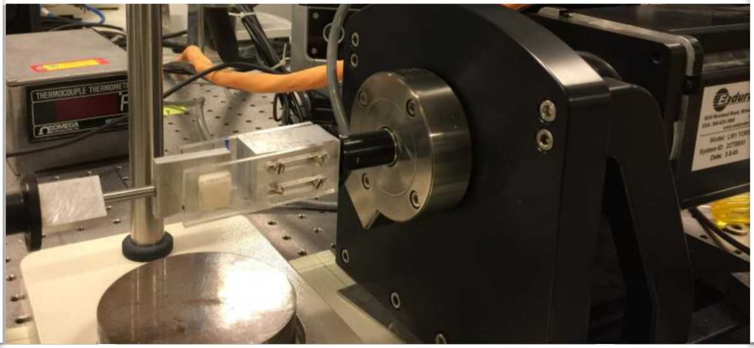

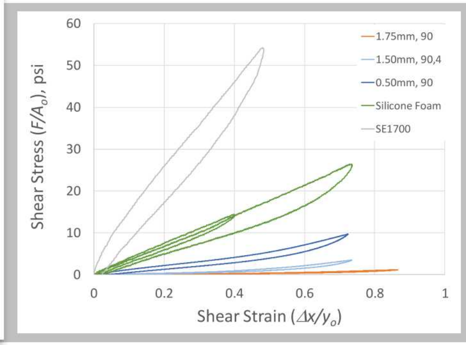

Compression and Shear Response of 3D Printed Foam Pads

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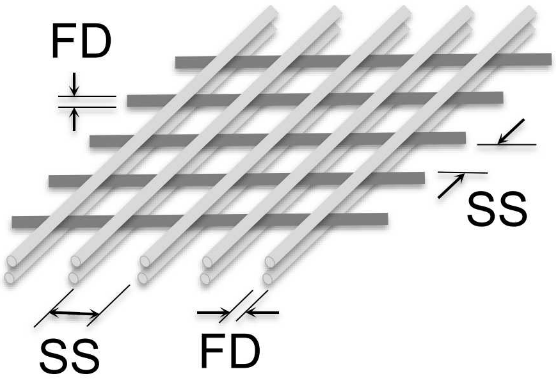
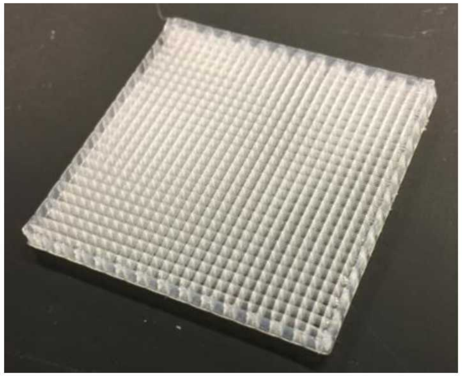
Introduction

- Foams are used for cushioning or absorbing the kinetic energy from impact
- Foam mechanical properties depend on the shape and structure of the cell
- New 3D printing fabrication method can now prepare components of foams with well-controlled array of cells
- Mechanical properties of printed foam pads could be tuned for application
- Compression and shear characterization of several printed foam pads are needed

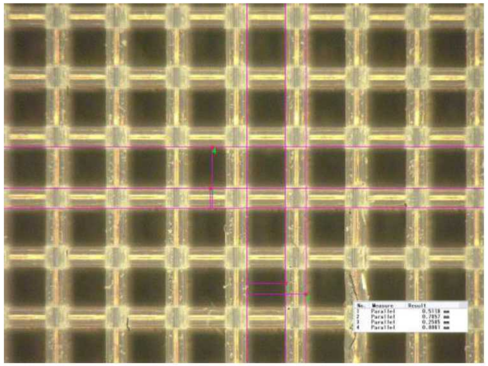
AM Silicone Foam Pads

- Material : SE1700
- Simple lattice architecture:
  Body Centered Cubic (BCC)
- Thin Pad Dimension:
  ~ 50 x 50 x 3.0 mm
- Filament Diameter (FD):
  0.25 mm
- Span size (SS):
  From 0 to 2.0 mm
- Solid sheet bottom





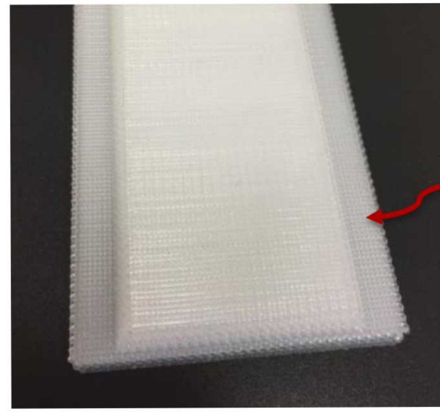
(A. Cook, SNL)

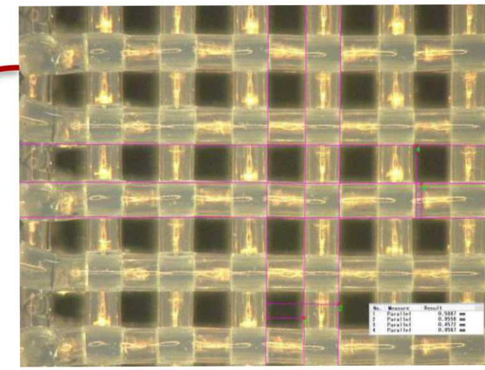


FD = 0.25 mm, SS = 0.5 mm

Thick Pad and Characterization

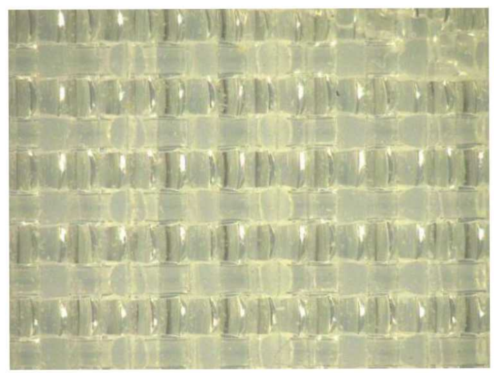
- Thick Pad
  - FD ≈ 0.5 mm
  - SS = 0.5 mm
  - Thickness t = 8.75 mm
  - Solid bottom & top



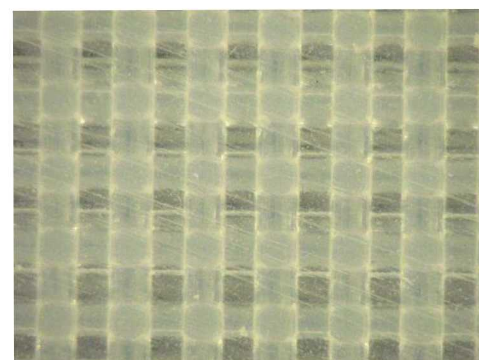


FD = 0.5 mm, SS = 0.5 mm

- Experiments
  - Compression
  - Shear
    - Single Lap Shear
    - Double Lap Shear (for thick pads)

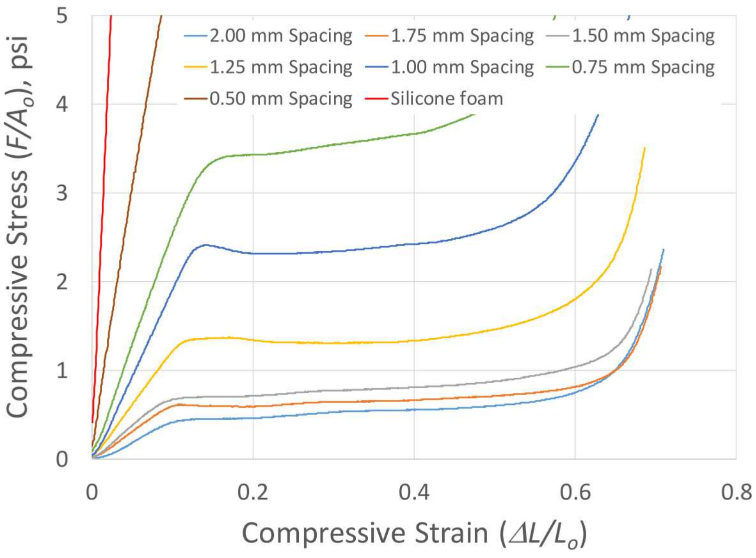


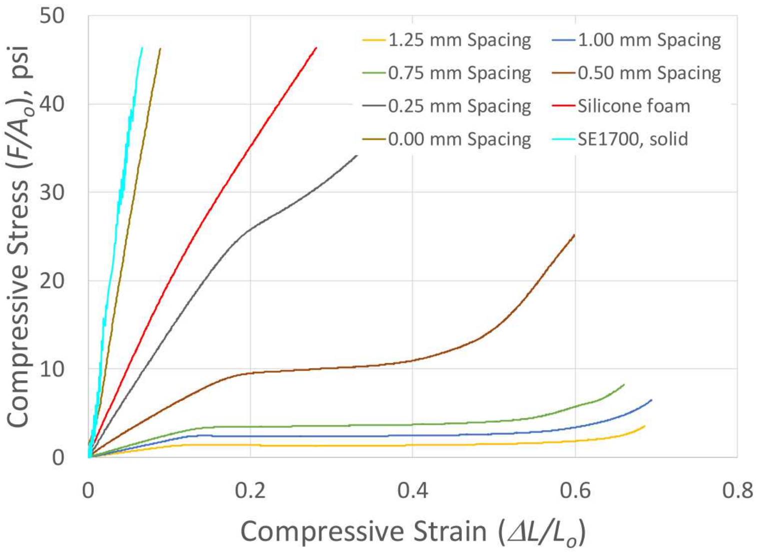
Top View



Bottom View

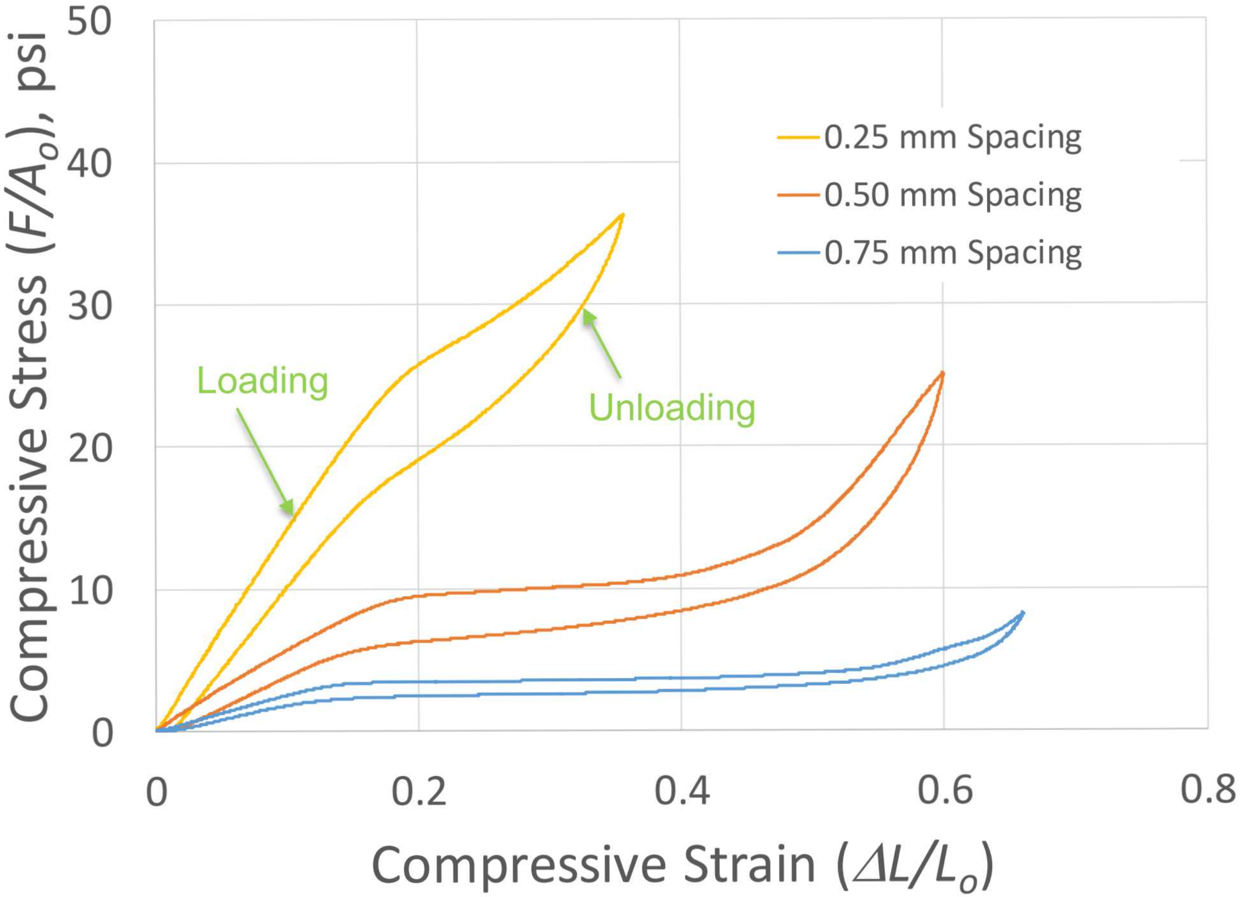
Compression Stress-Strain Curves





- Quasi-static, 0.001 s^{-1}
- Typical foam compression behavior
- Conventional silicone foam and solid SE1700 are included
- SS = 0 mm versus solid SE1700

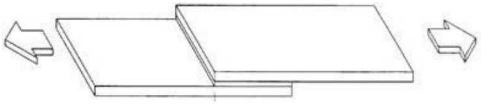
Loading-Unloading Curves

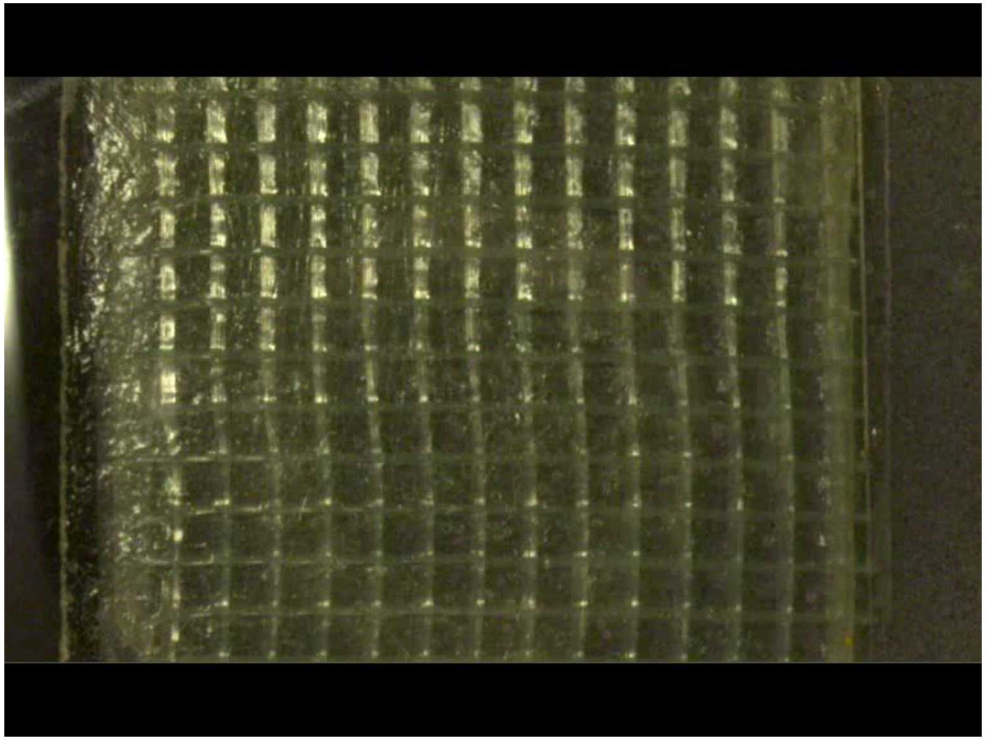


Single Lap-Shear

- Making lap shear specimens is very challenging
  - Filaments only on the top layer
  - Adhesives
- Anisotropy
- Loading orientation:

  0^o (or 90^o) and 45^o

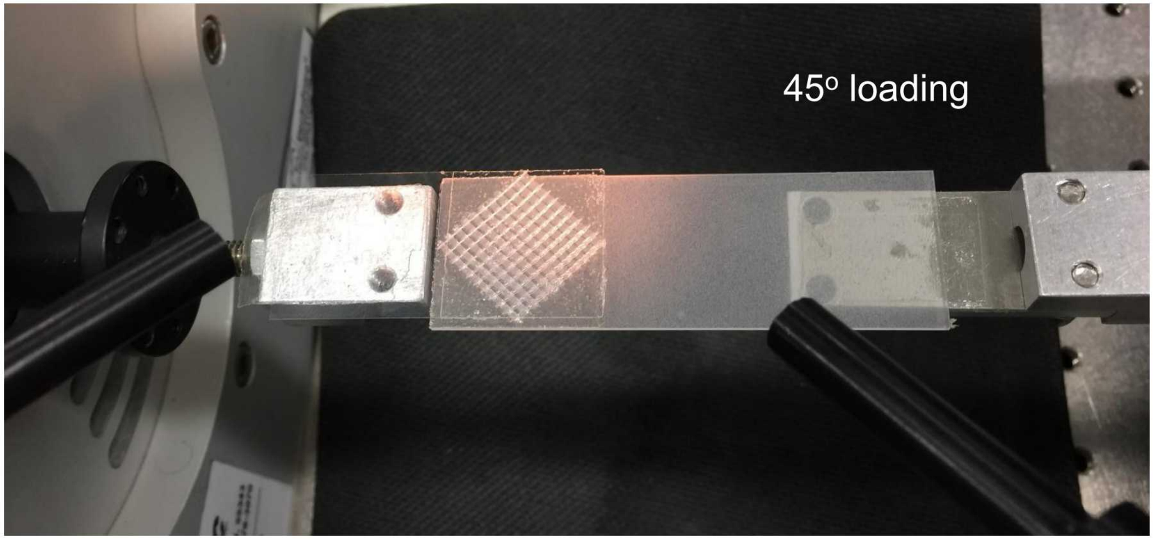




(video)
Unsuccessful shear specimen, bottom half not deformed

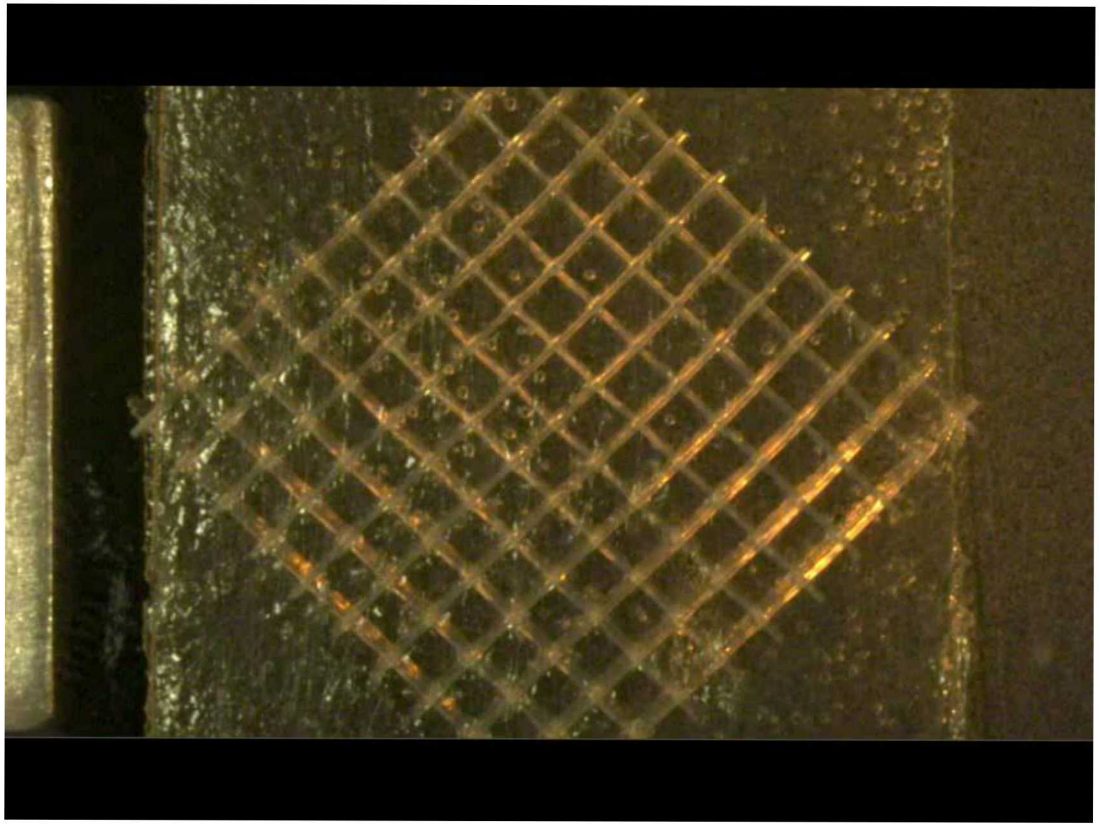
Test Setup for SS ≤ 0.5 mm

- ElectroForce Test Bench System
- Using transparent substrate (glass) so pad deformation and bonding surface integrity can be monitored



Shear of 1.50 mm Pad

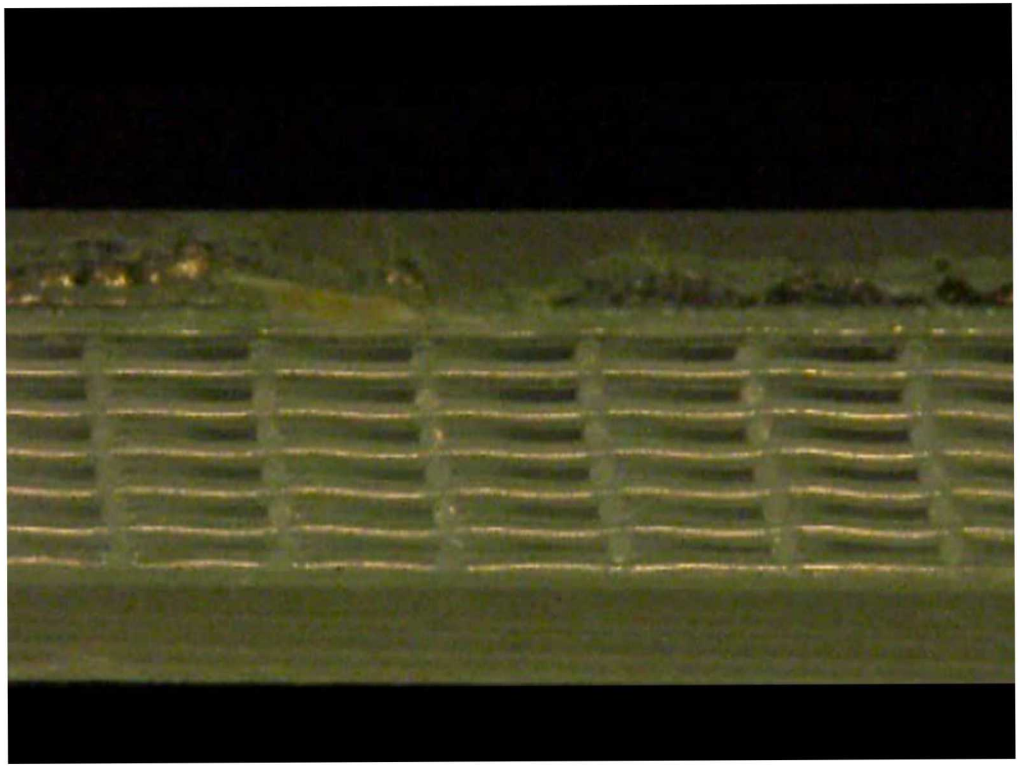
45^{o} Loading
Top View



(video)

Shear of 1.50 mm Spacing Pad

0° Loading
Side View

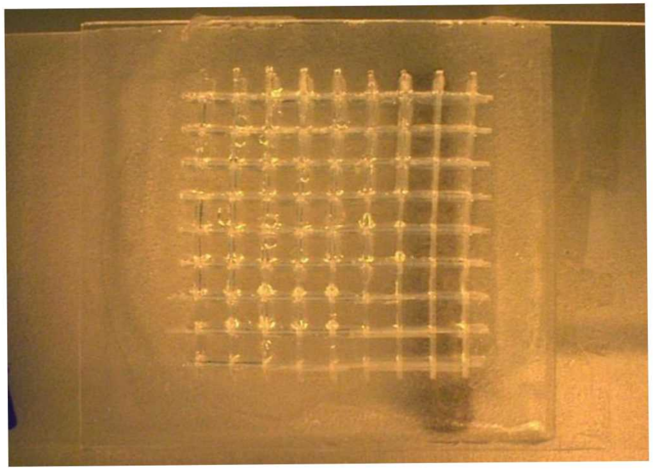


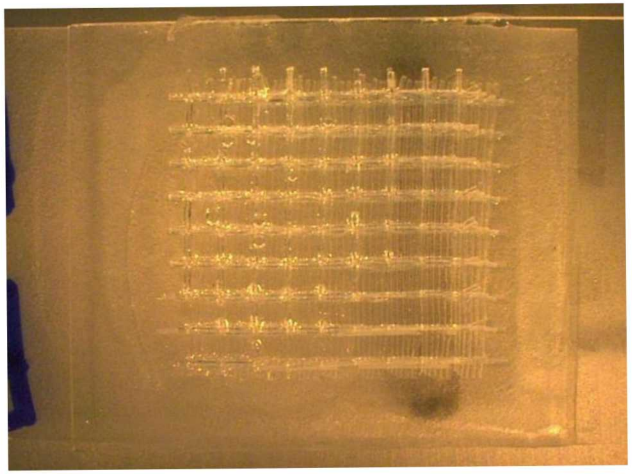
(video)

Shear of 1.75 mm Spacing Pad

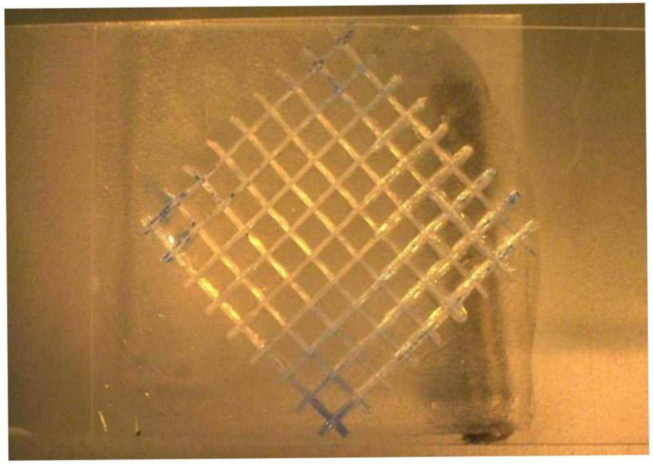
Undeformed | Deformed

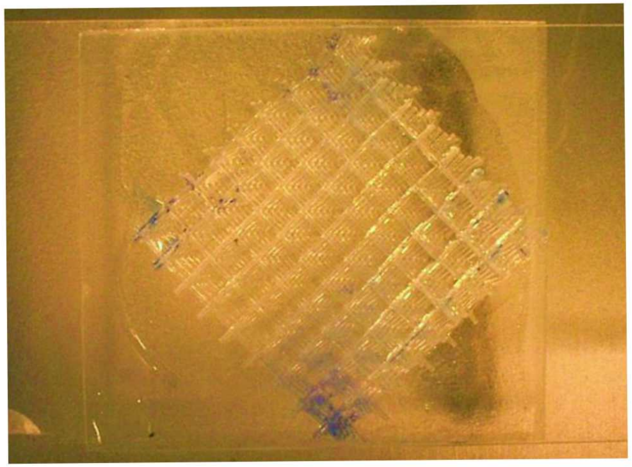
0^{o} Loading





45^{o} Loading



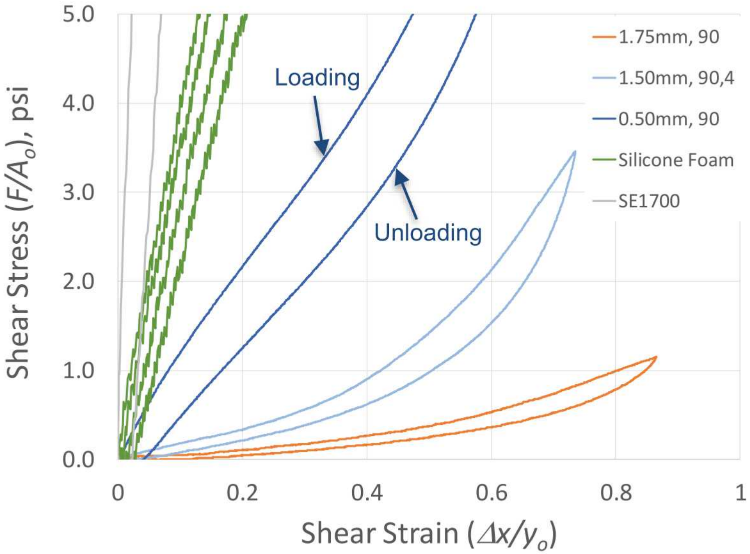


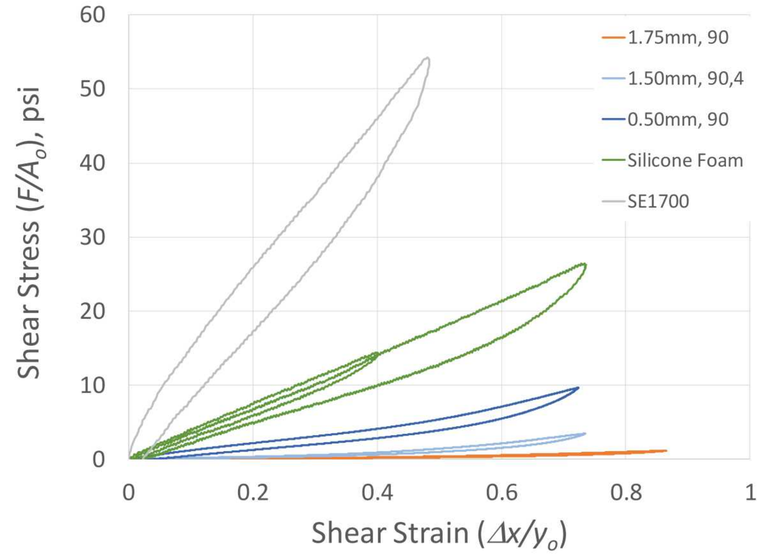
Shear of Silicone Foam

- MTS Mini Bionic System
- Aluminum substrate

Shear Stress-Strain Curves

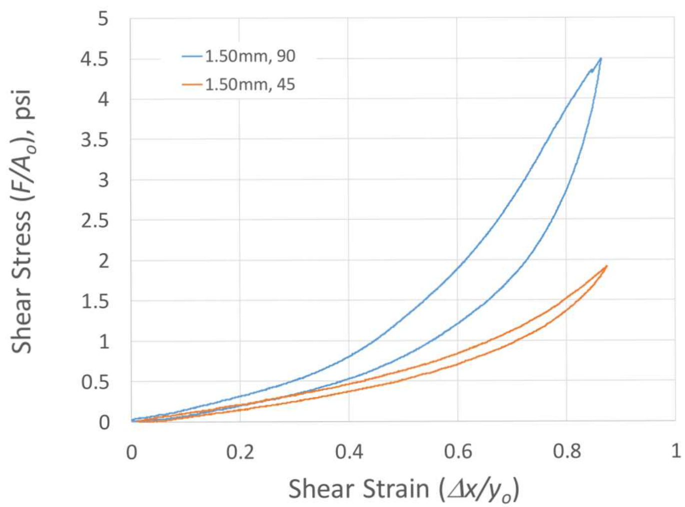
- Thin pads loaded in 0° (or 90°) direction

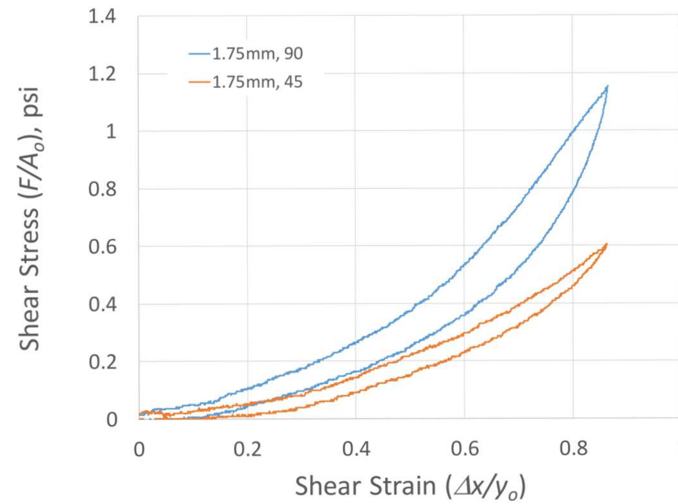




- Show effects of parameter SS (span size)
- The yield and plateau observed in compression curves are not obvious in shear curves

0° versus 45° Loading

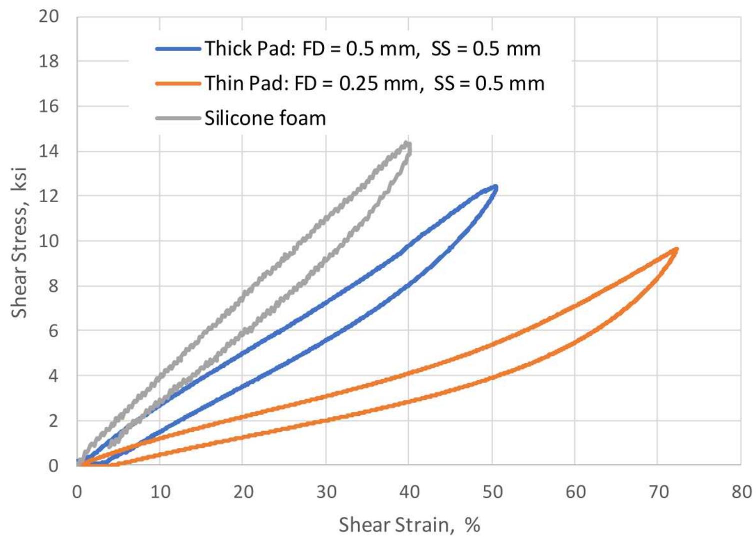


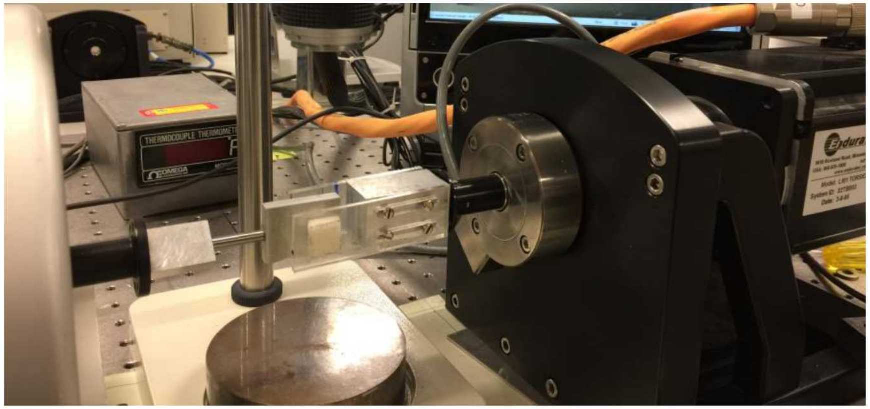


- Loading in 0° direction is stiffer than 45° direction and dissipates more energy (larger hysteresis loop)

Double Lap shear

- Results show effects of parameter FD

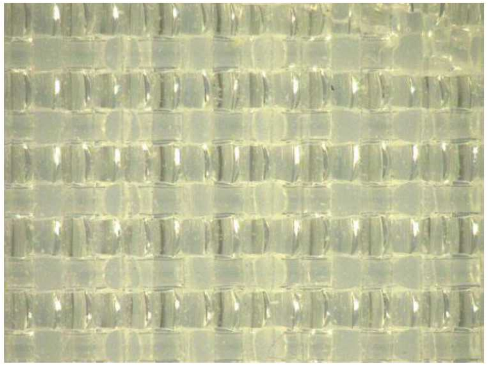




ElectroForce Test Bench System

Discussion

- Making good shear specimen is the key to obtain good shear data
- Many unsuccessful specimens for these given pads
- Double lap shear test has a more uniform stress distribution
- More interfaces and bonding steps, however, reduce the rate of having a successful shear specimen
- Top solid layer of thick pad is SS = 0 mm, which makes bonding Easier
- Adhesive SE1700 versus CA adhesive



Top View

Summary

- The compression and shear properties of various 3D printed foam pads were characterized
- Considering one cell shape and two variable, span size and filament diameter, a wide range of mechanical properties of printed foam pads, from compliant to stiff, can already be achieved by additive manufacturing process