Shear Stress Sensor Using Cholesteric Crystals

Group #3

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eng.fsu.edu/me/senior_design/2013/team3

OVERVIEW

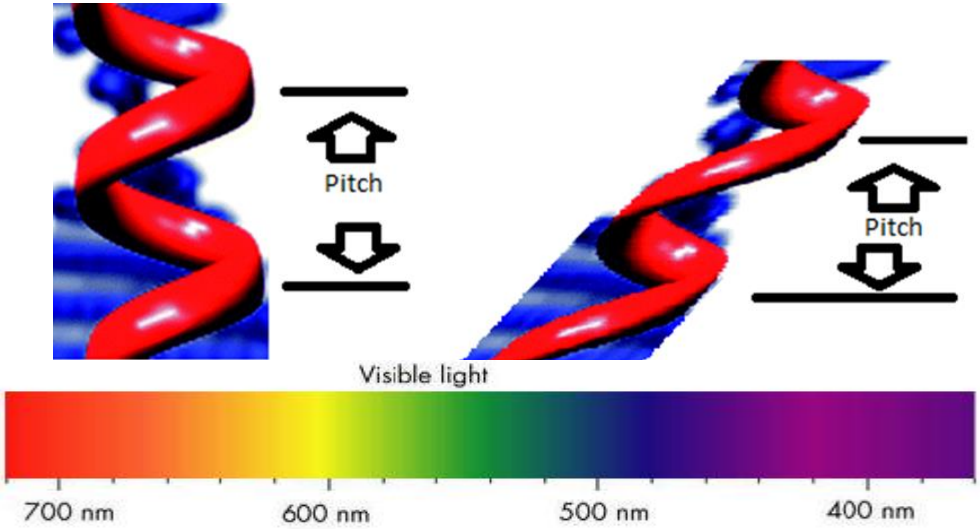
- Project Scope
- Theory
- Technical Approach
- Final Design
- Progress
  - Unit Cell, Load Cell, Normal Force Analysis, & Simulation
- Budget
- Schedule

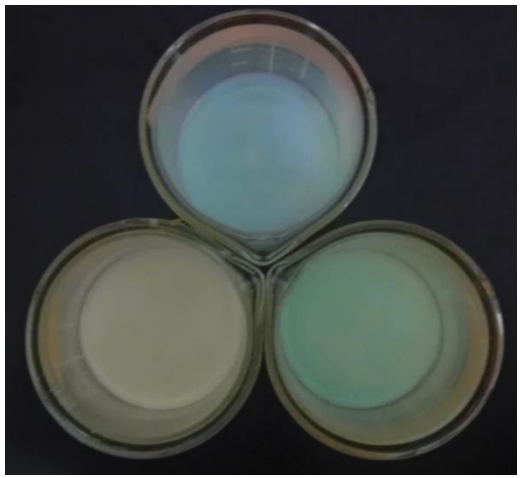
Project Scope

- Create Testing Apparatus
- Characterize cholesteric crystals
  - Maximum change in wavelength
    - Maximum force
  - Delay when responding to force
  - Accuracy
  - Appropriate sensor and light angles
  - Correlate applied force with wavelength

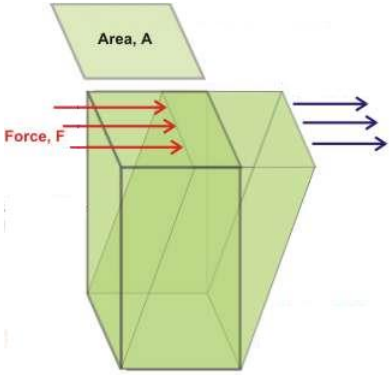
Cholesteric Crystals

- Originally discovered in cholesterol
- Helical Structure
- Pitch varies with the boundary conditions
  - i.e. electricity or outside forces
- Each color of liquid crystals made easily from 3-4 powders
- Polymer form made through many time intensive processes



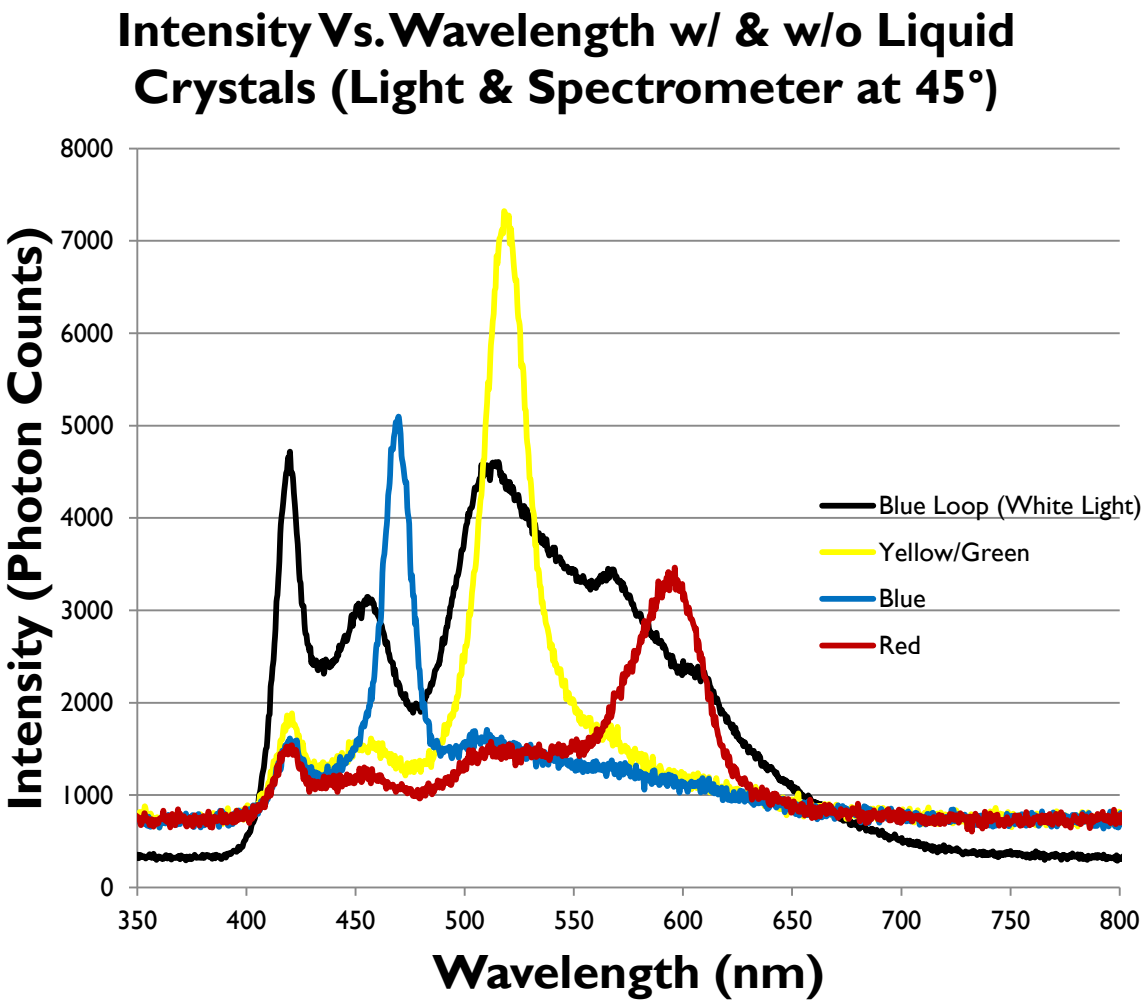


Technical Approach

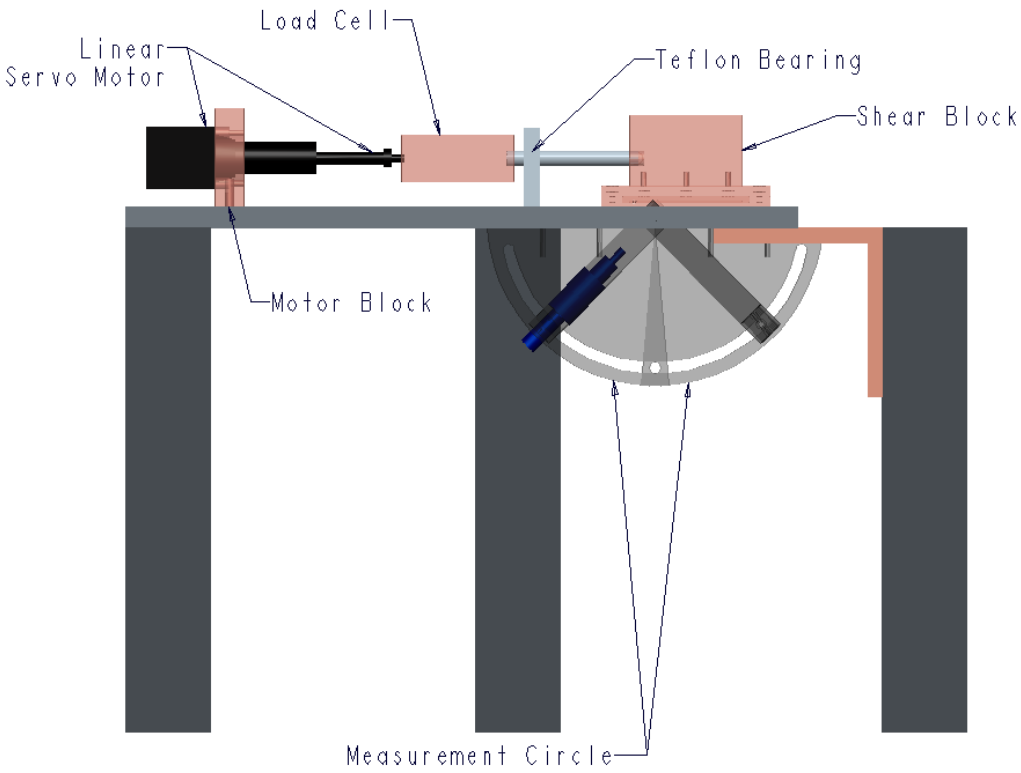


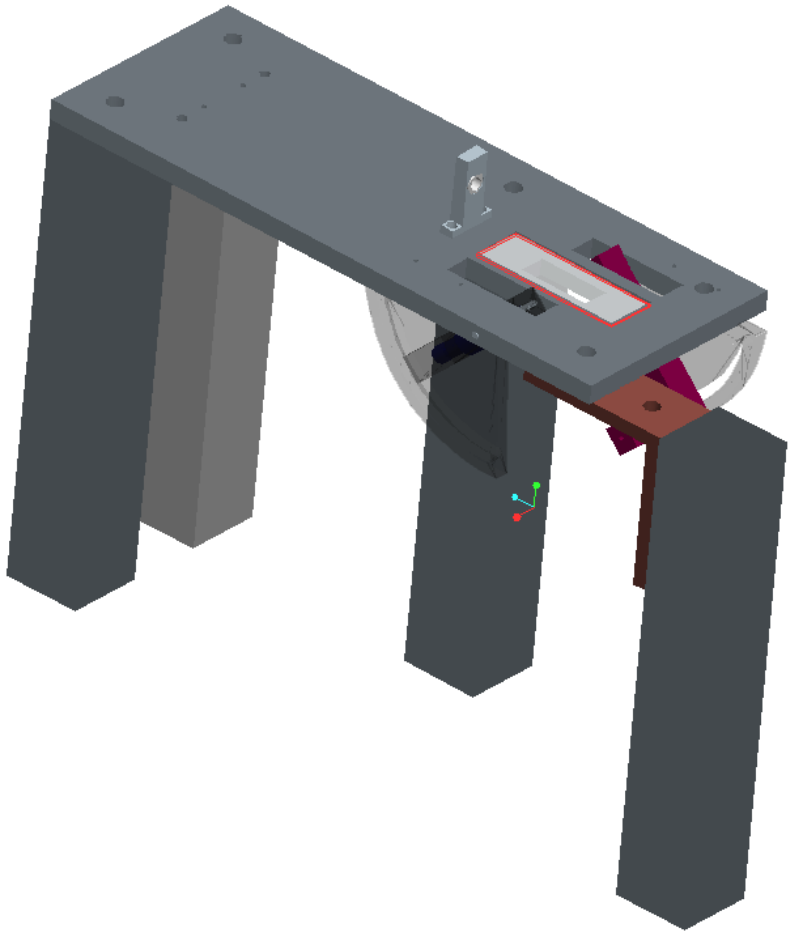
$$\tau = \frac{F}{A}$$

- Assume no slip condition for liquid crystal testing
- BluLoop Fiber Optic Light
- Spectrometer:
  - 200-1100 nm
  - 2048 pixels
- Linear Servo Motor:
  - 1 step = 1/64”
- Load cell:
  - 10N

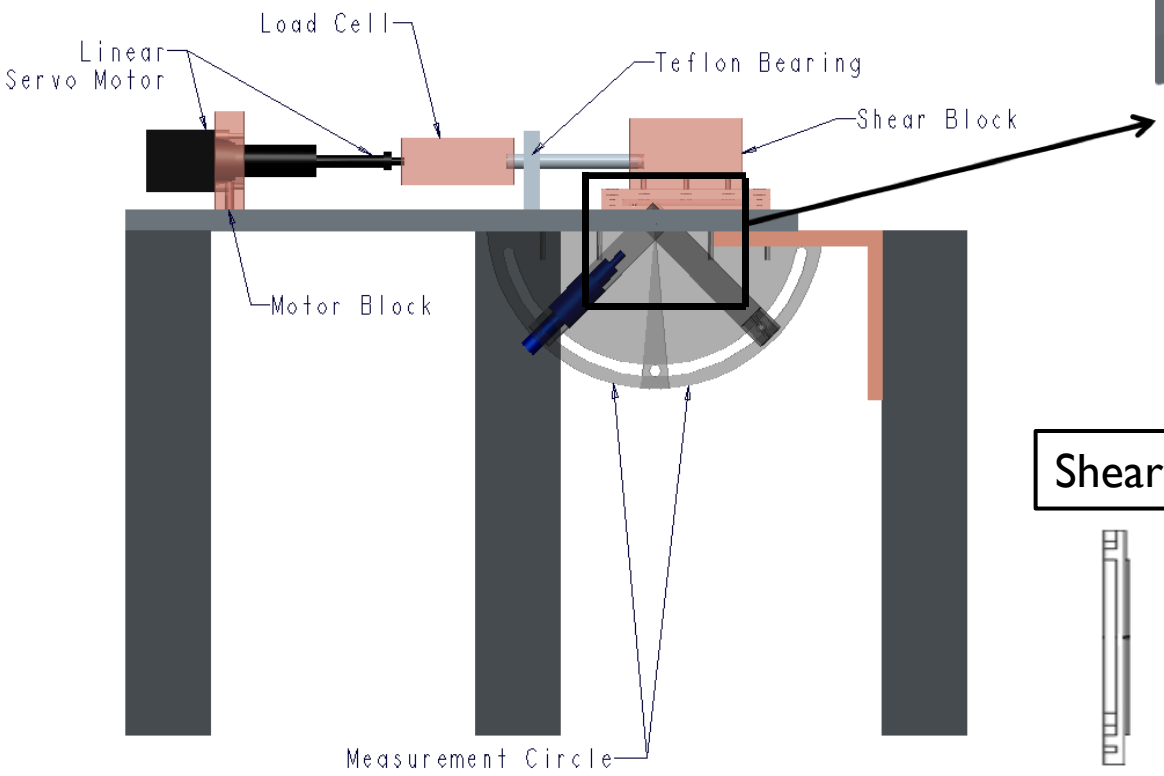


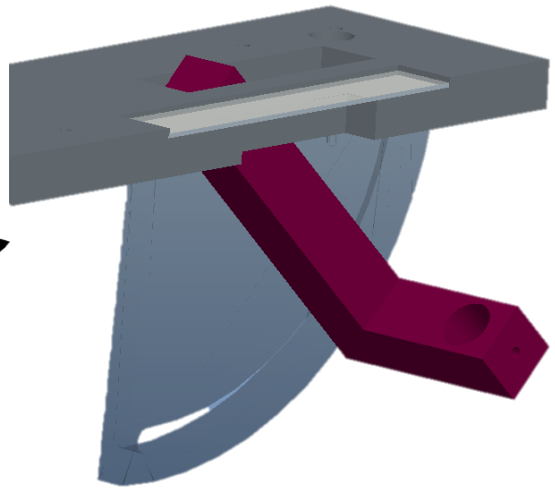
Final Design



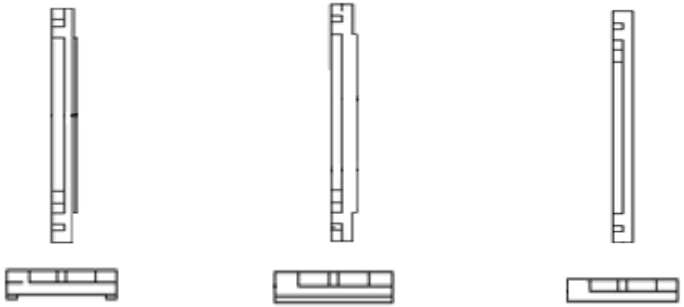


Final Design





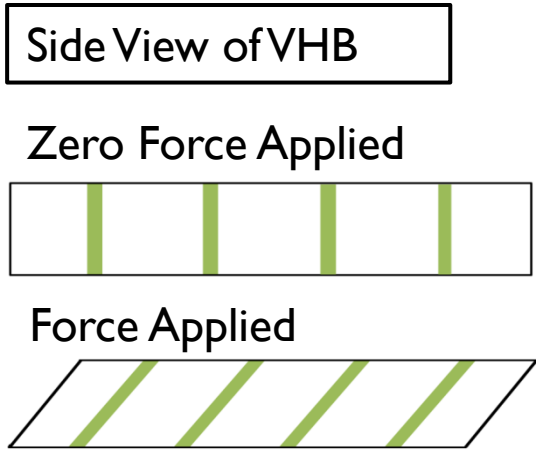
Shear Block Bases

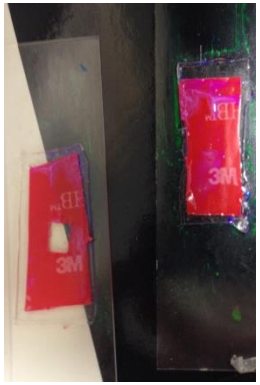


U-Shape Extended Shape Flat-Flush Shape

Unit Cell

- Unit cells- package liquid crystals
  - Using VHB tape or other material to contain liquid crystals
- Purpose is to have a manufacturable product for distribution
  - With the key feature of liquid crystal columns or a pocket to contain the liquid crystals
  - Cost in comparison to polymer form

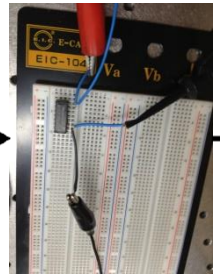




Load Cell

- 10N Range
  - Transducer- $\Delta V \rightarrow$ Force
- Emergency Shut Off Using Motor Microcontroller

LabVIEW



Micro-Controller Software

Load Cell

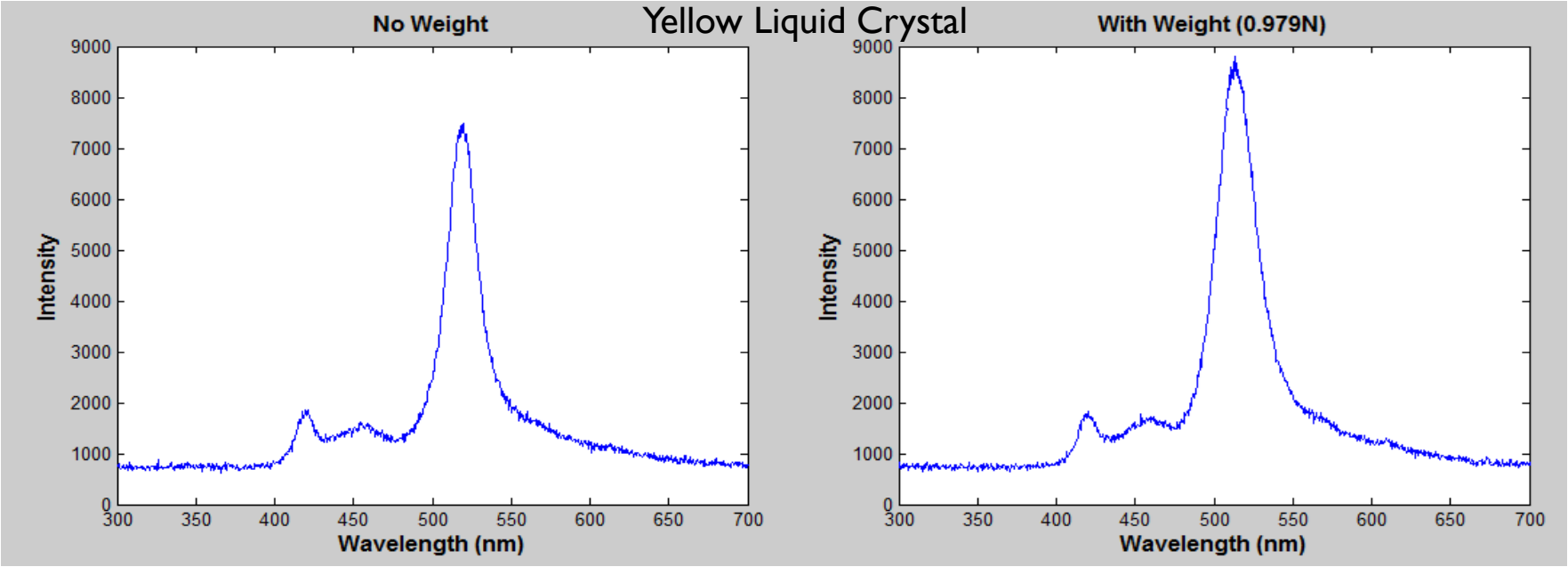
DAQ

Relay

Micro-controller

Shutoff

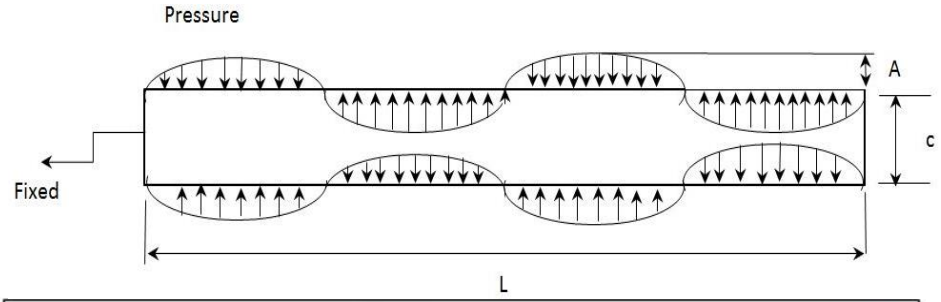
Normal Force

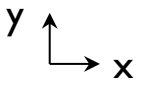


- **5 Trials for each condition**
- **Program a peak averaging function into Matlab**

	Color		
	Red	Blue	Yellow/Green
No Weight			
Average Wavelength (nm)	600.3	469.1	512.0
Range (nm)	5.9	3.1	3.0
Weight (0.979N)			
Average Wavelength (nm)	597.5	469.7	519.7
Range (nm)	7.2	2.2	3.1
Difference in Averages (nm)	2.8	0.6	7.7

Simulation – FEM (Finite Element Method)

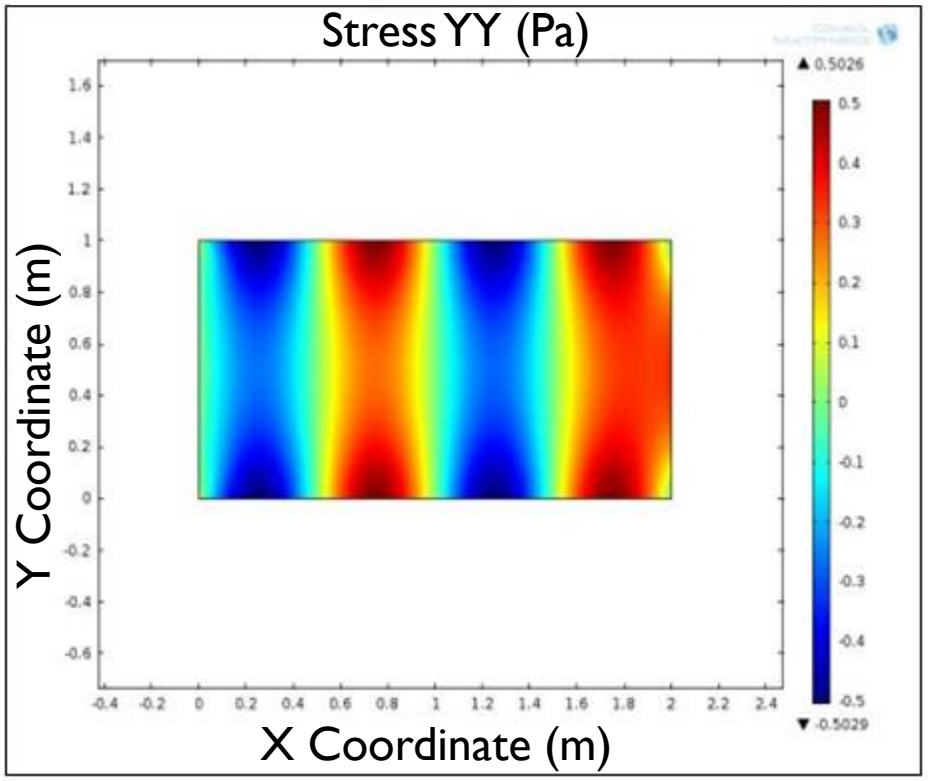




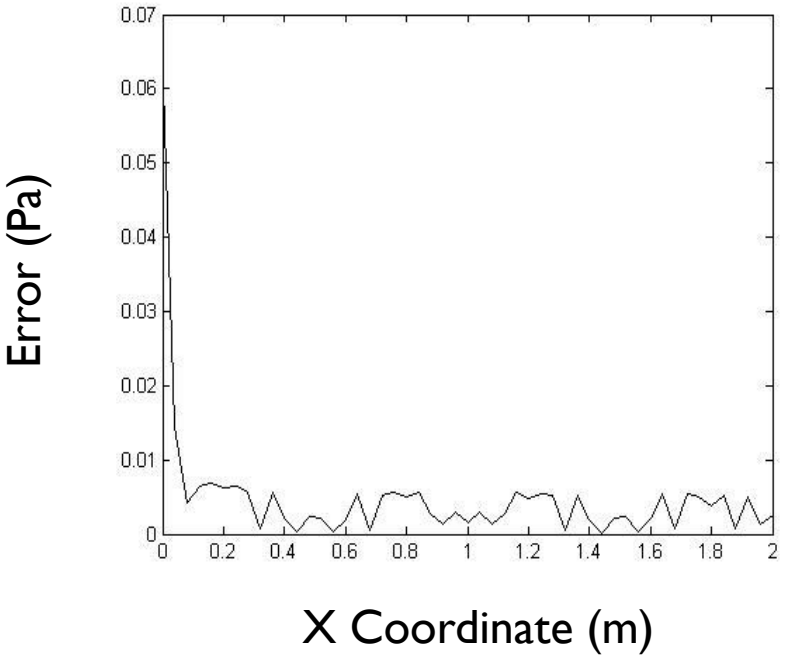
Pressure - Sine Load

-0.5 sin ((4π/L)*x) Pa - top

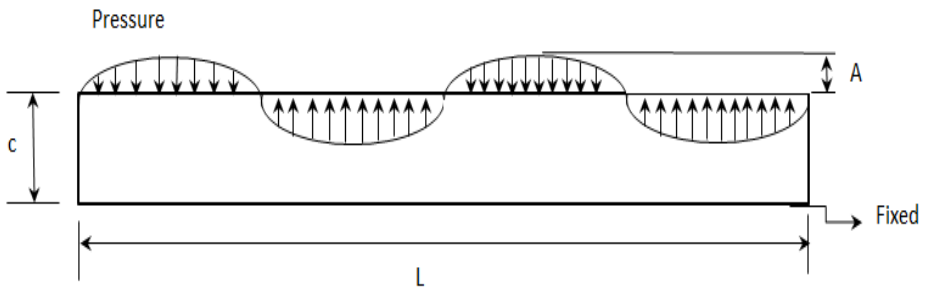
0.5 sin ((4π/L)*x) Pa - bottom



Pressure Error – Sigma YY (Pa)

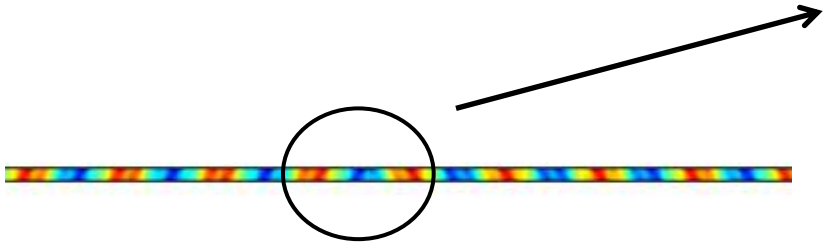


Simulation – FEM (Finite Element Method)

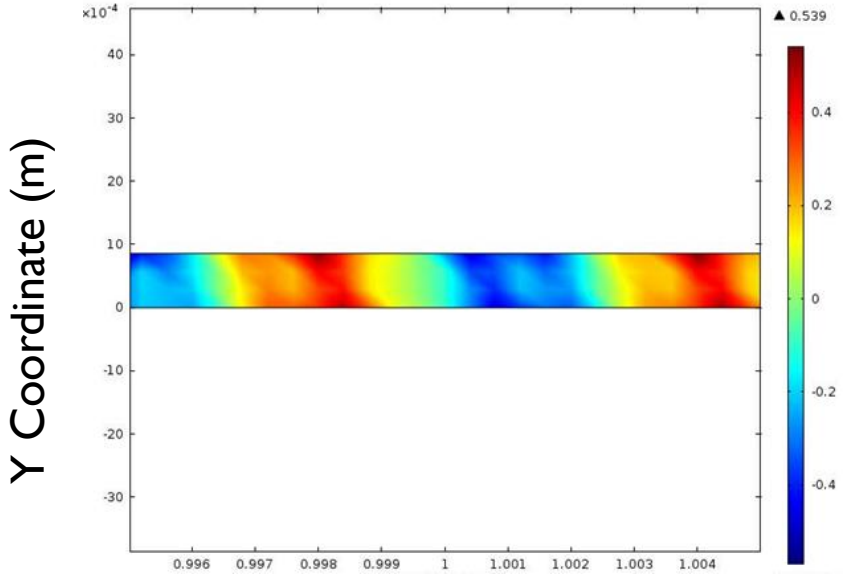


Thin film - L=2000 (c)

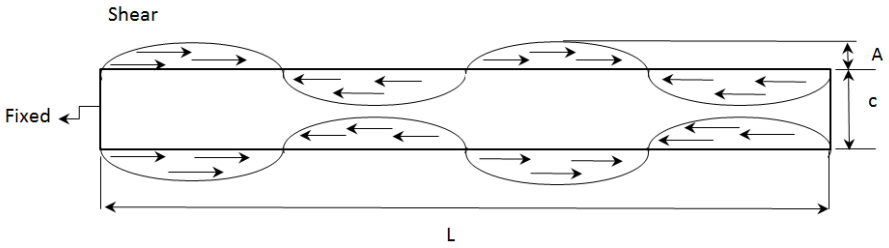
Pressure - Sine Load
-0.5 sin ((4π/c)*x) Pa - top

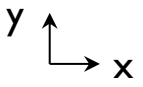


Stress YY (Pa)



Simulation – FEM (Finite Element Method)



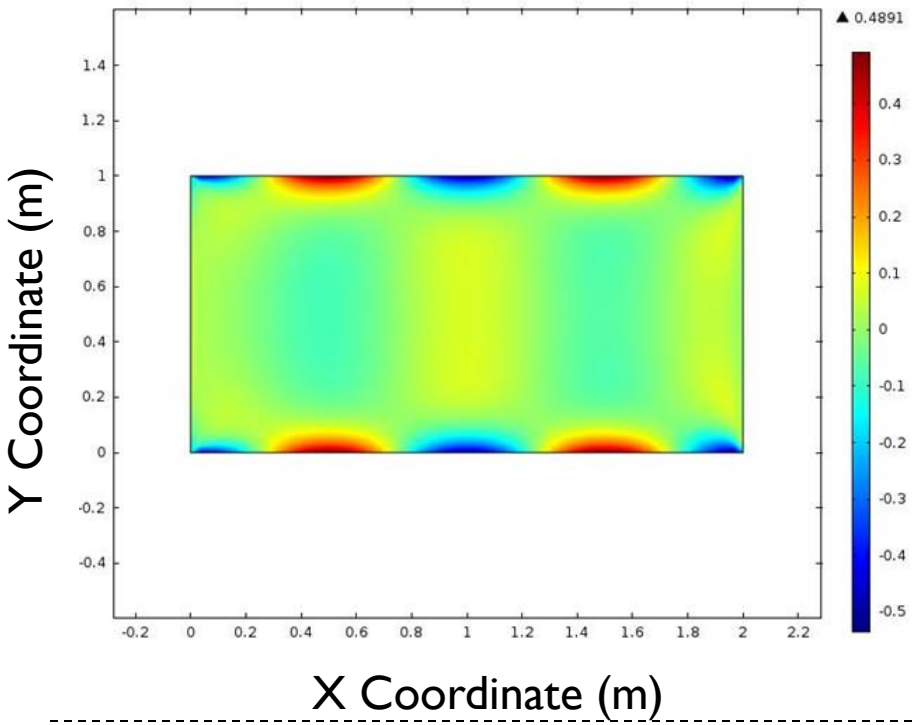


Shear - Cosine Load

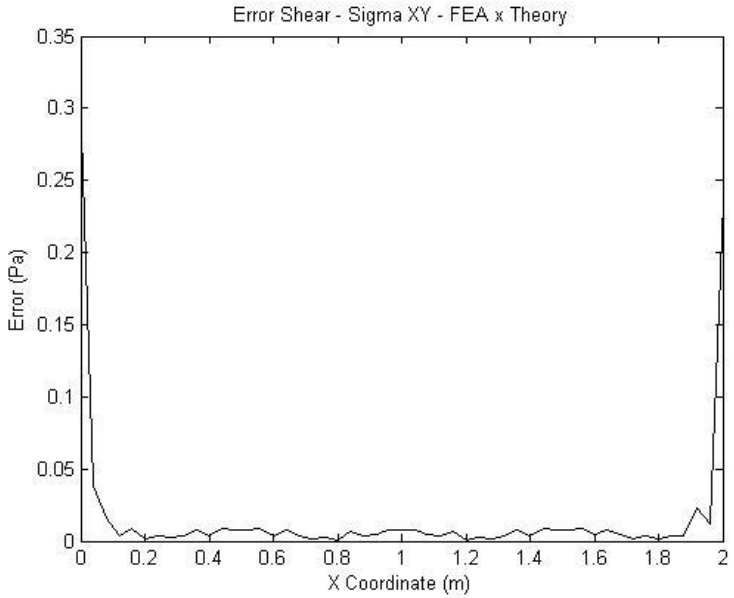
-0.5 cos ((4π/L)*x) Pa - top

0.5 cos ((4π/L)*x) Pa - bottom

Stress XY (Pa)

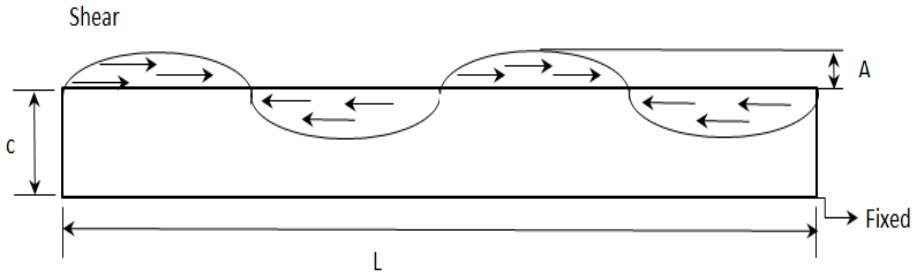


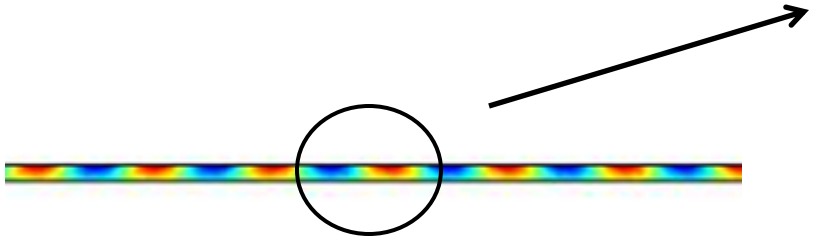
Pressure Error – Sigma XY (Pa)



X Coordinate (m)

Simulation – FEM (Finite Element Method)



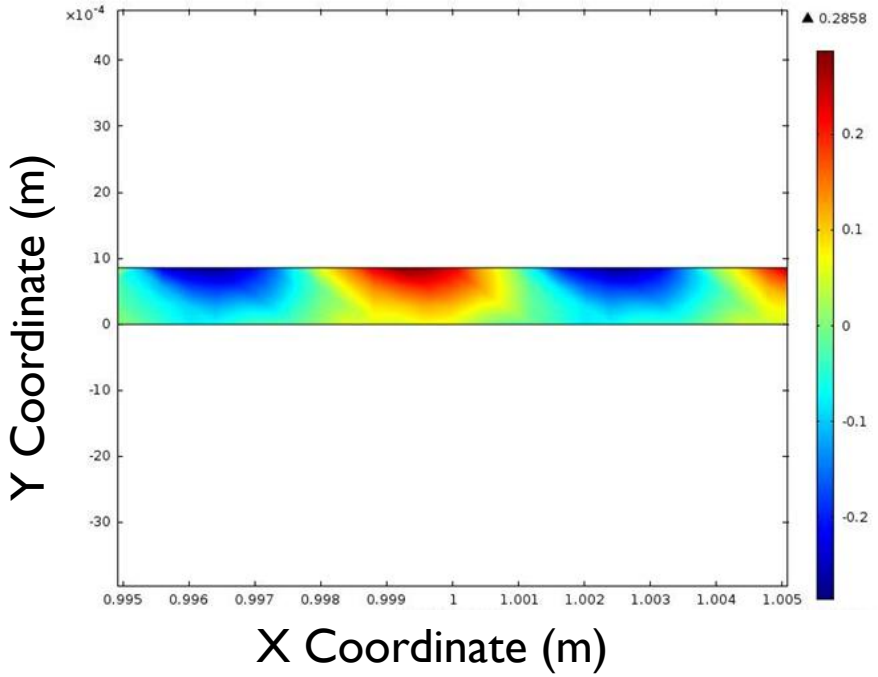


Thin film - L=2000 (c)

Shear - Cosine Load

-0.5 cos ((4π/c)*x) Pa - top

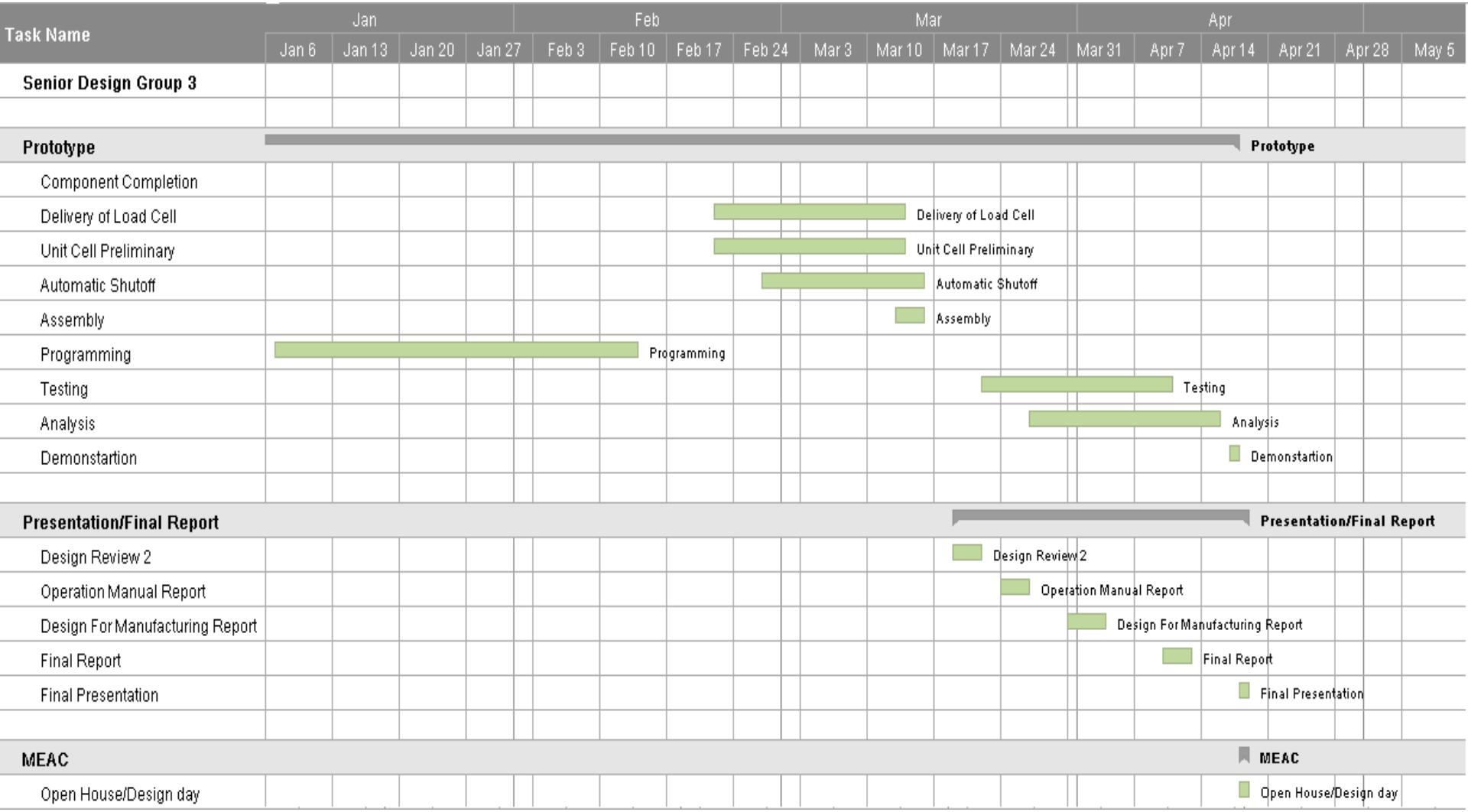
Stress XY (Pa)



Budget

Part	Unit Price	Quantity	Price
Teflon Bearing	$3.11	3	$ 9.33
Insulation	$9.03	1	$9.03
Heat sheet	$38.90	1	$38.90
Fasteners	- -	- -	$21.85
LEDs	$23.74	1	$23.74
Thermocouple	$19.00	2	$38.00
Load Cell- 10N	$485.00	1	$485.00
Liquid Crystals	$75.00	3	$225.00
		Total	$850.85

Schedule


Task Name
Jan
Feb
Mar
Apr
Jan 6
Jan 13
Jan 20
Jan 27
Feb 3
Feb 10
Feb 17
Feb 24
Mar 3
Mar 10
Mar 17
Mar 24
Mar 31
Apr 7
Apr 14
Apr 21
Apr 28
May 5
Senior Design Group 3
Prototype
Prototype
Component Completion
Delivery of Load Cell
Delivery of Load Cell
Unit Cell Preliminary
Unit Cell Preliminary
Automatic Shutoff
Automatic Shutoff
Assembly
Assembly
Programming
Programming
Testing
Testing
Analysis
Analysis
Demonstartion
Demonstartion
Presentation/Final Report
Presentation/Final Report
Design Review 2
Design Review 2
Operation Manual Report
Operation Manual Report
Design For Manufacturing Report
Design For Manufacturing Report
Final Report
Final Report
Final Presentation
Final Presentation
MEAC
MEAC
Open House/Design day
Open House/Design day

Summary

- New 10N load cell calibrated and added to the apparatus
  - Load cell overload protection added to setup
- COMSOL shear analysis
- Preliminary trials for unit cell packaging

- Next steps
  - Testing and analysis
  - Vary testing conditions and test polymer form of Cholesteric Crystals

Questions/Comments

Budget (Supplied Parts)

Part	Unit Price	Quantity	Price
Aluminum	$64.00	--	$ 64.00
Fiber-Optic Spectrometer	$2,775.00	1	$2,775.00
Linear Servo Motor	$75.00	1	$75.00
BluLoop Light Source	$1,575.00	1	$1,575.00
Software	$2,669.00	--	$2,669.00
Multimeter	$15.00	1	$15.00
DAQ Board	$369.00	1	$369.00
Amplifier- SGA power signal converter	$345.00	1	$345.00
		Total	$7,887.00