# 3D Mesostructures Formed by Compressive Buckling


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## Introduction

Three-dimensional (3D) mesostructures formed through mechanical buckling principles is one of the focal points of my professor's research, Professor Hangbo Zhao. Together with our graduate student mentor, Qinai Zhao, we designed and tested multiple two- dimensional (2D) structures to see how they would buckle and compress in a controlled fashion into 3D objects with the help of origami and kirigami design principles.

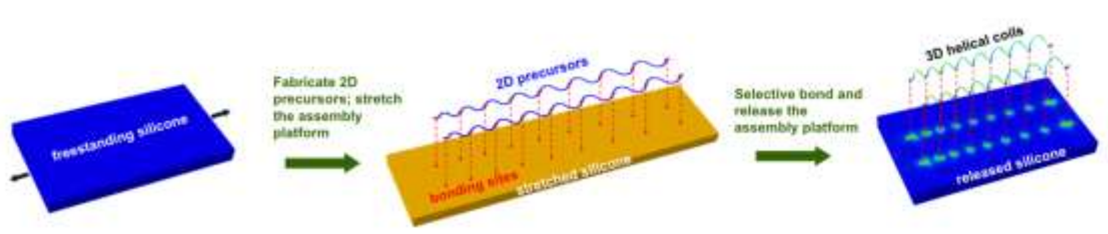



*Figure 1.* Schematic illustration of the mechanical buckling process to form 3D structures. Reference: *Science*, 347.6218 (2015): 154-159.

## Objective & Impact of Professor's Research

Since Professor Zhao's research is not only limited to one specific objective it has many different uses. Some of the possible applications of the research include micro/mesoscale sensors, biomedical tools, foldable electronics, and micro robotics. An example of the possible medical applications for the researched structure could be applied to new sensing tools surgeons can use to help enter the human body.

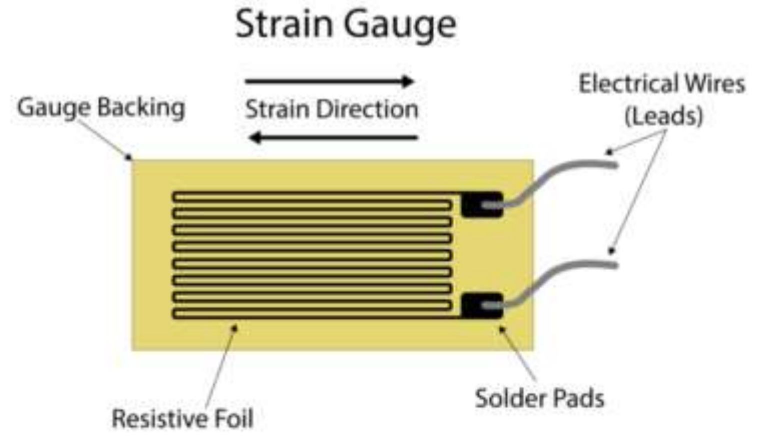



*Figure 2.* Piezoresistive Sensor, sensor attached to mesostructure able to read forces applied by displaying as change in electric current, Michigan Scientific Corporation

## Skills Learned

Throughout the program we were familiarized with two different software tools to help us continue with our research virtually.

The first program we used was AutoCAD, a computer aided design program which allows the user to design 2D and 3D objects with accurate dimensions and complex assemblies. Both my lab partner and I had some previous experience using this program but during our lessons I learned new ways to use the program by using it to make 2D structure which was new to me (*Figure 3*).

The second program we used was called Abaqus. Similar to AutoCAD this program can be used outside of our research. The purpose of Abaqus was to simulate how our mesostructures would react when they were compressed and stretched accurately to how they would react in real life (*Figure 4*). With Abaqus we were able to simulate different controlled forces and compression while not having to use any physical materials. Outside of the research Abaqus can be used to simulate the amount of pressure a certain 3D object may experience in real life.

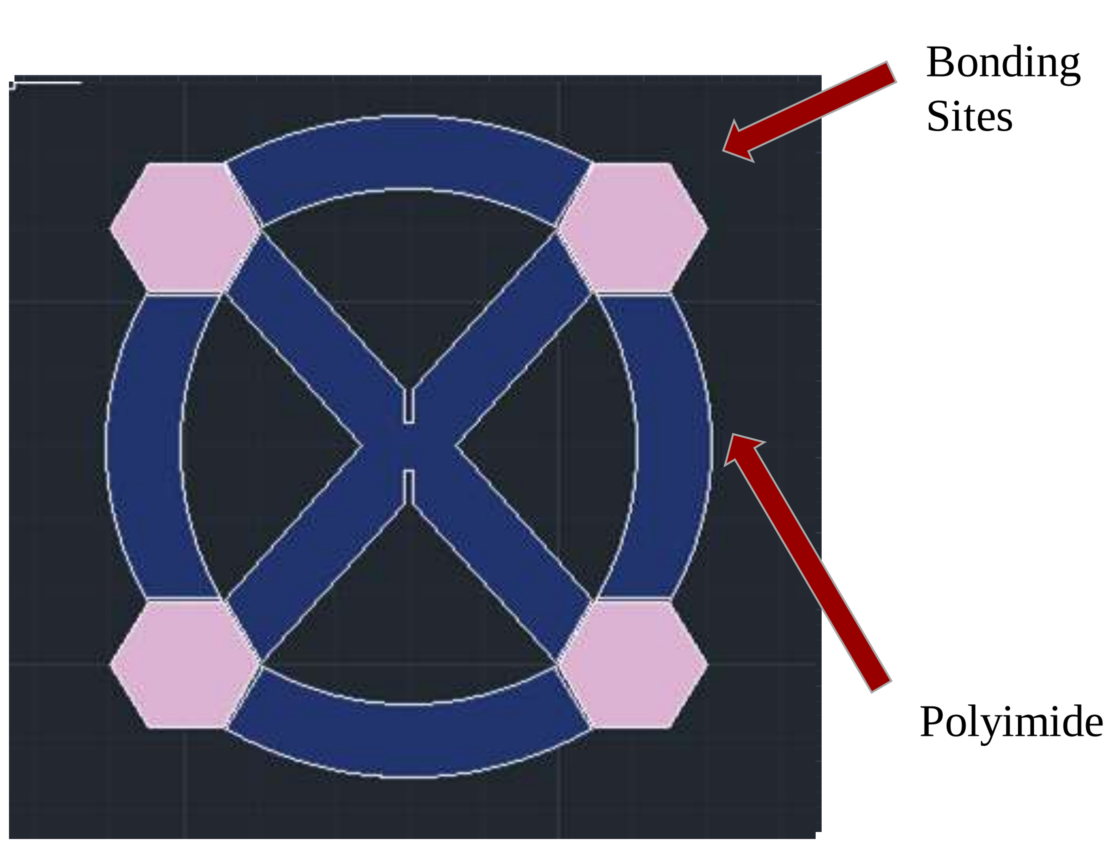



*Figure 3.* 2D AutoCAD Design, Amado Ochoa

## Results

During our testing through Abaqus the program produced statistics on how the thickness and rigidity of the material could affect the final shape the 2D design could create. For the results on the graphs below they represent simulations for 3D structures that are under a vertical load. The first graph underneath was made using the information of a test where the design (*Figure 3)* had a thickness of 0.01 mm and as the applied force of 0.004 N increased the displacement increases as well.

Repeating the previous program test with 5 different thicknesses all in increments of 0.005 mm I was able to get 5 data points to compare the thickness of the design to the bending stiffness. As we can see in the second graph there is a positive correlation between the thickness of the material and the bending stiffness meaning as the thickness increases so does the stiffness. The third graph demonstrates the correlation between the bending stiffness and the Young's Modulus of the material.

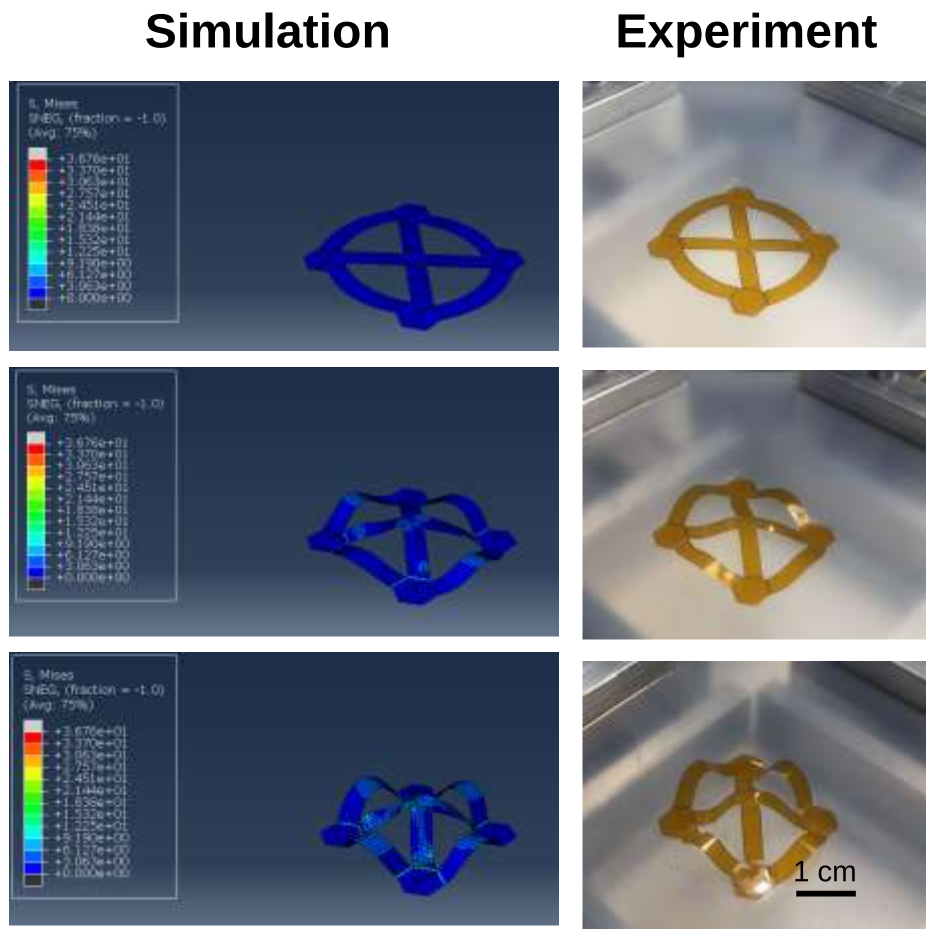
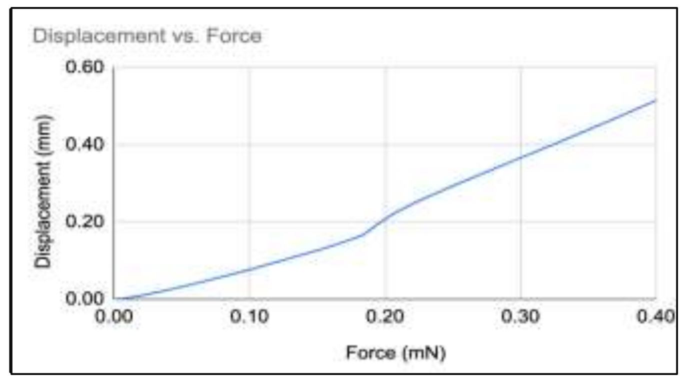
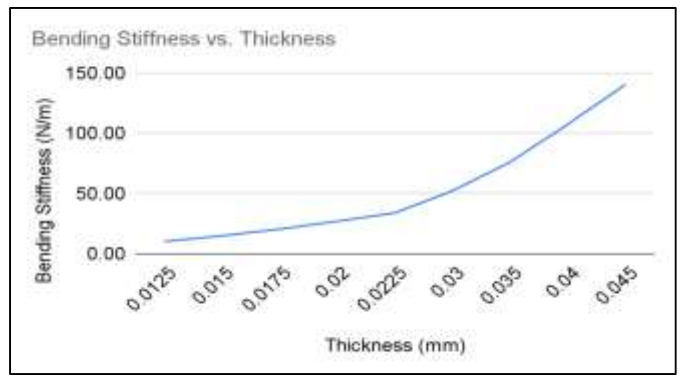
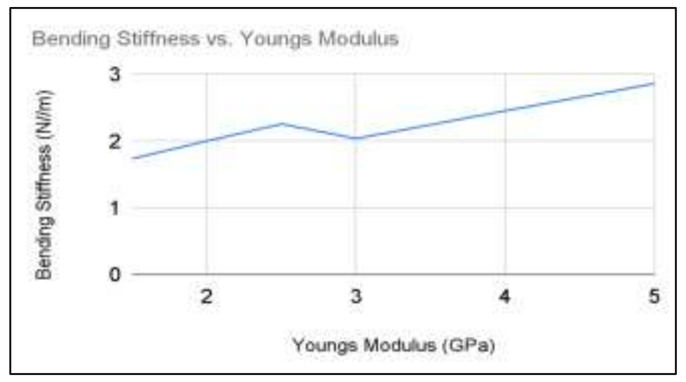



*Figure 4.* Abaqus simulation compared to real life images of a 3D structure formed by compressive buckling based on design in Figure 3, Amado Ochoa




## Advice for Future SHINE Students

If I had to choose one tip I could have given myself at the beginning of this program it would have been to not bother being shy. When we first had our full group meetings cohort meetings it was hard to get volunteers to speak and by the time I had become comfortable with speaking in front of everyone the program was already ending.

## Acknowledgements


I would like to thank Dr. Mills, Monica Lopez and everyone who helped to make SHINE possible for us this year. I would also like to thank Professor Zhao and our graduate student mentor Qinai Zhao for their knowledge and expertise. Thank you to my center mentor Monserrat Alegria and all the members of my sub-cohort, it was always fun talking to you guys in the meetings and during check-ins.