# Performance Evaluation of Additive Manufacturing Enabled Thin Walled Spinodoid Structures

James Watt School of Engineering

Chandra Sai Kamal Nadendla(2719689N@student.gla.ac.uk)

**Supervisor:** Professor Shanmugam Kumar

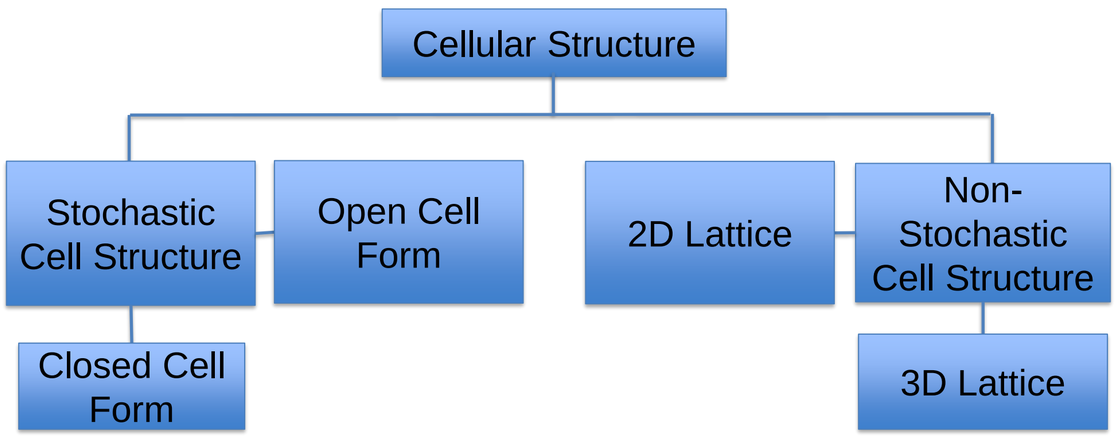
**Second Supervisor**: Lecturer Paul Prentice

## Background

Additive manufacturing is a process of producing 3-dimensional parts one layer at a time from a given material.

Metamaterial is any material engineered to have a property that is not found in naturally occurring materials [1].

Cellular structure of material is porous microstructure with solid and void networks.




Spinodoid Metamaterial: Metamaterial consist of smooth, non-intersecting, and bi-continuous surfaces that avoid points of stress concentration [2].

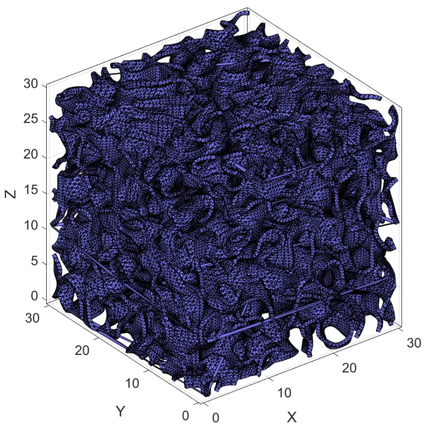
## Aim and Objectives

**Aim**

The aim of this project is to evaluate mechanical and piezoresistive performance of additive-manufacturing enabled thin-walled spinodoid structure using multi walled carbon nanotube (MWCNT) reinforced polyether ether ketone (PEEK).

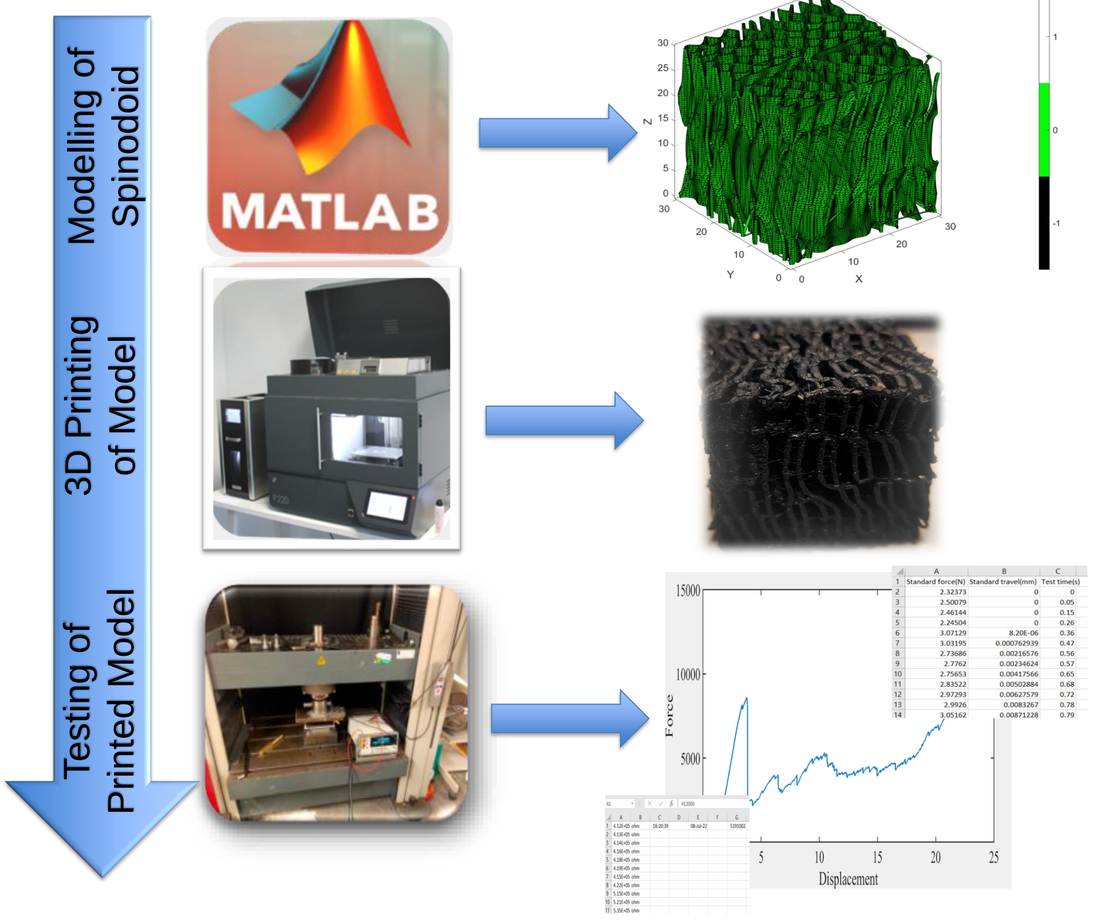
**Objectives**

- Develop a model and 3D print the same using reinforced PEEK/MWCNT composite
- Perform Mechanical and Electrical analysis on the model
- Evaluate results with different structures to understand model and material in detail




## Methodology

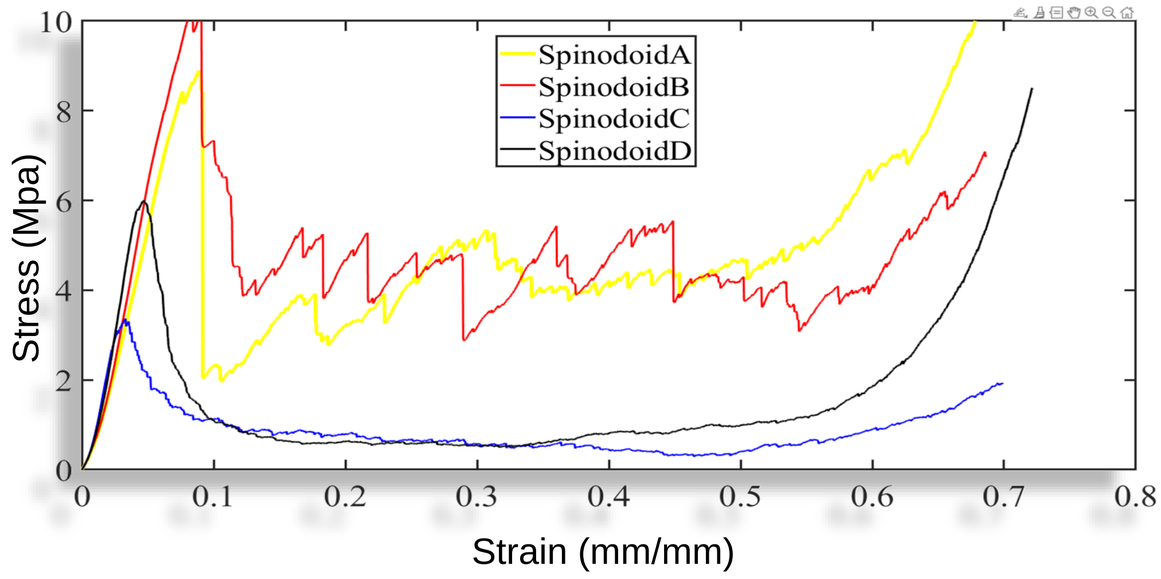
The thin walled spinodoid is modelled in MATLAB using gibbon tool box. This spinodoid is then 3D printed with the help of Apium P220 3D printer. Later the printed object is subjected to compression test where force, displacement and time readings are recorded along with resistance readings with the help of a multimeter. These readings are used to make comparison between samples to understand their properties.



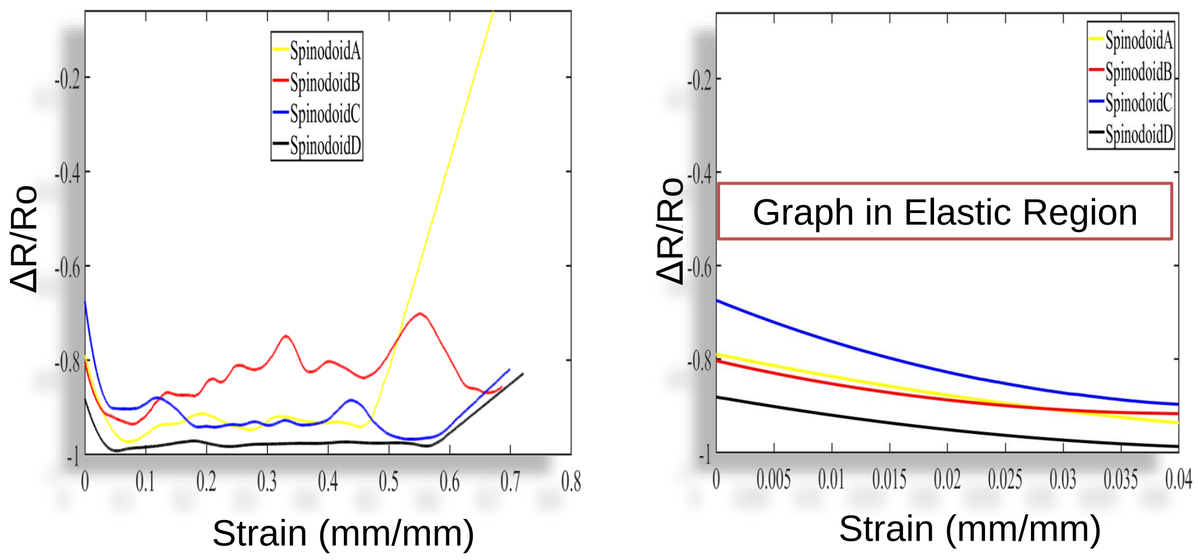

## Results and Discussions

This study discusses the effects of axis orientation and surface wall thickness on spinodoids. The analysis of compression test results identified that the structure with axis orientation of [90 0 0] exhibited superior mechanical performance.

| Sample | Surface Wall Thickness | Surface Orientation of [X Y Z] |
|---|---|---|
| SpinodoidA | 0.4 mm | [90 0 0] |
| SpinodoidB | 0.48 mm | [90 0 0] |
| SpinodoidC | 0.4 mm | [45 0 0] |
| SpinodoidD | 0.48 mm | [45 0 0] |




It is observed from the below graphs that there is a gradual fall of normalized resistance change(ΔR/Ro) with respect to strain.




This data was used to create a model to predict deformations and damages in future samples of this material from electrical readings.

## References

1.R.S.Kshetrimayum (2004). ""A brief intro to metamaterials". IEEE Potentials. **23** (5): 44–46. doi:10.1109/MP.2005.1368916. S2CID 36925376.

2.Inverse-designed spinodoid metamaterials; Siddhant Kumar, Stephanie Tan, Li Zheng and Dennis M. Kochmann npj Computational Materials, vol. 6: no. 1, pp. 73, London: Nature, 2020.