

The Impact of Graphene Additives on Residual Stress in 3D Printed Parts

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Introduction

- Fused deposition modeling (FDM) is a 3D printing process with a promising future in markets ranging from medicine to space travel
- FDM has poor heat transfer leading to development of residual stresses

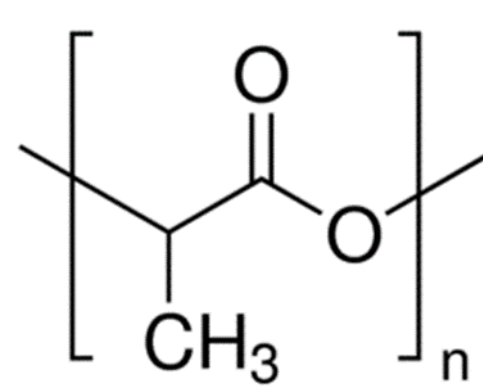


Figure 1: PLA⁴

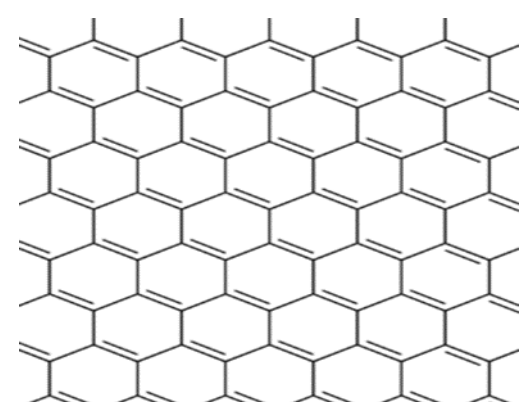


Figure 2: Graphene sheet⁵

- Poly(lactic acid) (PLA) is a common FDM material
- This study seeks to explore a correlation between thermally conductive graphene composites and residual stress

Materials and Methods

- Graphene was incorporated into PLA at 0.5%, 1%, and 2% by mass
- Printed at 190 °C onto a 70 °C bed, cooled, then annealed in an oven at 85 °C

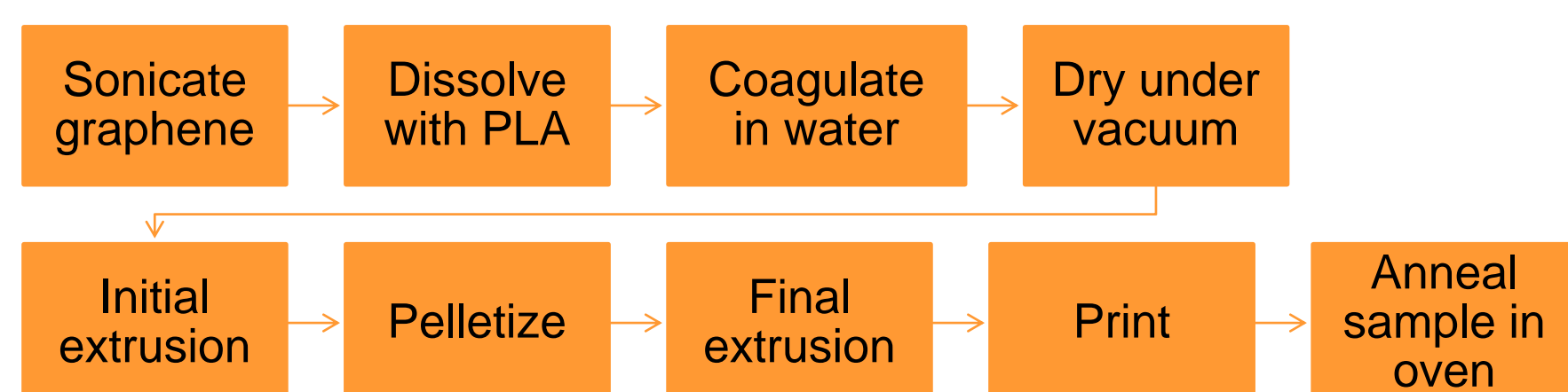


Figure 3: Flow chart of experimental process

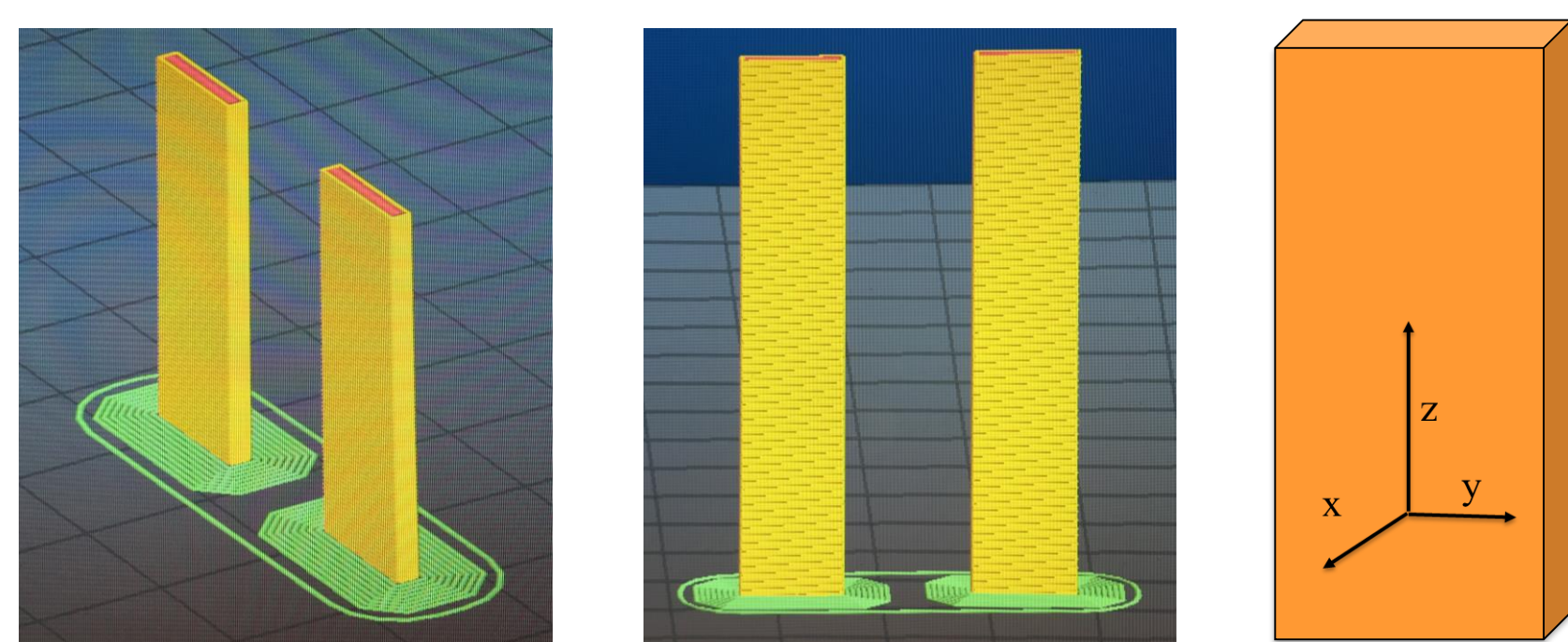


Figure 4: Build orientation on printer bed with axes designated

Results

- Magnitudes of irreversible thermal expansion (ITE) evaluated by
- $$\varepsilon_{i,T} = \frac{L_{anneal} - L_{original}}{L_{original}}$$
- ITE magnitude is known to be directly proportional to residual stress

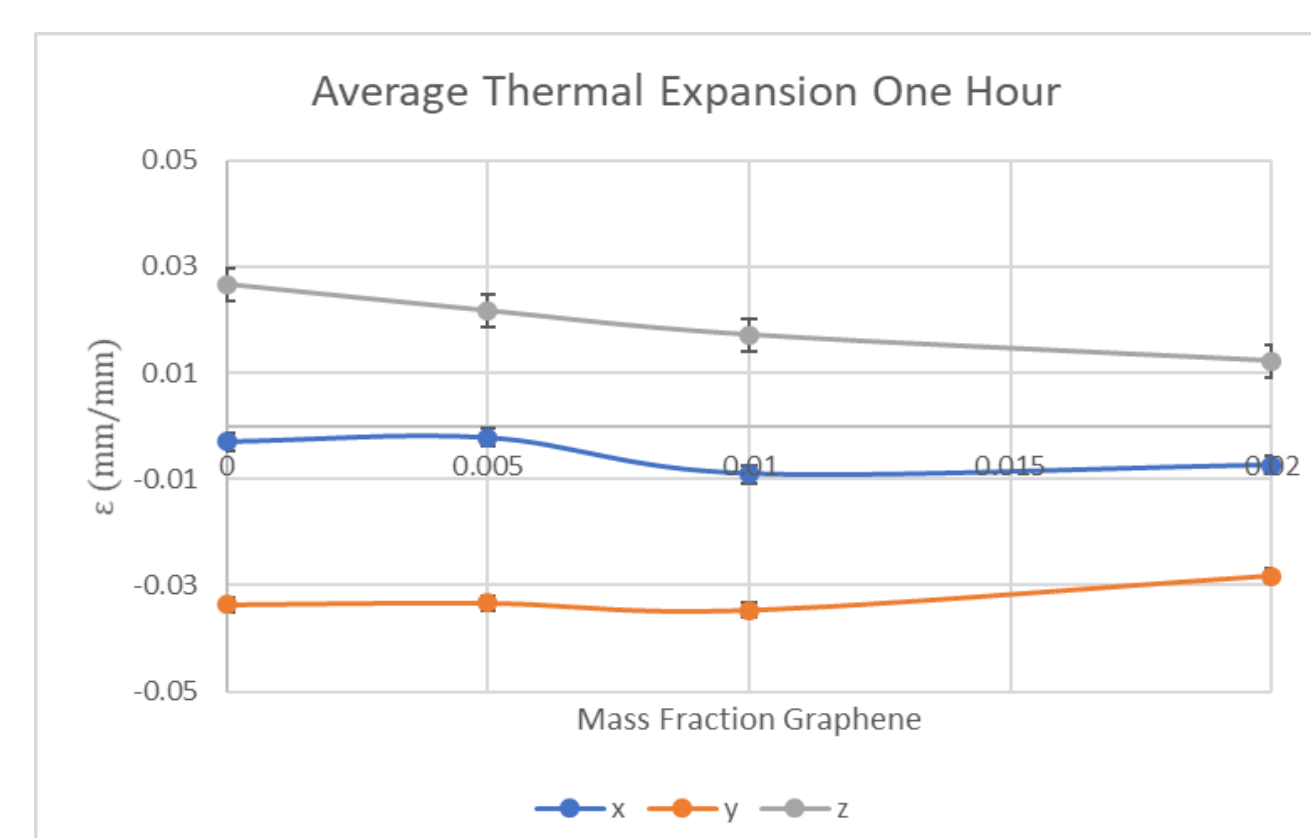


Figure 5: $\varepsilon_{i,t}$ as a function of graphene loading after 1 hour annealing with respect to each axis

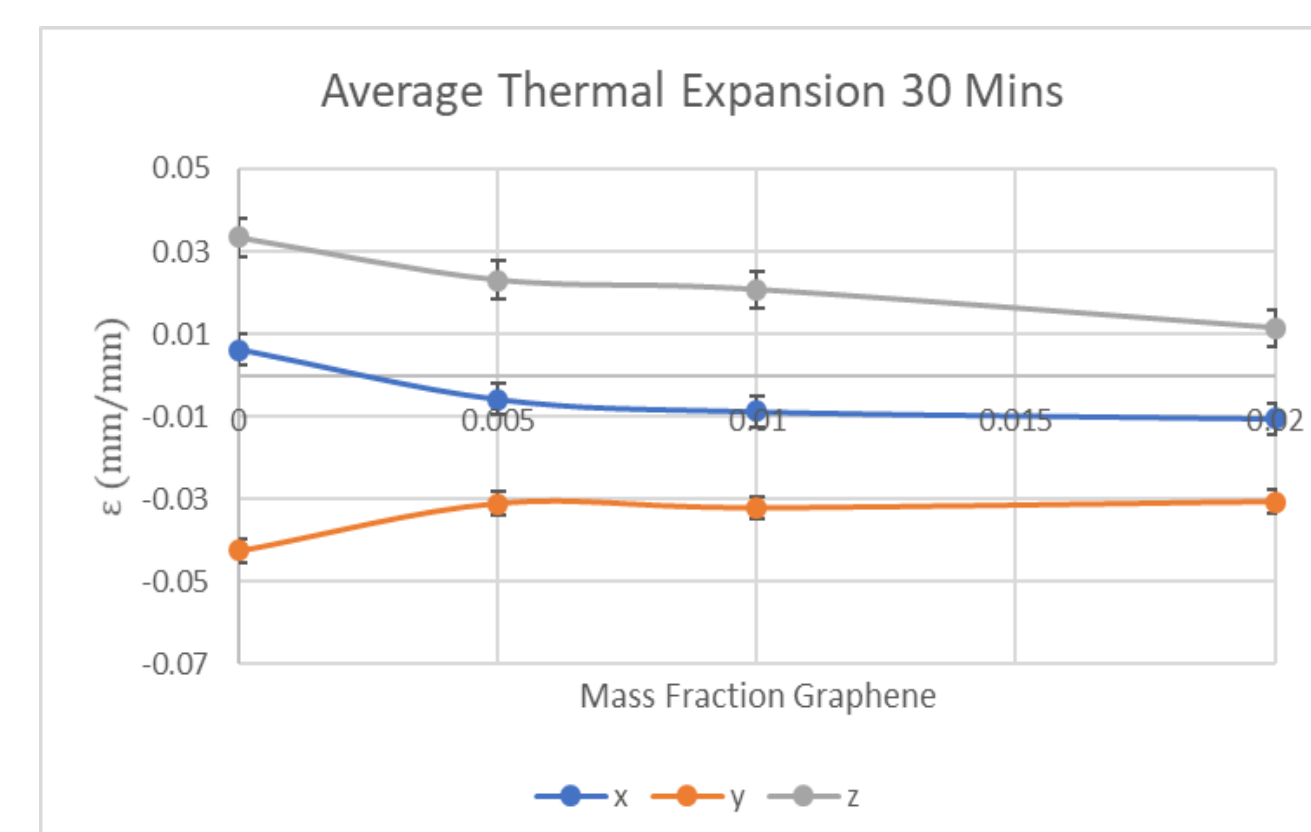


Figure 6: $\varepsilon_{i,t}$ as a function of graphene loading after 30 minutes annealing with respect to each axis

- Negative or positive values indicate contraction or expansion respectively

Conclusions

- The study has determined that adding graphene to PLA significantly reduces residual stress development
- 54%** and **92%** decrease of $\varepsilon_{i,t}$ in the z direction post annealing at 85°C for 1 and 0.5 hour, respectively
- Accuracy and tolerance of FDM parts can be improved by adding graphene to the print material

References

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