Design of FDM Mesostructures for Thermoplastic Materials Under Manufacturability Constraints

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Design of FDM Mesostructures for Thermoplastic Materials Under Manufacturability Constraints

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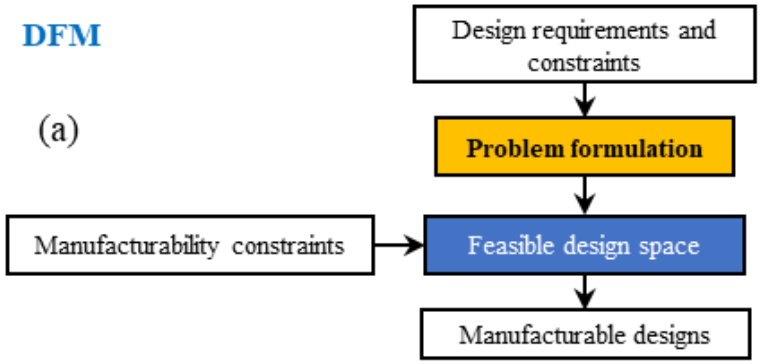
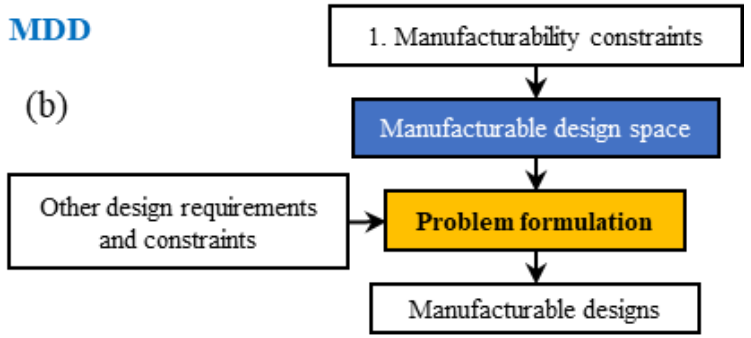
Overview and Motivations

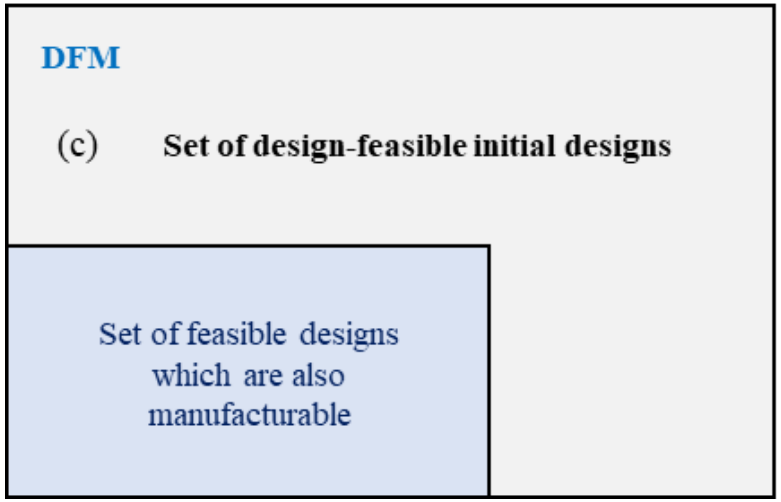
- **Design and manufacturing methods have rapidly advanced**
  - Design is now far more advanced than manufacturing methods
  - Additive manufacturing and advanced casting/molding methods
  - Algorithm-based design methods
    - topology optimization, generative design, optimal design
  - Design freedom, needs restrictions [1]
  - Additive manufacturing is both a help and a major cause of the problem [2-3]
- **Need a way to bridge the gap between advanced D & M**
  - Little control on processes and do not want to hurt advances in design
- **Previously: Design-for-manufacturing (DFM) methods were used**
  - Simple design, cheap materials, liberal tolerances, etc. [4-5]

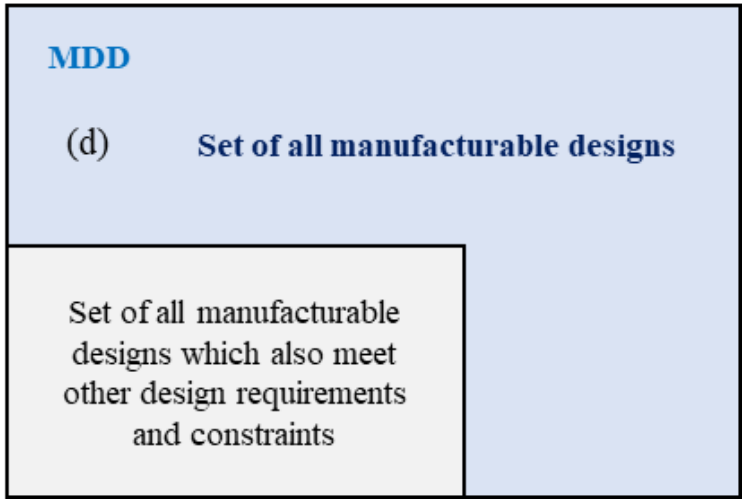
Manufacturability-Driven Design

- **Manufacturability-Driven Design (MDD) is a design approach where manufacturability is the prime or co-prime requirement**
  - Minimal restriction
  - Drive new manufacturing processes
  - Less dependent on expert intuition
  - Process-induced material effects!



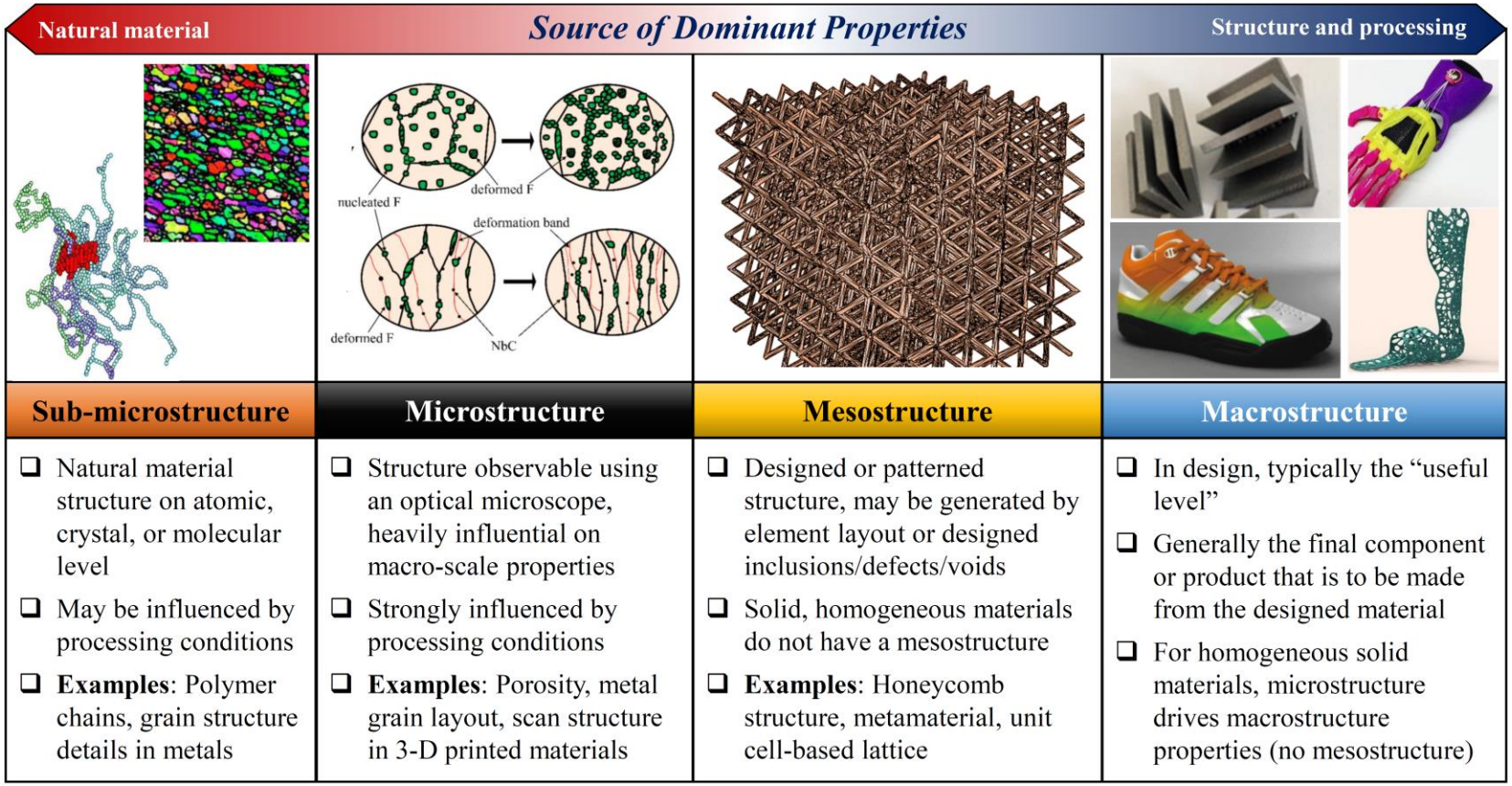




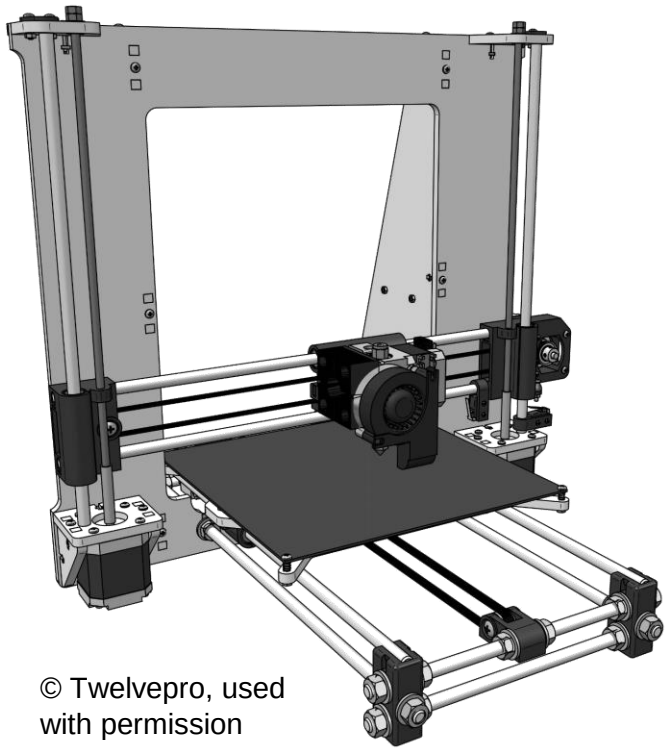


FDM-Driven Structured Materials

- **AM Materials are naturally hierarchical**
  - Especially true for those built using scanning-type AM processes
- **New class of structured materials can be defined by combining MDD principles and the hierarchical nature of AM materials: Manufacturing Process-Driven Structured Materials (MPDSMs)**



FDM-Driven Structured Materials



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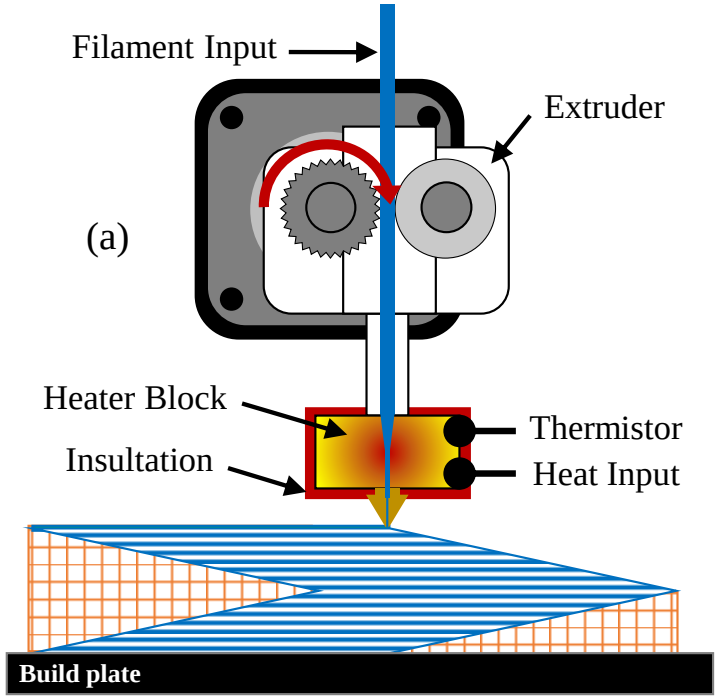
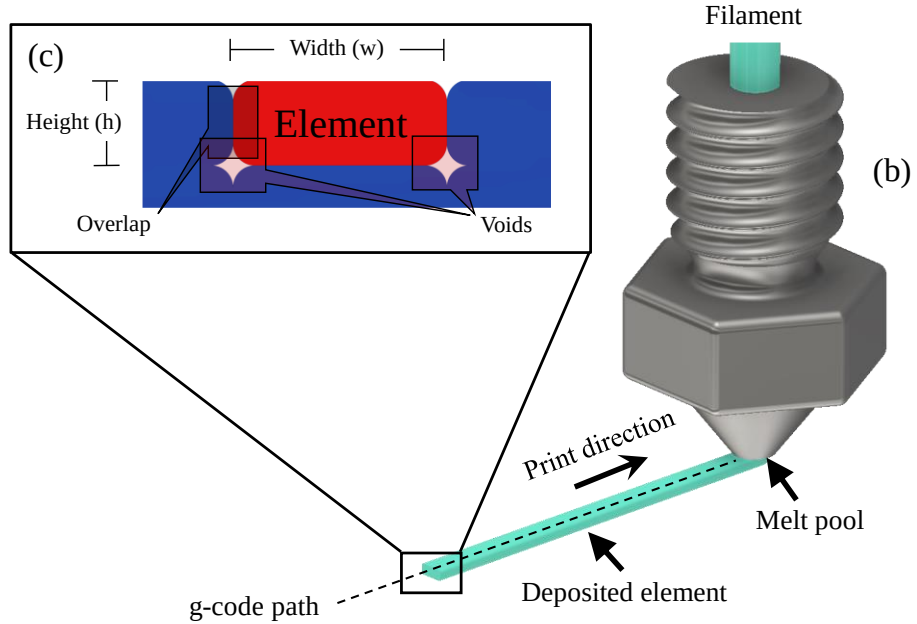


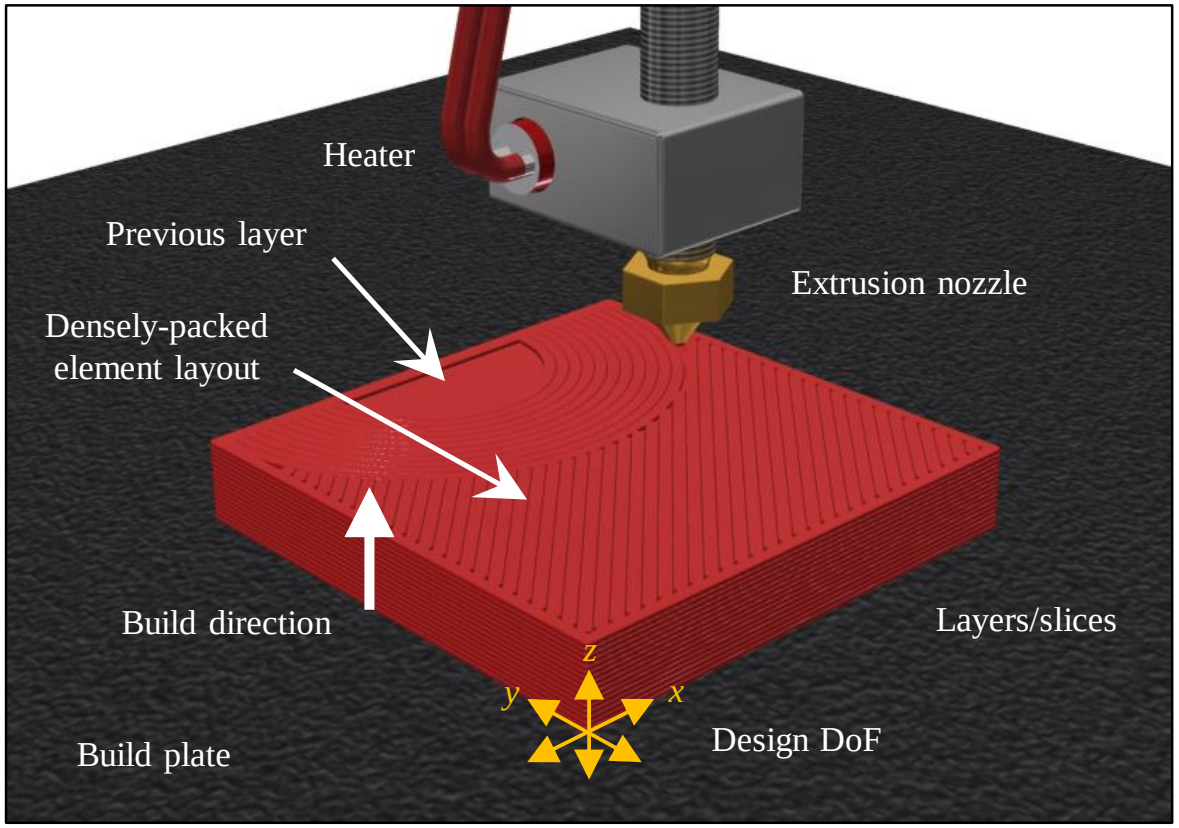


Isotropic and constant CS!

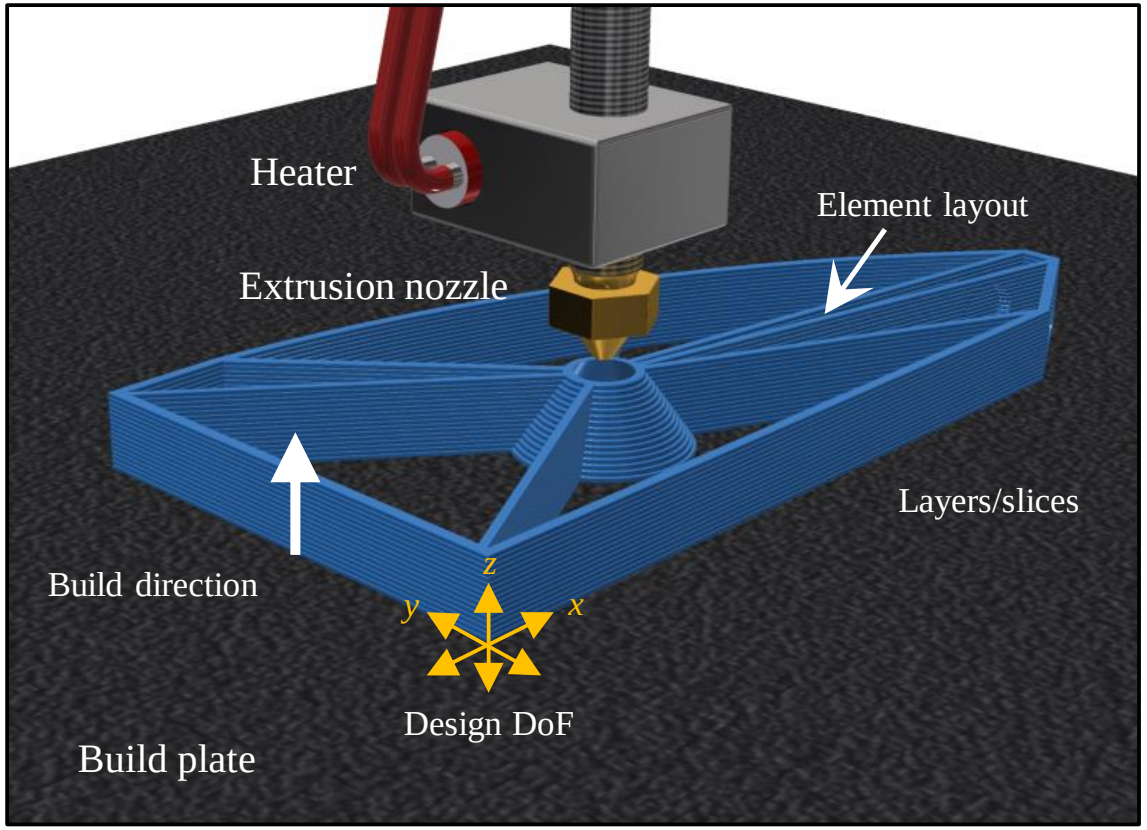
g-code!

FDM-Driven Structured Materials

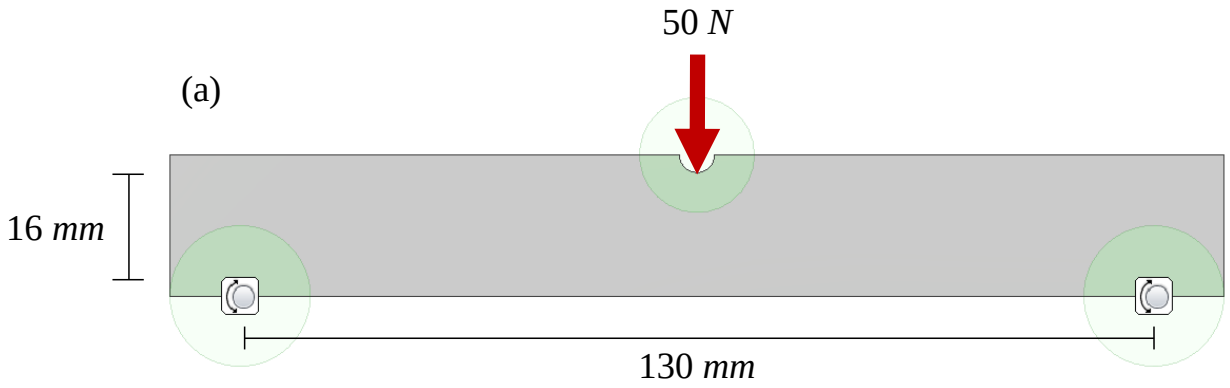
(e) High-density FDM-based 3-D MPDSM

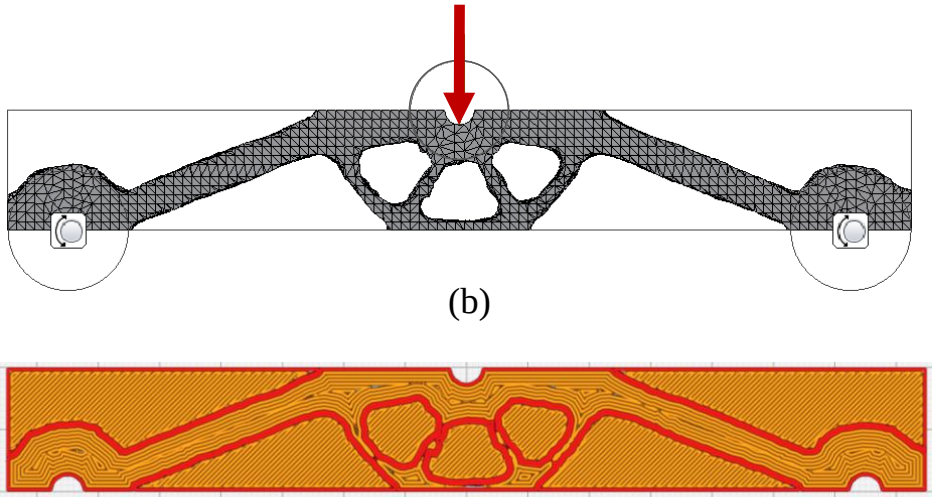


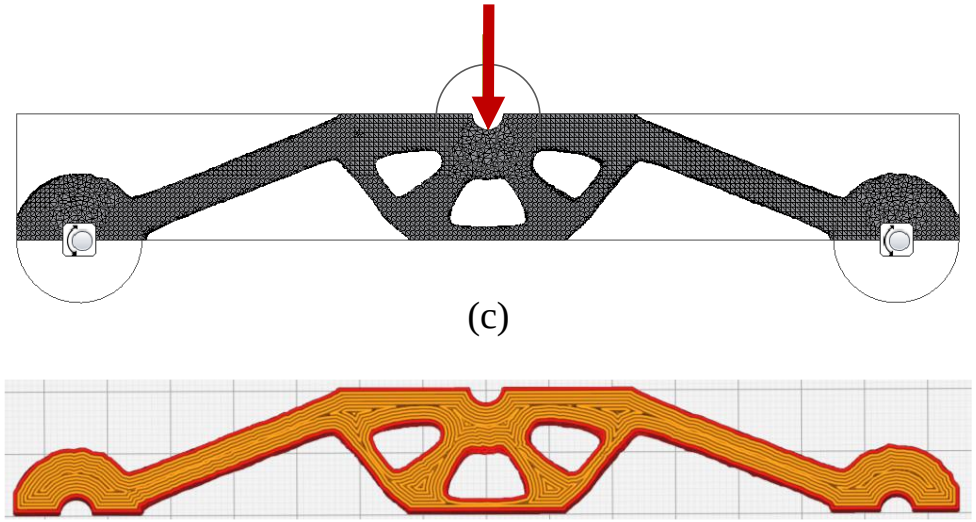
(d) Low/medium-density FDM-based 3-D MPDSM



Case Study I

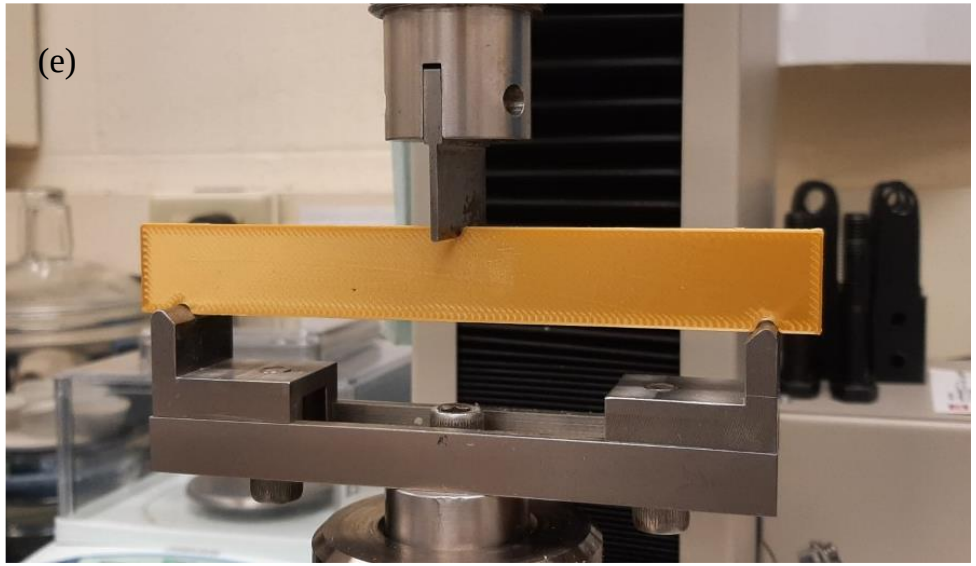


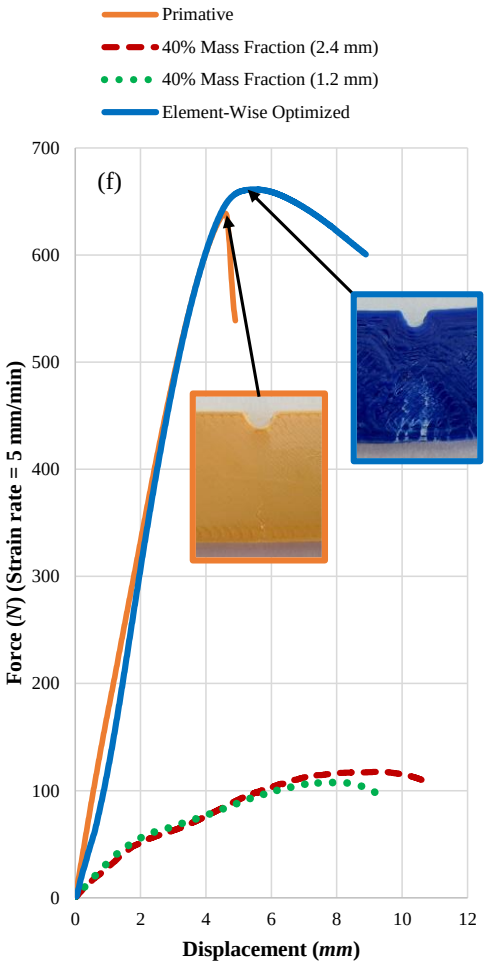




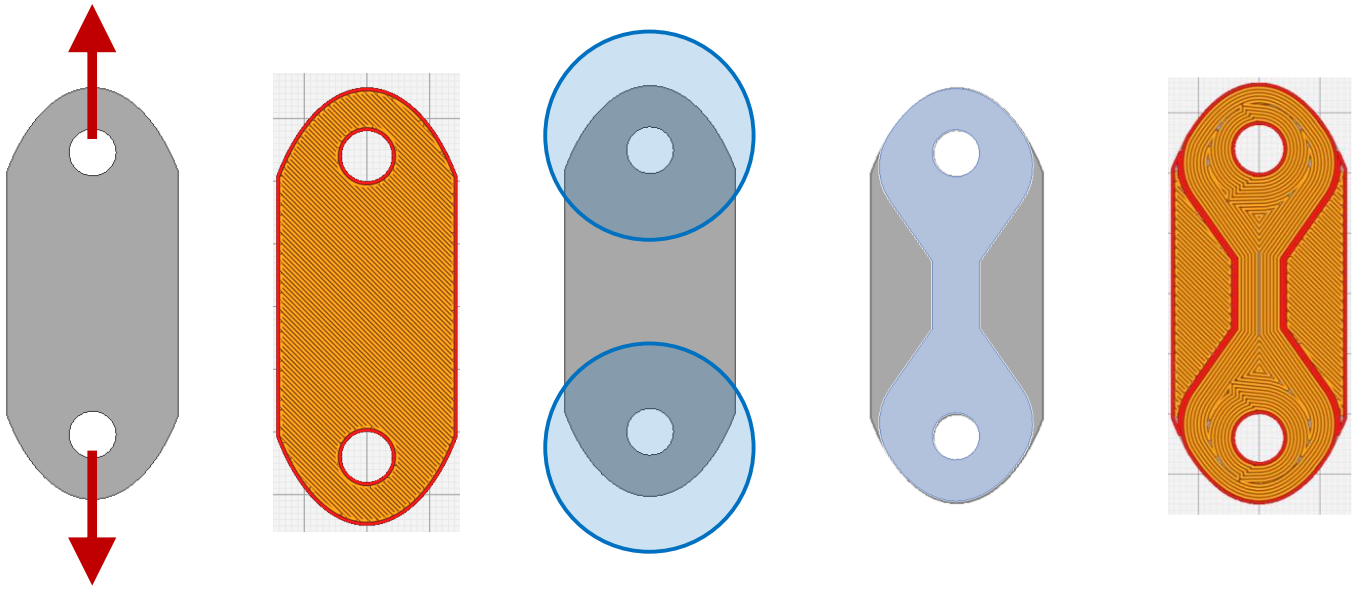
Case Study I


(a)
(b)
(c)
(d)


(e)

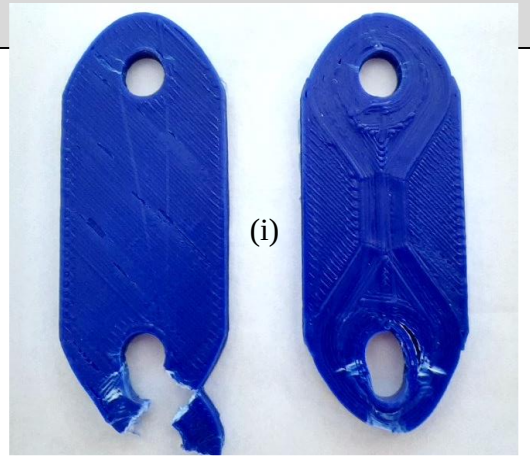

Primative
40% Mass Fraction (2.4 mm)
40% Mass Fraction (1.2 mm)
Element-Wise Optimized
(f)
Force (N) (Strain rate = 5 mm/min)
Displacement (mm)
0
100
200
300
400
500
600
700
0
2
4
6
8
10
12

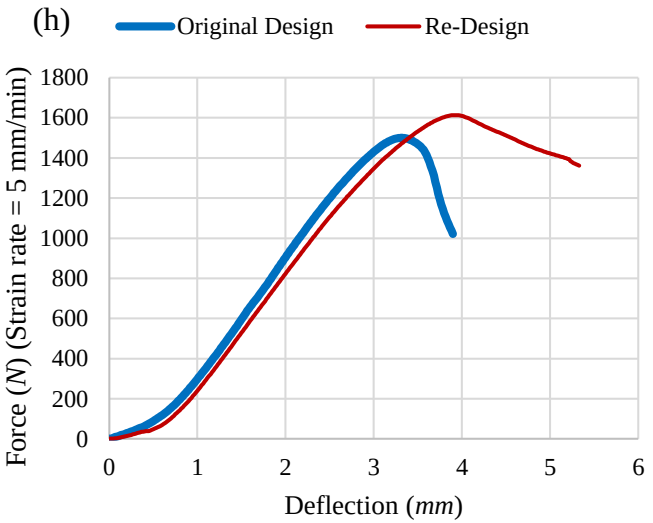
Case Study II



(a) (b) (c) (d) (e)

Original Re-Design





Closing Remarks

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