Multi-scale Morphology Control of 3D-printed Structures using Frontal Polymerization

Pranav Krishnan

Sottos Research Group – MatSE

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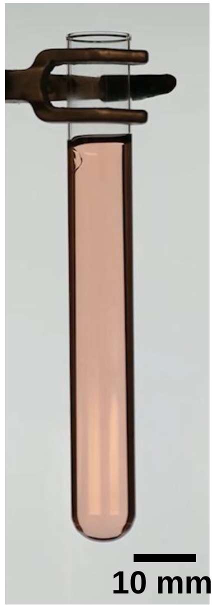
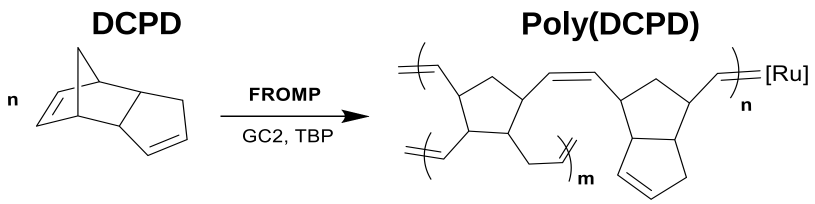
Energy-efficient 3D Printing of strong, deconstructable thermosets



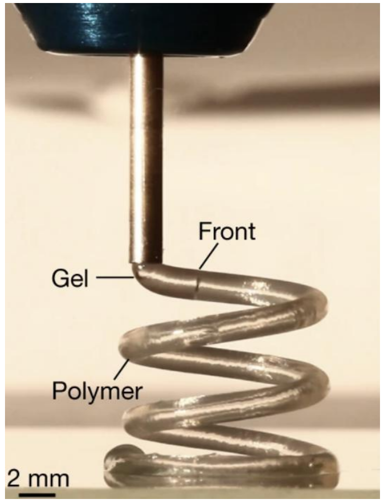
Frontal Polymerization

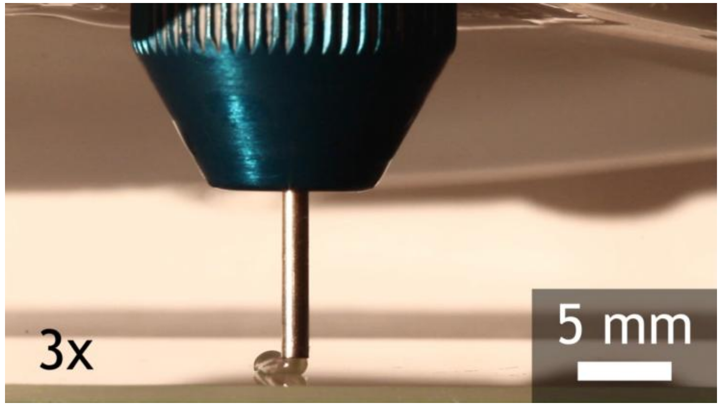


Problems:

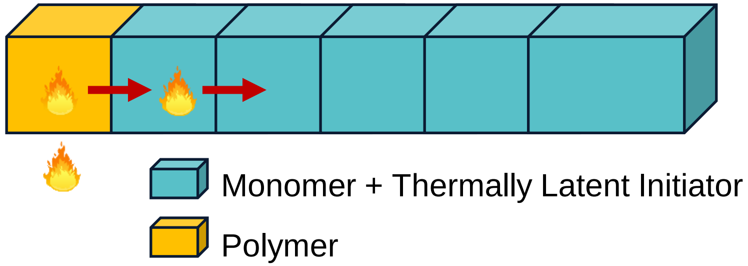
- High-performance thermoset polymers and composites consume huge amounts of energy to manufacture
- These materials are not recyclable and end up in landfills

Direct-ink Writing

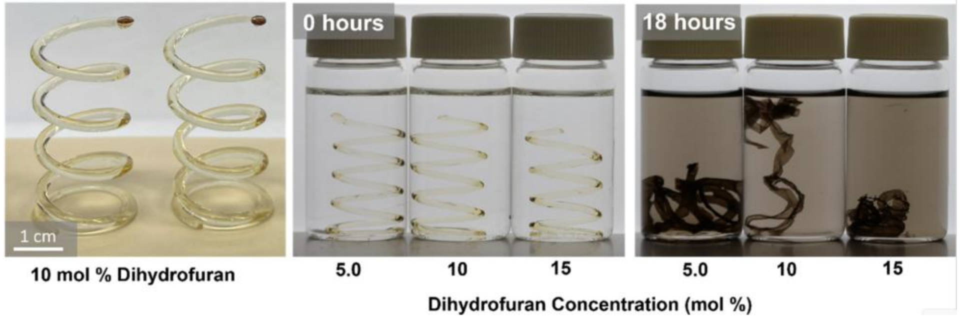




Gap-spanning features



Chemical deconstruction



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*Roberston, I. et. al. Nature, 557, 223 – 227, (**2018**)*
*Davydovich, Oleg, et al. Chemistry of Materials 34.19 (**2022**): 8790-8797.*
*Aw, Jia En, et al. Advanced Materials Technologies 7.9 (**2022**): 2200230.*

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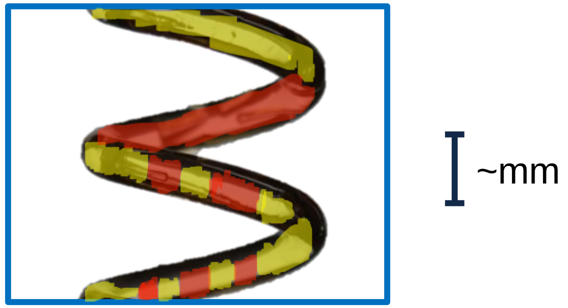
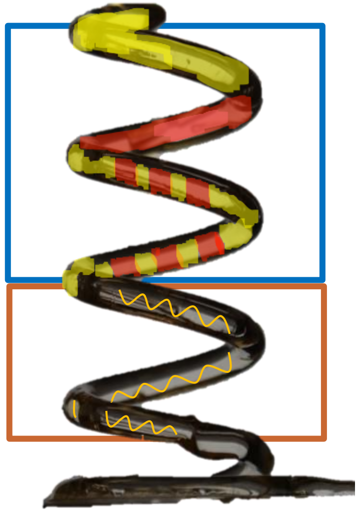
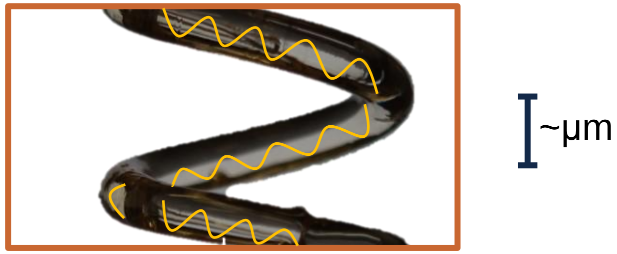
Tuning Composition and Microstructure During 3D Printing

Multi-material FP printing





Patterned FP printing



- Printed structures with tunable properties by varying ink **composition**
- On-the-fly ink mixing and printing of
  a) multiple comonomers to change properties,
  b) catalyst to start the reaction
  c) degradable links for recycling

- Harnessing or imitating instabilities in FP for **microstructure** control via:
  a) crystallization,
  b) phase separation
- Replicate spin mode front propagation by
  a) local thermal gradient,
  b) shear flow at front

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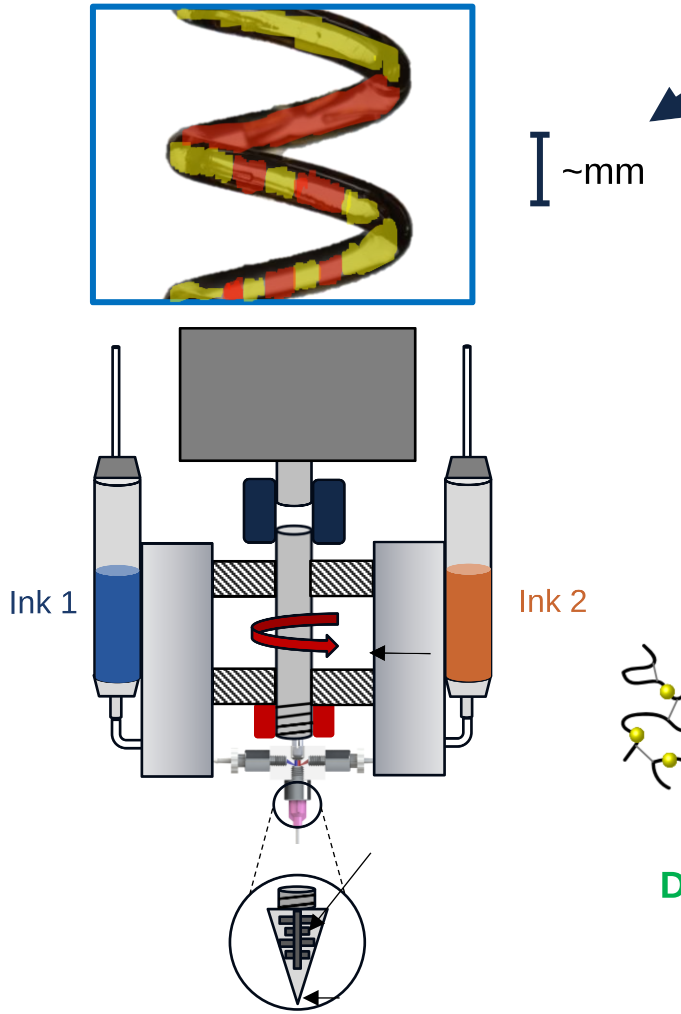
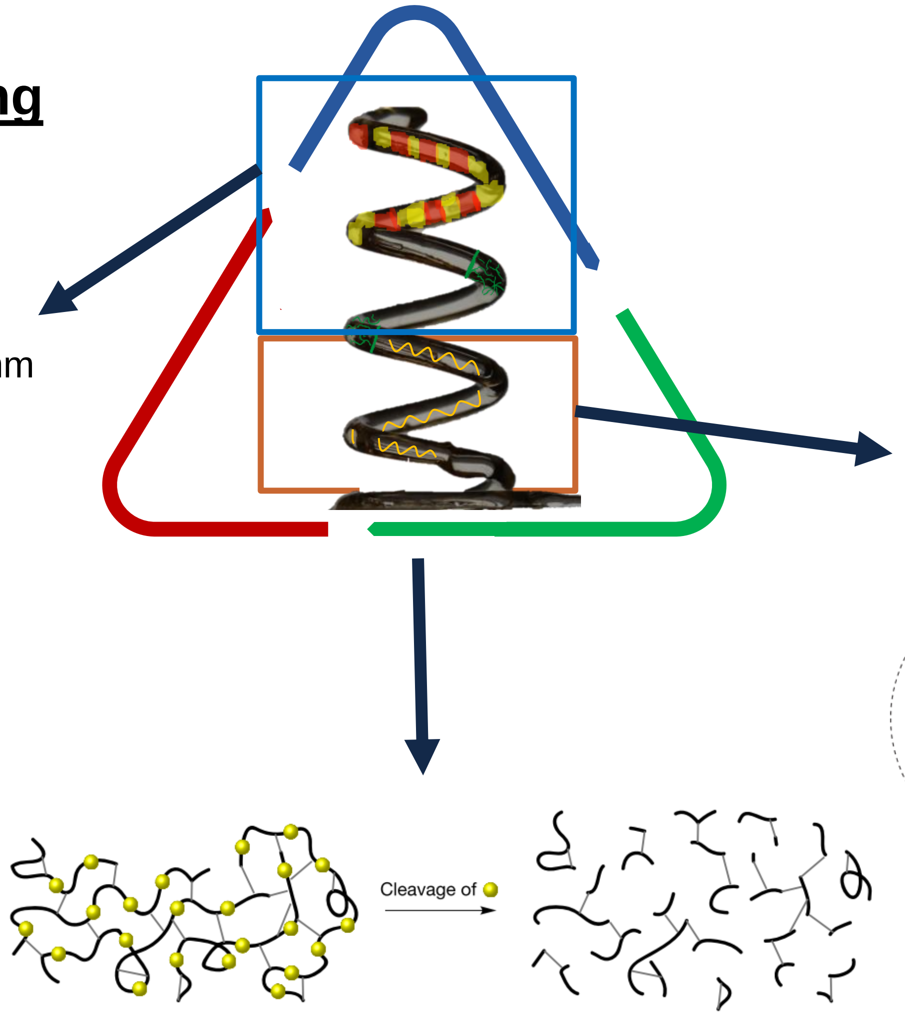
Multi-material FP printing

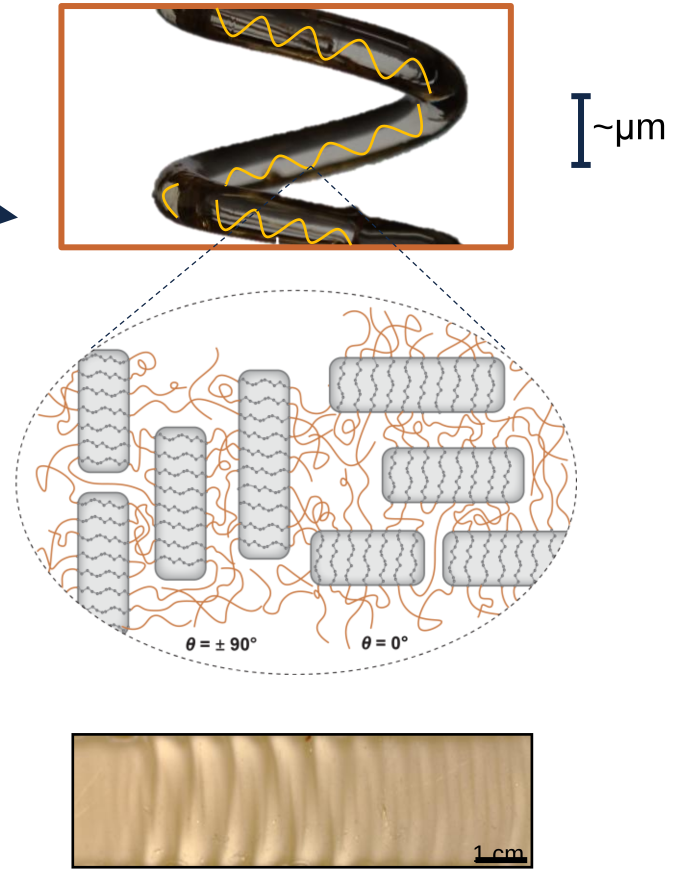
Patterned FP printing



Active mixing enables composition control in 3D printing



Degradable links enable chemical recycling



Controlled crystallization enables bio-inspired gradients of performance