The University of Akron
OHIO's POLYTECHNIC UNIVERSITY
College of Polymer Science and Polymer Engineering

3D Printed Polymers For Biomedical Applications

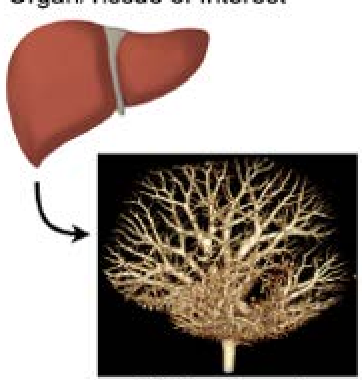
S. Raj Govindarajan, Tanmay Jain, Abraham Joy
Dept. of Polymer Science, University of Akron

Katherine Vorvolakos, Irada Isayeva
FDA

JOY Lab
Chemistry | Polymers | Biology

The promise of 3D Printing Bio-Structures

- Potential to print:
  - Complex structures
  - Personalized medical solutions
  - Structures with gradient properties (modulus, composition, functionality)

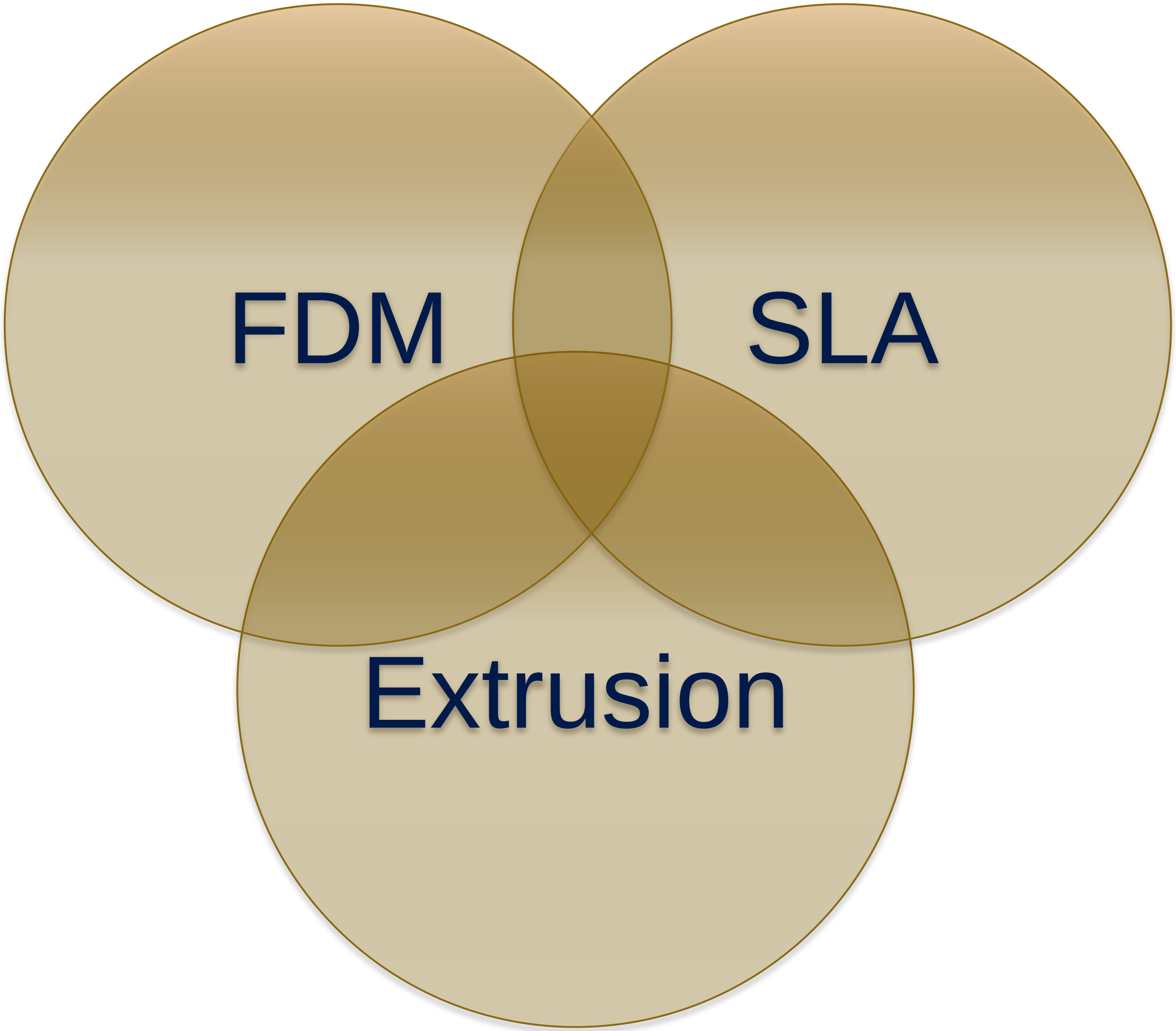


- Need:
  - Novel chemistry
  - Process optimization for reproducible structures

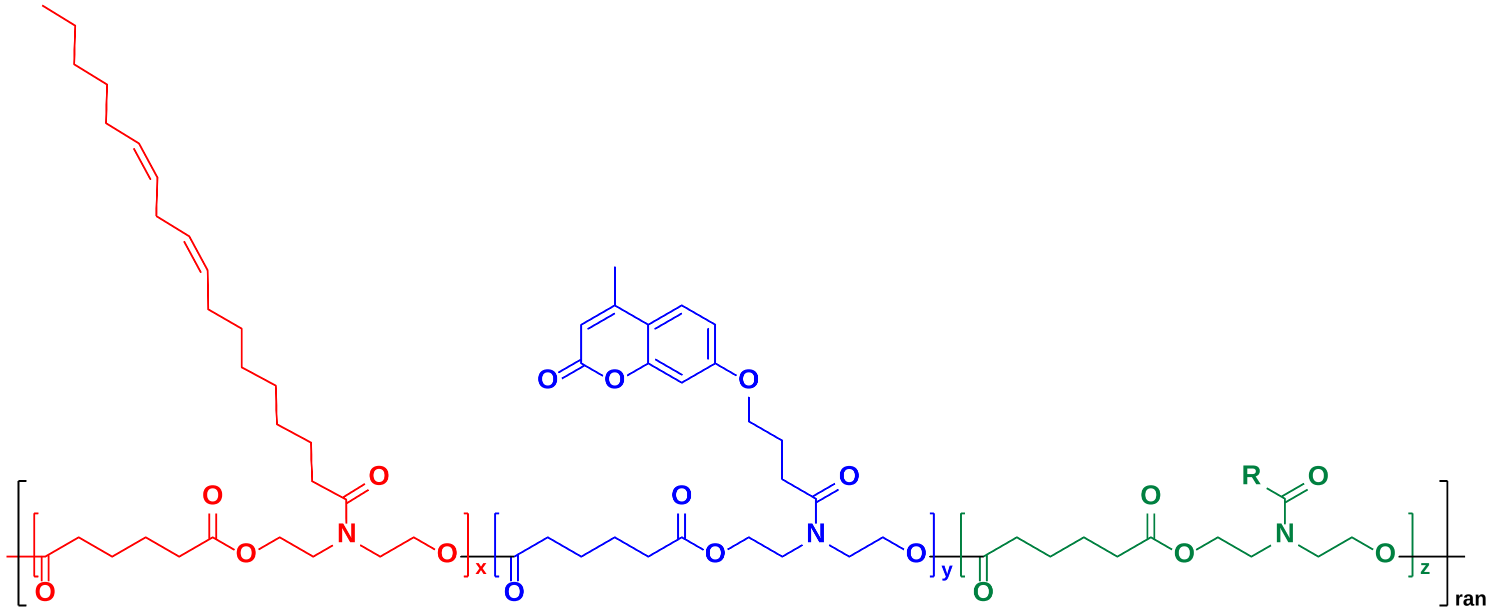
Methods for 3D Printing Scaffolds for Biological Applications

	Advantages	Disadvantages
FDM	• Good resolution structures with reproducible features • Scaffold 3D printed from pure polymer	• High temperature used in FDM is deleterious to cells and biologicals • High modulus structures
SLA	• Very fast printing of 3D objects • High resolution of prints • Diverse chemistry, instrumentation, software available	• Product contains residual monomers, oligomers, initiators etc. – not fully characterized
Extrusion	• Enables ambient temperature printing • Allows incorporation of biologicals, cells in printing process	• Slow 3D printing process • Scaffold features are of lower resolution
Ink-jet	• High resolution • Very fast printing of 3D objects	• Low viscosity materials only

Materials Selection for 3D Printed Scaffolds



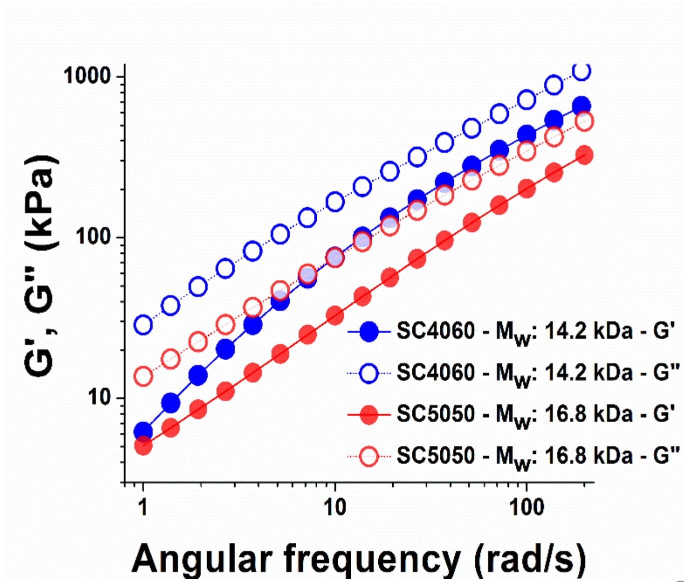
Viscoelastic Polyesters for 3D Printing

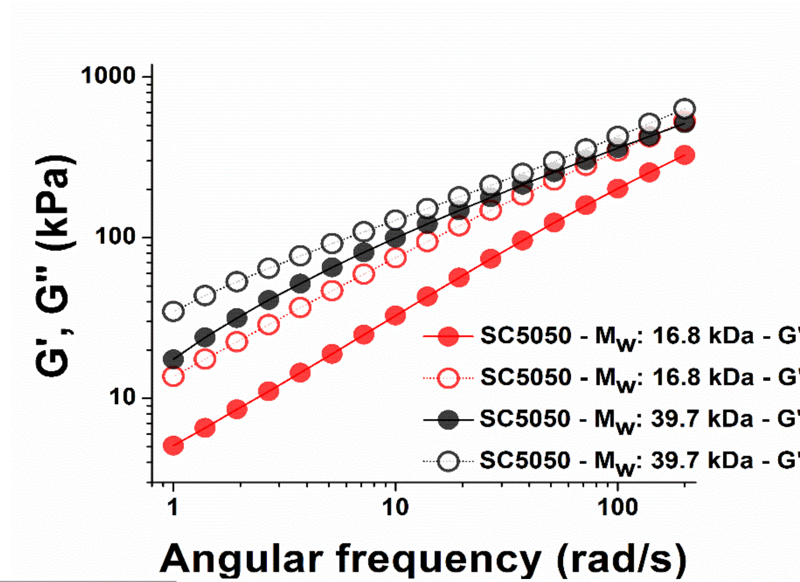


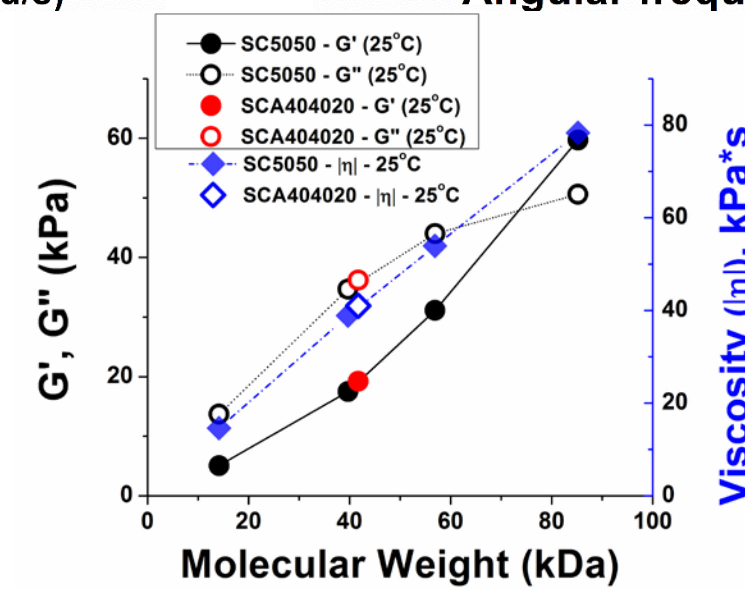
- Solvent-free, low modulus polymer enabling room temperature 3D printing
- Degradable, high MW polyester
- Tunable modulus, functionality
- Light induced transition from viscous liquid to elastomeric solid

S. Govindarajan et al.; Macromolecules, 2016, 49, 2429

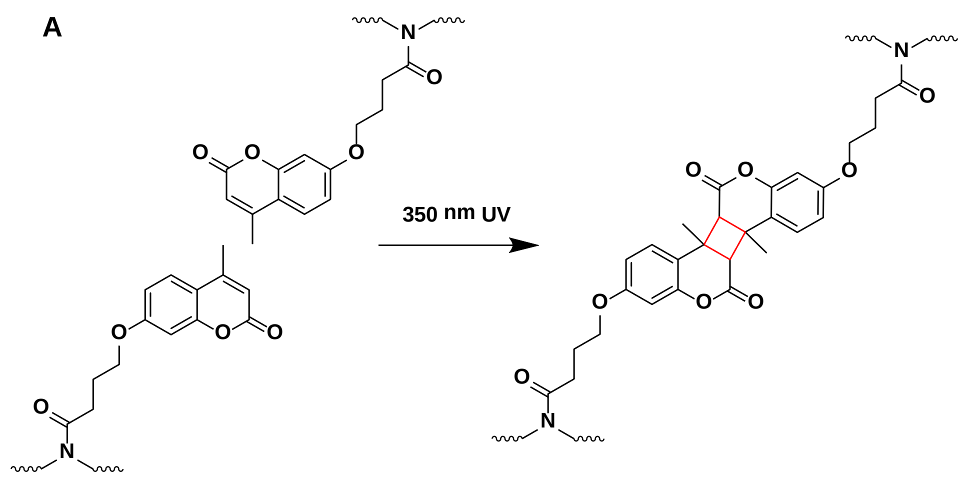
Rheological Properties of SC5050

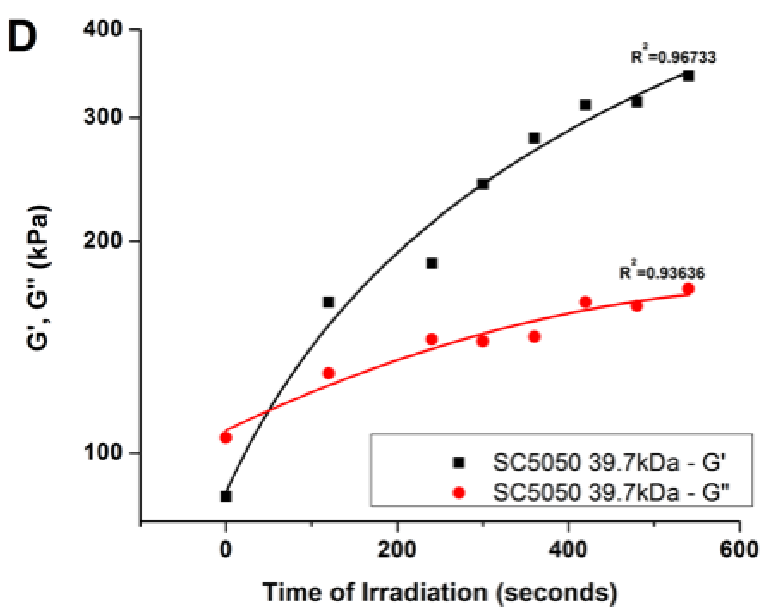


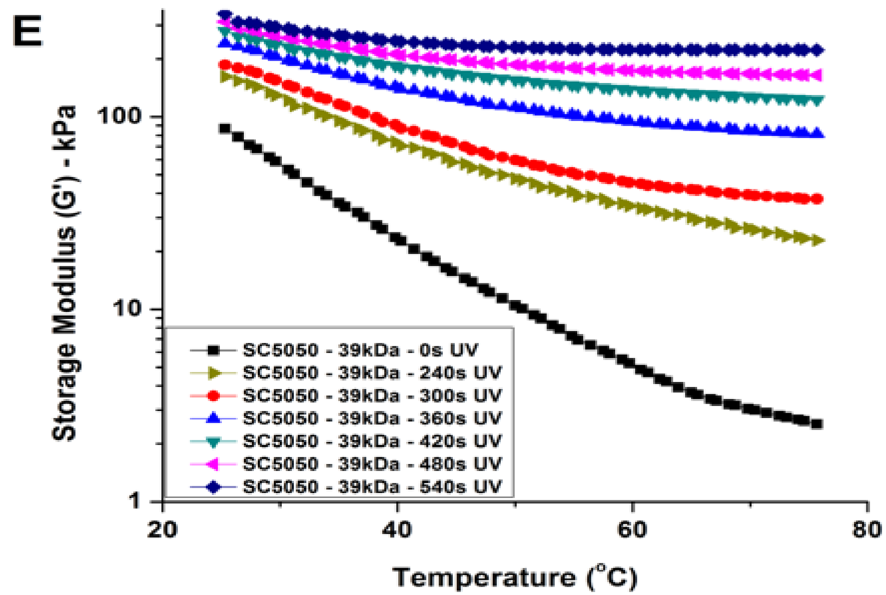




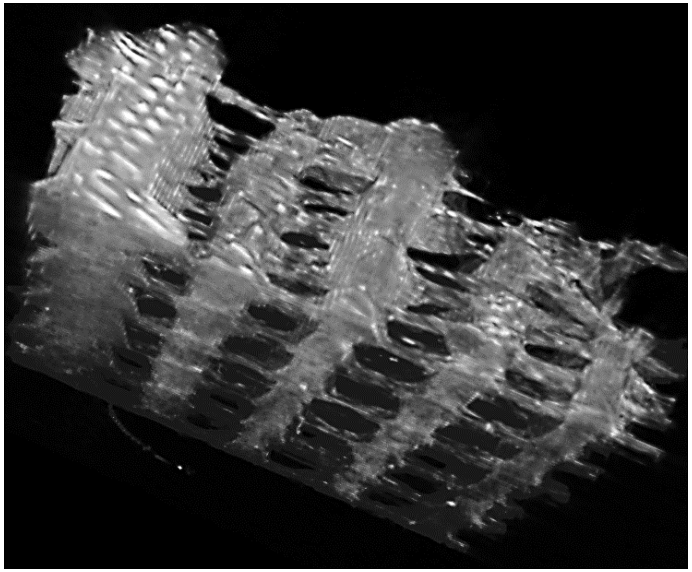
Rheological Properties of SC5050

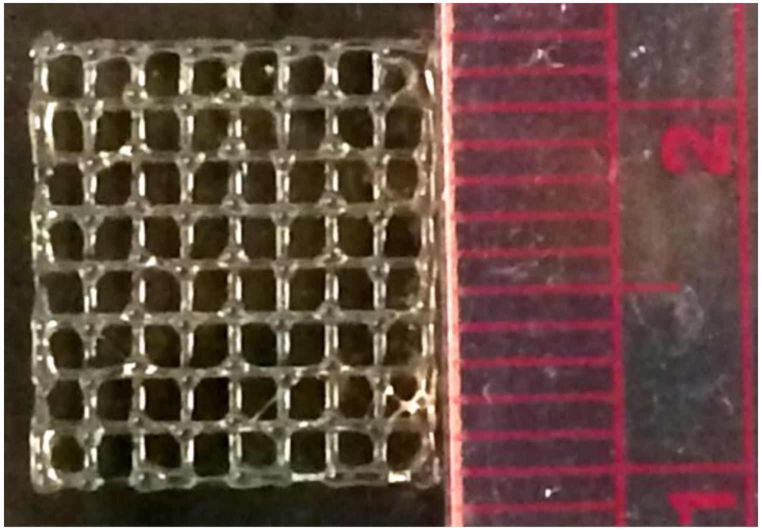


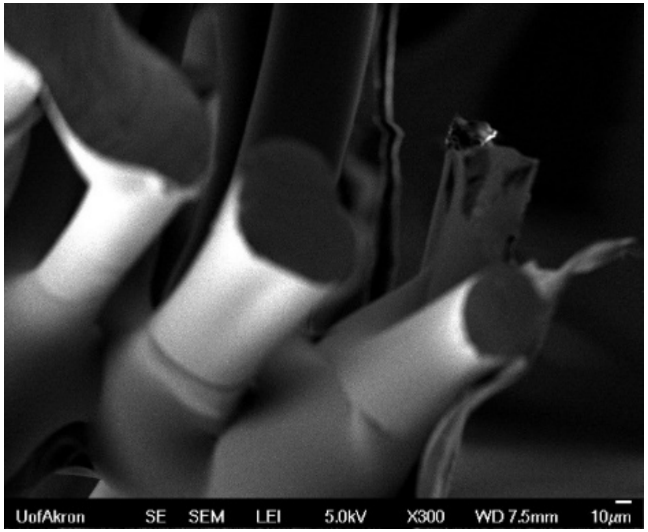


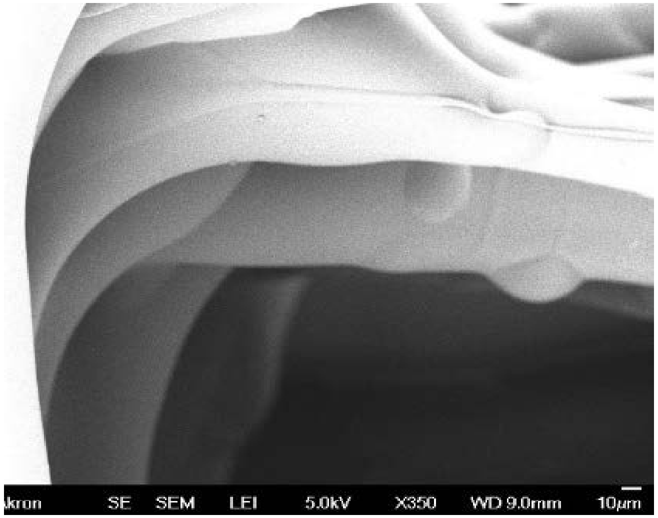


3D Printed Viscoelastic polyesters









S. Raj Govindarajan, Tanmay Jain

Process optimization

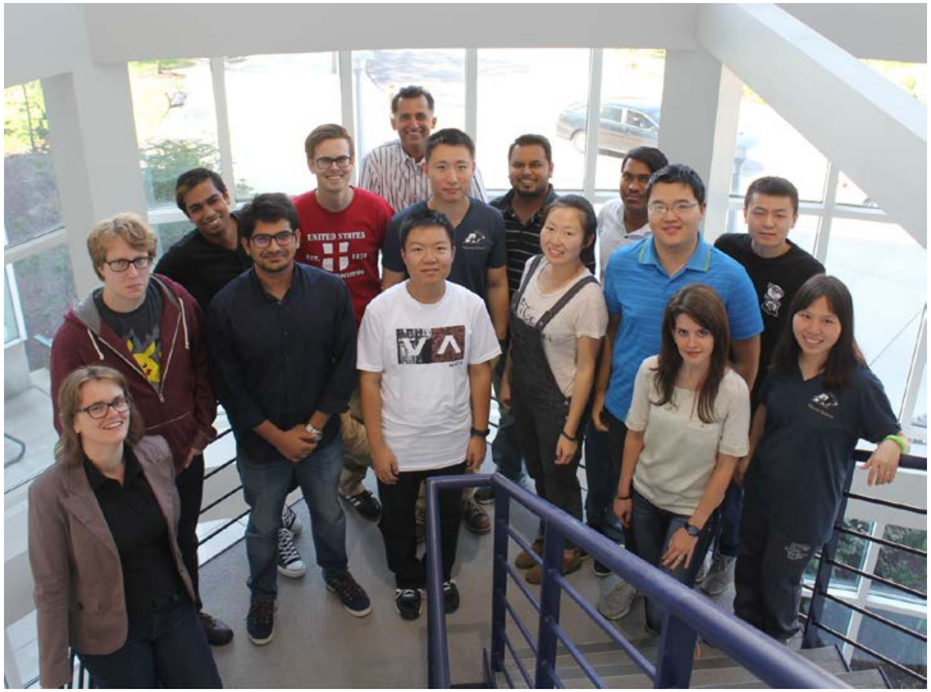
CHALLENGES

- Trade-off between printing speed and print quality
- Mechanical failure of a printed structure because of adhesion failure in between layers

NEEDS

- Correlation between material bulk properties and print parameters
- Methods to quantify filament adhesion to substrate and previous layers
- Quantitative methods to determine localized stress

Thank You



Collaborators:

- Irada Isayeva, FDA
- Katherine Vorvolakos, FDA
- Jae-Won Choi, UA

Students on the project:

- S. Raj Govindarajan
- Tanmay Jain

Funding

- NSF
- FDA Orise fellowship (SRG)