

JOSEPH THOMAS TOOMBS

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EDUCATION

PhD, Mechanical Engineering

University of California, Berkeley, CA

Expected graduation: May 2024

B.S., Mechanical Engineering

University of Illinois, Urbana-Champaign, IL

May 2018

RESEARCH/WORK EXPERIENCE

UCB Dept. of Mechanical Engineering

Aug. 2018 – Present

PhD student in Design for Emerging and Nanoscale Manufacturing Lab of Prof. Hayden Taylor

- Berkeley student representative in NSF NASCENT ERC (UT Austin, Texas)
- Constructed optomechanical system for volumetric additive manufacturing (VAM) of silica glass microstructures
- Optimized photochemistry with real-time FTIR spectroscopy and demonstrated 10× reduction in minimum feature size compared to prior VAM system in the lab
- Published work in *Science*
- Designed optical and mechanical systems for novel roll-to-roll microscale VAM system involving use of dynamic optical components including electrically tunable lens and galvanometer mirrors
- Validated optical resolution of the roll-to-roll system with optical design software
- Published work in *SPIE Advanced Lithography* and presented work at International Conference on Micro- and Nano-devices Enabled by R2R Manufacturing
- Designed system for parallelized VAM for evaluation of the technology on a parabolic microgravity test flight and secured a grant for \$400,000
- Lead team of 5 undergraduate and graduate students in the design and manufacturing phase of the project
- Developed novel real-time tomographic refractive index optical metrology technique for observation of photopolymerization kinetics in resin-based 3D printing
- Published work in *SPIE LASE* and *ACM Symposium on Computational Fabrication*

NASA Marshall Space Flight Center (MSFC), Huntsville, AL

May 2017 – Aug. 2017

Research Associate (Space Hardware and Robotics Academy)

- Designed and developed a test bed for soldering investigations in microgravity on interdisciplinary team of 4 interns
- Produced 3D models and 2D construction drawings for manufacturing of the sheet metal prototype
- Designed circuit with power regulation, thermocouple data collection, and LCD interface
- Published work in *Gravitational and Space Research*

UIUC Dept. of Mechanical Engineering

May 2015 – May 2017

Undergraduate Research (Manufacturing)

- Developed a low-cost process for manufacturing laminated flexure-based composite micro machines
- Designed and constructed 3-axis parallel kinematics stage capable of 1 micron resolution in a 4mm radius
- Published work in *Journal of Manufacturing Processes*
- Developed early iterations of a single-point diamond turning lathe for micro lens applications involving work with precision air-bearing spindles and linear actuators
- Researched precision machine design and gained hands-on experience with precision actuation components such as aerostatic and hydrostatic bearing technology and voice coil flexure stages, and displacement sensors including capacitive gauges, high accuracy magnetic encoders, interferometers

TECHNICAL SKILLS

Experimental: Optical: FTIR, UV-Vis spectroscopy, interferometry, confocal microscopy, optical system design, Mechanical: rheology, tension/compression/flexural testing, Micro/nanofabrication: basic photolithography and mask design, microfluidics

Computational: Programming: Python, Matlab, Optical simulation: Zemax Optic Studio, tomographic reconstruction, phase retrieval, CAD: Autodesk Inventor, Solidworks, AutoCAD, Autodesk Simulation Mechanical, Creo Parametric, Keyshot, Word/graphics processing: Microsoft Office, Adobe Illustrator

GRANTS/AWARDS

NASA Technology Advancement Utilizing Suborbital Flight Opportunities

Hayden Taylor and Joseph Toombs. (2021). Evaluation of Computed Axial Lithography for rapid, volumetric additive manufacturing under low-gravity conditions.

PUBLICATIONS

Joseph T. Toombs, Manuel Luitz, Caitlyn C. Cook, Sophie Jenne, Chi Chung Li, Bastian E. Rapp, Frederik Kotz-Helmer, and Hayden K. Taylor. (2022). Volumetric Additive Manufacturing of Silica Glass with Microscale Computed Axial Lithography. *Science* 376.

Charles M. Rackson, **Joseph T. Toombs**, Martin P. De Beer, Caitlyn C. Cook, Maxim Shusteff, Hayden K. Taylor, and Robert R. McLeod. (2022). Latent Image Volumetric Additive Manufacturing. *Optics Letters* 47.

Chi Chung Li, **Joseph Toombs**, Sui Man Luk, Martin De Beer, Johanna Schwartz, Maxim Shusteff, and Hayden Taylor. (2022). Computation optimization and the role of optical metrology in tomographic additive manufacturing. In *SPIE LASE: Advanced Fabrication Technologies for Micro/Nano Optics and Photonics 2022*. Best paper award.

Joseph Toombs, Chi Chung Li, Hayden Taylor. (2021). Design of a Tomographic Projection Lithography System and Material for Roll-to-Roll Fabrication of 3D Microstructures. In *Proceedings of the 2021 International Conference on Micro- and Nano-devices Enabled by R2R Manufacturing*.

Joseph Toombs and Hayden K. Taylor. (2021). Design of a tomographic projection lithography process for roll-to-roll fabrication of 3D microstructures. In *SPIE Advanced Lithography: Novel Patterning Technologies 2021*.

Indrasen Bhattacharya*, **Joseph Toombs***, and Hayden Taylor. (2021). High fidelity volumetric additive manufacturing. *Additive Manufacturing* 47.

William S. Harley, Chi Chung Li, **Joseph Toombs**, Cathal D. O'Connell, Hayden K. Taylor, Daniel E. Heath, and David J. Collins. (2021). Advances in biofabrication techniques towards functional bioprinted heterogeneous engineered tissues: a comprehensive review. *Bioprinting* 23.

Charles M. Rackson, Kyle M. Champley, **Joseph T. Toombs**, Erika J. Fong, Vishal Bansal, Hayden K. Taylor, Maxim Shusteff, and Robert R. McLeod. (2021). Object-space optimization of tomographic reconstructions for additive manufacturing. *Additive Manufacturing* 48.

Kevin Coulson, **Joseph Toombs**, Magnus Gu, and Hayden Taylor. (2021). Adaptive voxelization for rapid projection generation in computed axial lithography. In *Solid Freeform Fabrication 2021: Proceedings of the 32nd Annual International*, Austin, Texas.

Chi Chung Li, **Joseph Toombs**, and Hayden Taylor. (2020). Tomographic color Schlieren refractive index mapping for computed axial lithography. In *Proceedings - SCF 2020: ACM Symposium on Computational Fabrication*.

Shannen Daly, Micah Hardyman, James Ragan, **Joseph Toombs**, Tracie Prater, and Richard N. Grugel. (2017). MMaJIC, an Experimental Chamber for Investigating Soldering and Brazing in Microgravity. *Gravitational and Space Research* 5, 2.

Jorge E. Correa, **Joseph Toombs**, Nicholas Toombs, and Placid M. Ferreira. (2016). Laminated micro-machine: Design and fabrication of a flexure-based Delta robot. *Journal of Manufacturing Processes* 24.

* indicates equal contribution

CONFERENCE PRESENTATIONS

Joseph Toombs, Chi Chung Li, Hayden Taylor. (2021). Design of a Tomographic Projection Lithography System and Material for Roll-to-Roll Fabrication of 3D Microstructures. In *2021 International Conference on Micro- and Nano-devices Enabled by R2R Manufacturing*.

Hayden Taylor, **Joseph Toombs**, Chi Chung Li, Sui Man Luk, Weisa Wang, Ingrid Shan, Vishal Bansal, and Alexander Watson. (2021). Emergence of Multi-Material Volumetric Additive Manufacturing—Overprinting and Particle Inclusion. In *MRS SF02: Additive Manufacturing—From Material Design to Emerging Applications*.

Hayden K. Taylor, **Joseph Toombs**, Sui Man Luk, Samira Feili, Hossein Heidari, Chi Chung Li, Vishal Bansal, Kevin Coulson, and Elyas Goli. (2021). Modeling of light propagation in computed axial lithography with photopolymers. In *SPIE OPTO: Emerging Digital Micromirror Device Based Systems and Applications XIII*.
