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PTC, TAMU News & SPE Student Chapter

Mark Your Calendars for the PTC Fall meetings!

**Scratch Behavior of Polymers Consortium-SCRATCH**

**Polymer Technology Industrial Consortium-PTIC**

**SCRATCH SPRING meeting-March 21st, 2024**
Texas A&M University-College Station, TX

**PTIC SPRING meeting-March 21st & 22nd, 2024**
Texas A&M University-College Station, TX

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**Single-digit micrometer resolution, and multi-material high-speed 3D printing technologies for soft materials**

**Hsiao Research Group**

Dr. Kaiwen Hsiao is starting as an assistant professor in the Department of Materials Science and Engineering Department at Texas A&M University in January 2024. Her research interests focus on exploring nanoscale molecular arrangement and their impact on soft-material performances for advanced additive manufacturing applications. Recent advances in healthcare and sustainability have accelerated the need to develop transformative manufacturing technologies that transition precise, molecularly assembled materials to scalable 3D architectures with optimal transport properties and molecular selectivity. However, a compromise between pattern resolution and print speed has rendered most high-resolution additive manufacturing technologies unscalable with limited applications. To address this challenge, innovative approaches at the intersection of additive manufacturing (AM), polymer physics, and non-Newtonian fluid dynamics to enable scalable fabrication of micron to nanoscale structures are critical for developing next generation biomedical and soft-electronics applications.

The ability to form 3D structures with feature sizes in the microscopic length scale and hierarchical complexity in the macroscopic length scale offers powerful engineering design options for microsystem technologies where conventional planar architectures currently dominate. The three most prominent and common issues that render most AM technologies unscalable and difficult to compete with traditional lithography approaches are the layer artifacts that lead to mechanical anisotropy, reduced resolution, and slow build rates. During Dr. Hsiao postdoctoral research, she developed a high-resolution CLIP technology that allows the fabrication of 3D structures containing single-digit-micrometer features at a print speed that is $10^5$ times faster than commercially available high-resolution 3D printers (Fig 1).

**Figure 1. Demonstration prints from the single-digit-micrometer-resolution CLIP-based 3D printer.**

Continues on Page 3
Professors I. Borazjani (MEEN) and H. -J. Sue (MSEN) have been awarded a grant to study the rheology of “hairy nanoparticles” that have polymer chains covalently bonded to the surface. The polymer chains were added to improve the dispersion of the nanoparticles in the host polymer and prevent aggregation. Such nanoparticles can dramatically improve properties, such as modulus and permeability, at relatively low loadings in comparison to conventional fillers. Hairy nanoparticles exhibit shear-thinning behavior, which is desirable for many applications. Polymer rheology is critical to the efficient production of quality articles, but unfortunately the understanding of the rheology of liquids containing nanoparticles is at a nascent stage.

In the scanning electron microscope (SEM) images below, non-dispersed 2D nanoparticles composed of zirconium phosphate (ZrP) with various aspect ratio are shown.

The objective of this work is to (1) experimentally investigate the rheology of nanocomposites with different hairy NPs; (2) develop and validate computational tools to simulate such suspensions; and (3) investigate the main reasons for the deviation from the theory, thereby pave the way to improve theoretical/simplified models for advanced manufacturing needs.

The working hypothesis is that the increase in graft density and length increases the shear thinning behavior while the non-spherical shape of the hairy nanoparticles (e.g., 2D NPs) increases the viscosity relative to spherical (0D) ones as the non-dimensional moment of inertia (around the vorticity direction of shear flow) and non-dimensional surface-to-volume increases when other conditions (such as volume fraction and Reynolds number) are similar.
This is accomplished by combining the CLIP technology with a custom-designed projection optical lens and an in-line contrast-based focusing system. To maneuver the shallow depth of focus for a high-magnification objective lens, we developed a projection optical lens and an in-line contrast-based focusing system. To maneuver this, we combined the CLIP technology with a custom-designed projection optical lens and a high-magnification objective lens. To achieve an understanding of photopolymerization kinetics on print resolution and the impact of resin transport on print speed for our system, we have introduced a numerical model that considers all fundamental elements in our high-resolution 3D CLIP printing system, including optical projection, photopolymerization reaction kinetics, and resin mass transport. This model allows us to develop a printing strategy that uses the understanding of fundamental transport phenomena and determine print parameters for the printer software control system (Fig. 3). Aside from optimizing the print process, the model also provides insights into 3D CLIP printing in general, with accurate predictions of the surface finish of a printed part, dead-zone thickness, and resin curing during the 3D printing process.

In addition to working on enhancing resolution in high-speed AM technologies, during her post-doctoral research Dr. Hsiao also worked developing iCLIP (injection CLIP) technology. This work further accelerates printing speeds to 10-fold over CLIP printing methods, expands the accessible viscosity range of resin materials, and enables heterogeneous multi-material 3D printing capabilities. Detailed process parameters governing iCLIP are characterized (Fig. 4) and demonstrated with use cases including rapidly printing carbon nanotube-filled composites, multi-material features with length scales spanning several orders of magnitude, and lattices with tunable moduli and energy absorption (Fig. 5).
Texas A&M Ranked No. 1 University In The State By Wall Street Journal

![NO. 1 IN TEXAS](image)

Texas A&M University is one of the top institutions of higher education in the country, according to rankings recently published by The Wall Street Journal.

Texas A&M was ranked first in the Lone Star State and sixth in the nation among all public universities in the 2024 Best Colleges in the U.S. rankings published by The Journal in collaboration with College Pulse and Statista. Overall, Texas A&M was ranked 38th in the nation. All but one university in the top 20 are private colleges.

In Texas, A&M was followed by Rice University, which ranked 64th nationally; The University of Texas at Austin, which finished at 118 nationally; University of St. Thomas, at 158 nationally; and Southern Methodist University, at 175 on the national list.

Full story: [https://bitly.ws/UIPf](https://bitly.ws/UIPf)

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### SPE STUDENT CHAPTER officers for 2023-24

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### Polymer Specialty Certificate Updates

Students that have applied for the Polymer Specialty Certificate: 87

Students that have received the Polymer Specialty Certificate: 75

For more information, please visit: [http://ptc.tamu.edu/polymer-specialty-certificate/](http://ptc.tamu.edu/polymer-specialty-certificate/)

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Edited by: Dr. Michael Mullins