Materials Science and Engineering Department

Winter Seminar Series

Bridging Rheology, Processing, and Performance in Direct Ink Writing

Prof. Nicolas Alvarez
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Drexel University

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11AM-12PM | Hill Seminar Room (LeBow 240)

Additive manufacturing of soft and liquid-derived materials presents a central challenge at the intersection of fluid mechanics, materials science, and mechanics: how to reliably transform flowing matter into structures with controlled geometry and performance. In this talk, I will provide an overview of our research group's efforts to develop physics-based frameworks that connect material properties, processing conditions, and emergent structure across a range of manufacturing and transport phenomena.As a focal example, I will highlight recent work on Direct Ink Writing of thermoset resins, where low-viscosity and weakly structured fluids must be deposited with high dimensional fidelity. We show how filament spreading, layer cohesion, and final part integrity are governed by a competition between gravity, viscous relaxation, interfacial forces, and, when present, curing or non-Newtonian effects. By identifying relevant timescales and dimensionless groups, we establish predictive models that enable a priori control of bead morphology across Newtonian, shear-thinning, and curing systems. More broadly, this work illustrates our group's approach to additive manufacturing as a problem of controlled fluid-to-solid transition, emphasizing scalable design rules rather than empirical tuning. I will conclude by discussing how these ideas extend to multi-material printing, particle-filled systems, and emerging manufacturing platforms, and how they inform the rational design of inks, processes, and architectures for next-generation functional materials.

Nicolas J. Alvarez is a Professor in the Chemical and Biological Engineering at Drexel University. He earned a BS in Chemical Engineering from the University of Florida in 2006 and a Ph.D. in Chemical Engineering from Carnegie Mellon University in 2011. After three years of postdoctoral work at the Technical University of Denmark in Lyngby, he joined the Department of Chemical and Biological Engineering at Drexel as an Assistant Professor in 2014.
His lab develops experimental tools to characterize the behavior of polymers and surfactants in nonlinear flows, at interfaces, and in bulk. These tools are used to understand how certain processing windows lead to advantageous material properties. One such tool, used for the characterization of extensional rheology, has been commercialized by Alvarez and colleagues. To support research goals, Alvarez is developing a consortium of companies to develop analytical tools to better understand the relationship between chemical structure, processing, and material performance. To prepare Drexel students for real-world engineering problems, Alvarez teaches an elective course on non-Newtonian fluid mechanics to introduce students to materials encountered in modern-day chemical plants.
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FOR MORE INFORMATION

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