The Department of Mechanical Engineering
College of Engineering and Applied Sciences
Stony Brook University

Mechanical Engineering Seminar

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Lecture Title: Designing Composite Architectures via 3D Printing and Colloidal Assembly
Friday, November 20, 2015 at 1:30 PM, Room 173 Light Engineering Building

Abstract

Continuous fiber reinforced composites offer an attractive combination of high strength-to-weight ratios, high stiffness, and remarkable fracture toughness. However, CFRCs are commonly manufactured by hand and can only be implemented in simple geometries like sheets. Complex geometries require discontinuous reinforcing particles that are amenable to polymer processing technologies like injection-molding, tape-casting, and 3D printing. However, discontinuous reinforcements are generally much weaker than their continuous counterparts. To make composite materials a possible selection for applications with non-simple geometries, a new manufacturing technology termed ***3D Magnetic Printing*** has been developed by us to assemble these small reinforcing particles in systematic and programmable ways within a synthetic composite. This technique combines real-time colloidal assembly processes to orient reinforcing particles within a polymer during conventional SLA or FDM 3D Printing. The colloidal assembly relies upon a hierarchical interplay of magnetic nanoparticles surface labeled to ceramic microparticles. These assemblies exhibit an ultra-high magnetic response that can be exploited to program a limitless family of reinforcement architectures. 3D Magnetic Printing enables us to write the reinforcement micro-architecture directly into composite blocks with 100 micron voxel resolution. Such control over the microstructure lets us recreate many complex biological composite architectures, and further design customized synthetic micro-architectures to produce composites that exhibit enhanced strength, stiffness, and fracture toughness. With control over local reinforcement orientation we demonstrate the ability to manipulate crack paths making them tortuous. I will also discuss their new proposal to build micro-graded composites in which the stiffness mismatch between the reinforcing particles and the ductile matrix is alleviated by locally crystallizing polymer in an intermediate layer. All of these techniques are targeted towards improving the mechanical properties of discontinuous composites to make them a viable option in applications that require non-simple material geometries.

Biography

Randall Erb is an assistant professor at Northeastern University in Boston, MA. He leads the Directed Assembly of Particles and Suspensions (DAPS) group in the Mechanical and Industrial Engineering Department. Randall did post-doctoral research in the Department of Materials at ETH-Zürich in Switzerland. He received his Ph.D. from Duke University in Mechanical Engineering and Materials Science in 2009 and his B.S. in Electrical Engineering from the University of Rochester in 2004. He also worked as an electrical engineer at Washington Group International. Randall has 6 patents some of which received innovation awards (2012 SPARK innovation award and U.S. National Inventor's Hall of Fame's Collegiate Inventors Competition finalist). He has co-authored 4 book chapters, 26 papers in peer-reviewed journals including *Nature* and *Science*. His research interests include determining the optimal design of multiple field sources and the fundamental resolution and critical size regimes that enable robust assembly processes to make complex, yet highly tunable, materials out of simple building blocks.

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