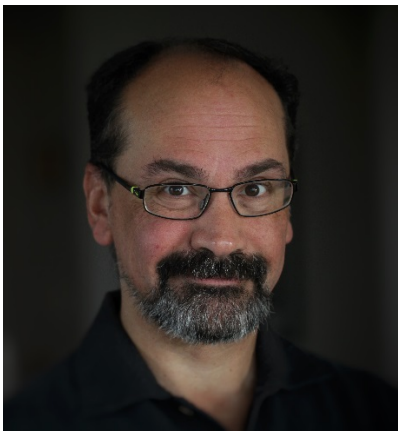
PURDUE UNIVERSITY

PURDUE MATERIALS ENGINEERING



Materials Engineering Fall 2016 MSE 690 Seminar Series

March 24, 2017

3:30 pm Coffee
3:45 pm Seminar
ARMS 1010

High performance naturally occurring materials: The role of architecture

Pablo D. Zavattieri
Lyles School of Civil Engineering
Purdue University, West Lafayette, IN, USA

Abstract

There is a strong demand for new paradigms of design and development of advanced high-performance structural materials with high specific strength, stiffness and toughness for new technological needs. Yet, most engineering materials have an inverse relation between these desired properties. This trade-off is often linked to our limitations in controlling the architecture of the materials across length scales. Recently, it has been demonstrated that the proper selection of the building blocks together with a clever distribution of weak interfaces can lead to controlled mechanical properties. The area of architectured materials seeks answers to some of the questions related to how geometry and topology could significantly improve the overall mechanical properties without changing the chemistry or composition of the building blocks. While computer power and progress on topology optimization methods may take us closer to those answers in the future, an alternative path is to look for clues in existing high-performance materials that already took millions of years to master this technique through a trial-and-error process: biological materials. By natural selection, Nature has evolved efficient strategies to synthesize materials that often exhibit exceptional mechanical properties that significantly break the trade-offs often achieved by man-made materials. In fact, most biological composite materials achieve higher toughness without sacrificing stiffness and strength in comparison with typical engineering material. Interrogating how Nature employs these strategies and decoding the structure-function relationship of these materials is a challenging task that requires (i) knowledge about the actual loading and environmental conditions of the material in their natural habitat, (ii) a complete characterization of their constituents and hierarchical architecture through the use of modern tools such as in-situ electron microscopy, small-scale mechanical testing capabilities, and (iii) solving some interesting solid mechanics problems that involve analytical and numerical models, as well as additive manufacturing. This talk will be focused on the convergent evolution of impact resistant naturally occurring materials and how we can use mechanics to evaluate some important hypotheses about the key morphological features of the microstructure and toughening mechanisms that are unique in these hierarchical materials.

Biography:

Dr. Pablo Zavattieri is an Associate Professor of Civil Engineering at Purdue University. Zavattieri received his BS/MS degrees in Nuclear Engineering from the Balseiro Institute, in Argentina and PhD in Aeronautics and Astronautics Engineering from Purdue University. From 2001 to 2009, he worked at the General Motors Research and Development Center as a staff researcher, where he led research activities in the general areas of computational solid mechanics, smart and biomimetic materials. His current research lies at the interface between solid mechanics and materials engineering. His engineering and scientific curiosity has focused on the fundamental aspects of how Nature uses elegant and efficient ways to make remarkable and more sustainable materials. He has contributed to the area of biomimetic materials by investigating the structure-function relationship of naturally occurring high-performance materials at multiple length-scales, combining state-of-the-art computational techniques and experiments to characterize the properties. His current research program includes the study of other remarkable natural microstructures, including mantis shrimp, chitons, beetles, fish scales, bird feathers, woodpeckers, bamboos, and organic nanocrystals. Prof. Zavattieri is the recipient of the NSF CAREER award, the Roy E. & Myrna G. Wansik Research Award; he is a National Academy of Engineering Frontiers of Engineering Alumnus and a National Academy of Science Kavli Frontier of Science Fellow. He was recently appointed a Purdue University Faculty Scholar for the period 2015-2020.