University of California, Irvine

THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MSE 298 SEMINAR

FALL 2025: MSE IN THE SPOTLIGHT

Professor
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Department of Materials Science and Engineering

RESEARCH TALK:
WHY MSE IS IMPORTANT FOR UNDERSTANDING NANOBUBBLES AND WHY NANOBUBBLES ARE IMPORTANT FOR MSE

Abstract: Nanobubbles typically have a diameter in the range of 20 to 1100 nm and can persist for weeks in aqueous environments. Our first principles theory for nanobubble formation describes how the process that makes stable nanobubbles seem improbable, microbubble shrinkage, can account not only their metastability but also their remarkable longevity. This theory is based in part on the strong affinity hydroxyl ions have for gas-water interfaces and the repulsive forces they can produce against surface tension for a shrinking nanobubble. The combination of strong attractive and repulsion forces in this context has interesting similarities with atomic bonding in crystalline materials. I will show how the derivation of our theory and our present understanding was facilitated by considering these similarities.Experimental evidence supporting our theory will also be discussed. We have also shown that nanobubbles can bind to embryonic nanoparticles below their solubility limit making them stable so that they do not dissolve back into solution.Observed dissolution of salts in scaling deposits on materials, such as calcium carbonate, has been attributed to this nanobubble/nanoparticle cluster formation phenomenon. Experimental evidence for this mechanism will also be presented.Finally, results demonstrating the efficacy of nanobubbles in protecting structural materials by eliminating deleterious scaling deposits will be presented.

Bio: James Earthman is a Professor of Materials Science and Engineering and Biomedical Engineering at the University of California, Irvine. He received his B.S. degree in Materials Science from Rice University and his M.S. and Ph.D. degrees in Materials Science and Engineering from Stanford University. Prof. Earthman's research activities include studies of a broad range of deformation and damage mechanisms in both man-made and biological materials, the development of systems for novel quantitative diagnostics of material characteristics and integrity, and the dissolution of deleterious materials using nanobubbles. In 2022, he was a Distinguished Summer Faculty Fellow at the Naval Research Laboratory in Washington, DC for research on nanobubbles.He has authored and co-authored over 120 peer-reviewed research publications including two chapters on biomaterials and tissue engineering and two chapters in materials handbooks published by ASM International. He is an inventor on 16 issued US patents, several international patents, and several pending US patents. He is also co-founder of Perimetrics, Inc., a diagnostic device company headquartered in Seattle, WA. He has also served as editor for three books in the fields of Materials Science and Biomedical Engineering. He was elected Fellow of ASM International in 2023.

DATE: Thursday, October 23, 2025
TIME: 2:00 - 3:20 PM
LOCATION: McDonnell Douglas Engineering Auditorium