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# MSE 690 SEMINAR SERIES

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ARMS 1010



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### *Understanding the Mechanical Behavior of Small-scale Materials: Small for the sake of Big*

**Abstract:** Thin films are widely used as functional and structural elements in micro-electronic devices, large-scale integrated circuits, thin-film solar cells, electrical sensors, and electronic textiles. Understanding the mechanical behavior of thin films at different length scales and environmental conditions is essential for the design of reliable devices. However, it is difficult to precisely measure the properties of small-scale materials with the methods that are employed for bulk materials; probing micro/nano scale samples is challenged by the inherent difficulties associated with fabricating and handling of extremely small specimens.

In this presentation, I will introduce experimental studies utilizing micro/nano-scale manufacturing and mechanical characterization techniques to understand the mechanical behavior of small-scale materials. In the first topic, the effect of carbon addition and ultra-thin ( $< 10$  nm) passivation layer on the microstructure and mechanical behavior of freestanding metal thin films will be discussed. Tensile specimens with sub-micron thickness are fabricated via sputter deposition followed by standard silicon-based microfabrication techniques. Supersaturated aluminum-carbon (Al-C) thin films containing 10.3at% C exhibit yield strength of about 400 MPa, over three times the yield strength of the Al thin films. Films passivated with an ultra-thin layer ( $< 10$  nm) exhibit significant increase in the failure strain, which is attributed to delay in the strain localization due to constraint imposed by the passivation layer. In the second topic, constant strain rate membrane deflection experiment (MDE) technique that enables high-throughput measurement of in-plane mechanical properties of metal thin films will be introduced. By comparing with micro-tensile tests, it is demonstrated that the stress-strain curve of freestanding metal thin films can be successfully measured via constant strain rate MDE. Finally, I will discuss how these techniques are being used to develop metallic alloys such as NiTiCu shape memory alloy and nanotwinned Ni-Mo-W thin films.

**Biography:** Gi-Dong Sim is an assistant professor at Korea Advanced Institute of Science and Technology (KAIST) where he leads the in-situ characterization and reliability evaluation (iCaRE) laboratory in the department of mechanical engineering. Prior to joining KAIST in 2018, he conducted research at Johns Hopkins University, Harvard University, and at KAIST. His group research is focused on developing experimental techniques to test the mechanical behavior of metallic materials at various length-scales and in different environments, on the development of advanced metallic alloys and devices that can reliably operate in extreme environments, and on elucidating deformation mechanisms of materials in extreme environments.



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