Chemical Engineering Graduate Seminar

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"Atomic Layer Deposition for MEMS Applications"

Because of the small size of micromechanical (MEMS) devices interfacial interactions such as adhesion, friction, and wear often dominate their performance and reliability. While many tribological coating materials are available to mitigate these problems, most traditional surface coating processes are unable to apply conformal coatings to the high aspect ratio (height/width) structures typical of MEMS devices. Freestanding mechanical structures must be coated conformally to avoid stress gradients, and shadowed surfaces, such as the underside of mechanical structures, gear hubs, fluid channels, etc. with effective aspect ratio (depth/width of a channel) of up to 100, must be coated equally as well as exposed surfaces. The molecular flow and self-limiting surface chemistry characteristics of atomic layer deposition (ALD) makes these processes ideally suited to MEMS technologies. We will review the surface and coating requirements for a number of types of MEMS devices, and demonstrate that ALD films can be applied to high aspect ratio Si surface micromachined (SMM) structures. We will describe three different types of coatings that we have developed: monolayer organosiloxane coatings for adhesion control; hard coatings (W, WN, Al_2O_3) for wear resistance; and solid phase lubricant coatings. All coating processes are conventional cyclic exposure processes, using common precursors, carried out in a viscous flow ALD reactor. Measurement of the mechanical and tribological properties of very thin films is a significant challenge in this work. We will show examples of measurements of adhesion, friction, and mechanical properties using AFM-based force measurements, and specialized MEMS test structures, and results for a number of the materials under investigation.

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