ALD-Enabled NanoElectroMechanical Systems

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Abstract

Atomic Layer Deposition (ALD) and Molecular Layer Deposition (MLD) can be effectively used to deposit custom-designed, multi-material layers with atomic resolution on any micro- or nano-scale device surface. The nano-scale ALD/MLD coating can protect the devices from electrical short, charge accumulation, moisture-induced adhesion, wear, corrosion, creep, fatigue or anodic oxidation during short-term prototyping or long-term product life. The nano- and micro-electro-mechanical systems (N/MEMS) community has been looking for effective antistiction and environmental protection coatings for many years. ALD/MLD films achieve these goals similar to what CVD Si_3N_4 has been for CMOS. As devices further shrink toward nano-scale, ALD-based processes offer a new strategy for depositing conformal and precise films that may have important applications as a novel dielectric, a sacrificial layer for gap control in nanofabrication, or as a structural layer for NEMS. ALD relies on sequential, self-limiting surface reactions to deposit ultra thin films with the following characteristics: ALD film thicknesses can be precisely deposited from a few angstroms to hundreds of nanometers; ALD films can be deposited at low temperatures compatible with CMOS; ALD films are pinhole-free, dense, smooth and highly conformal; ALD films can be deposited on silicon, silicon nitride, metals, polymers, and ceramics; ALD can coat high surface area to volume ratio structures with complex geometries; ALD can deposit dielectric or conductive layers; ALD can deposit hydrophobic or hydrophilic layers covalently bonded to the surface. ALD materials can be selectively etched to create nano-scale gaps and free standing structures. The ALD technologies for N/MEMS, pioneered at the University of Colorado Boulder, represent breakthrough in nano-scale processes that can be used to fabricate custom-designed, multi-material layers with atomic resolution. These methods are proven, mature, and are available to serve the nano-scale systems community.