The Power of Atomic Layer Deposition: Moving Beyond Amorphous Films in a 3D, Nano World

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As electronics continue to shrink in this technological world and approach nanoscale dimensions, requisite devices continually grow in complexity often resulting in 3D architectures, multifunctional composites, and other intricate material stacks. This reduction in size often leads to new interesting phenomena, such as quantum confinement effects in electronics or strong localization of light in nanophotonics, which can potentially enable new technological advancements in many applications. Realization of novel device structures that exploit these effects often requires integration of scalable thin films of various electronic materials onto nanostructures. Atomic layer deposition (ALD) is a relatively new, but powerful, technique to produce a wide variety of thin film materials including oxides, nitrides, and metals for use in numerous applications. The sequential, self-limiting reactions that define ALD enable excellent conformality on high-aspect ratio structures, angstrom level thickness control, and tunable film compositions with large scale uniformity. Additionally, ALD is conducted at low growth temperatures (T_g) which allows for integration of dissimilar materials or soft materials as well as access new regions of phase diagrams in complex systems (i.e. metastable phases, miscibility gaps, etc) not possible with other methods. While the low T_g of ALD traditionally yields amorphous films, many emerging applications would benefit from an ability to incorporate thin, conformal crystalline materials. Therefore, we have started to explore strategies, such as plasma-enhanced ALD processes, that further expand the usefulness of this deposition method to a wider array of applications. Here, we will focus on the advantages and limitations of ALD processes through several case studies to show how this simple deposition technique can revolutionize thin film materials research and devices.

Bio: Virginia Wheeler is a Materials Research Engineer in the Wide Bandgap Materials and Devices group at the Naval Research Laboratory in Washington, DC. She received her BS and PhD in Material Science and Engineering from North Carolina State University in 2005 and 2009, respectively, where her PhD work focused on MOCVD growth of III-Ns, surface cleaning of GaN, and subsequent epitaxial rare earth gate oxide deposition by MBE for GaN MOSFET applications. In 2009, she received an ASEE postdoctoral fellowship at NRL working on reducing defects in SiC epitaxy, as well as epitaxial graphene growth, intercalation, and integration with ALD films. She received the Karles Fellowship at NRL in 2012, becoming a full-time government employee, where she continues to focus on the growth and characterization of complex ALD materials. She has over 10 years of experience in various materials growth and characterization techniques. She has published over 100 peer reviewed articles (H index of 19 and over 1000 citations) and a book chapter. She was a co-author on many feature or highlighted papers including the 36th Japanese Society of Applied Physics Outstanding Paper award and a Berman research publication award, and is a co-inventor on 10 US patents.