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“How Epitaxial Transition Metal Nitrides are Becoming Part of AFRL’s Functional Materials Toolbox”

Abstract

Transition metal nitrides are well-known to exhibit a remarkable range of unique and interesting physical properties including tunable optical and electrical properties, high-hardness and elastic modulus, and robust high-temperature oxidation resistance. Through the use of high-flux low-energy ion bombardment during film growth, one is able to control ion flux and energy independently from the neutral metal flux, facilitating unprecedented control over growth kinetics during high-rate reactive sputter deposition. Incoming ions impinging the growth front drastically increase adatom mobilities through momentum transfer, enabling high crystallinity epitaxial growth at substantially reduced growth temperatures. This scenario enables researchers to extend the single-phase composition field of a variety of immiscible or metastable alloys, as well as epitaxially grow these and other conducting materials on a wide range of single crystal substrates, orientations, and lattice constants. I will begin my talk by describing controllably-unbalanced reactive magnetron sputter deposition, using Hf$_{1-x}$Al$_x$N as a model system to extend the single-phase alloy composition field up to 50% AlN, while demonstrating the effects composition and nanostructure formation have on resultant film properties. I will continue by discussing the current status of our efforts at AFRL, and how we believe with our prior expertise in the area of epitaxial nitrides, as well as our newly renovated and revitalized epitaxy lab, can lead to game-changing advances in two key technical areas: high-quality epitaxial magnetolectric heterostructures (as interlayer electrode materials and templates of oxide overlayer growth) and robust materials alternatives for next-generation resilient plasmonics.

Dr. Brandon Howe is a Materials Engineer at Air Force Research Lab’s Materials and Manufacturing Directorate, Nanoelectronic Materials Branch. He was recruited to AFRL under the SMART (Science Mathematics, and Research for Transformation) Scholar program in 2006. He graduated in 2011 from University of Illinois at Urbana-Champaign, after studying under the guidance of Profs. Ivan Petrov and Joe Greene. During his time there he one several awards in the area of Thin Films and Vacuum Technology. He has spent the last two years renovating, redesigning and constructing a UHV PLD and magnetron sputter epitaxy suite and is now leading the Epitaxial Magnetoelectronics effort for Next-Generation Tunable RF/Microwave components.