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Topotactic anion exchange in epitaxial films: Synthesis advantages and characterization challenges

Statement of the Problem: Despite direct epitaxial deposition/facet-growth of innumerable materials in lab experiments, new lattice-matched buffer (interdiffusion-blocking) layers are desperately needed by the microelectronics industries. There is a need for "substrate agnostic" buffer layer(s) to template epitaxial growth on Si, GaN, Ni and others. Epitaxial templates, particularly ultra-thin oxide layers, have been demonstrated to be excellent epitaxial buffer layers, but the fabrication of epitaxial samples of many materials is frustrated by chemical or lattice mismatch. This talk focuses on a new, better approach to dealing with heterogeneous interfaces. A promising new approach—topotactic anion exchange (TAE) epitaxy. The approach is unique, with two steps—1st epitaxial deposition of a precursor layer; and 2nd a special gas anneal to exchange the anions in the solid for others; to ultimately yield a highly perfect epitaxial film of the product phase. Opportunities abound, as there are only two criteria to meet: (a) The initial film is formulated to match the surface-symmetry type and lattice parameter of the substrate; (b) A thermal, atmosphere-controlled step initiates the topotactic reaction. Ideally, compositions for TAE layers are chosen with end members commensurate—as the reaction front passes through the solid. Cations are sessile with anions are relatively mobile. Anions are exchanged diffusively; but because the resultant material is a different phase altogether, conversion can dramatically alter the magneto-opto-electrical behaviors of the layers. Characterization requires finesse at the atomic level. The typical anions all have roughly the same atomic mass, making a discernment between the two phases complicated. The results of *ex situ* and *in situ* anion exchange experiments towards an epi buffer for Si and GaN will be presented. Further discussion of analyses thus far will be presented.

Biography

Mark A Zurbuchen is an Adjunct Professor in EE and MS&E in the prestigious DRL (Device Research Lab) under the WIN and CEGN Programs and additionally leads the "2D Materials" sub-group and is affiliated with the "Quantum Physics & Devices" sub-group as well. He is a thin film scientist. Electron and X-ray beam methods (XRD, TEM, synchrotron). Expertise in epitaxial films and heteroepitaxial integration. Materials design, thin film deposition, microstructural characterization, crystallography and electrical behavior. 2D materials, oxide electronics, ferroelectrics, dielectrics, multiferroics, superconductors, nano-scale thermal behavior and biomaterials.

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