Next Generation Energy Materials: Challenges in Controlling Complex Oxides for Advanced Applications

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Complex oxide materials are increasingly being considered for next-generation electronic and energy applications which is driving the community to rapidly develop new modalities and deeper understanding of the complex interplay of processing, chemistry, and properties in these materials. Here we will discuss advances in controlling complex oxide materials with a precision that approaches that historically reserved for semiconductor systems. We will highlight work on SrTiO$_3$ and LaAlO$_3$/SrTiO$_3$ systems where challenges in controlling the cation stoichiometry of these materials can have dramatic impact on the structure and properties. The implications of variations cation stoichiometry for the crystal structure, dielectric, thermal, and electronic properties will be reviewed. In particular, we will examine how non-stoichiometry can lead to asymmetric property evolution and how even relatively small variations in cation chemistry can result in large effects – such as changes in interfacial conductance in excess of 7 orders-of-magnitude. Overall we will demonstrate a strong link between the growth process, the stoichiometry of the resulting materials, the desired properties of the system, and the implications for understanding the physics and how to engineer these materials.