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Oxide-Semiconductor Heterostructures: Challenges and Opportunities

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Crystalline oxides form a broad class of materials with a wide range of properties including ferroelectric, ferromagnetic, piezoelectric, pyroelectric, electro-optic and superconducting. Such oxides on semiconductors are becoming important as an enabling technology for the integration of multifunctional oxide based electronics with mature existing semiconductor applications. Integration of such devices with standard Si-based electronics together with the need for a replacement gate dielectric for Si CMOS devices has been the thrust for the development of epitaxial oxides on semiconductors. Research into the growth of epitaxial perovskite oxides on silicon and compound semiconductor has led to the use of unique buffer layers and growth processes through molecular beam epitaxy that has yet to be replicated by any other growth technique. In addition, there has also been a tremendous increase in the research activities into using III-V compound semiconductors as alternative channels materials in future Si-CMOS devices. Although these are suitable candidates due to their high mobilities, they suffer from a lack of a suitable gate dielectric material and integration pathway on silicon. In this presentation, I will first outline the challenges in the deposition of epitaxial oxides on semiconductors and the steps necessary to control the growth kinetics and its effects on the oxide/semiconductor interfacial properties. As an extension of oxide applications, the development of an oxide based multilayer gate dielectric on GaAs that results in an unpinned Fermi level and has the required properties for the realization of GaAs-based MOSFET devices will be discussed.