High K dielectrics play a key role in modern microelectronic circuitry, given their ability to provide reduced leakage currents while providing adequate capacitance in ever smaller nano-dimensional MOSFET devices. Recently, the ability to modulate the magnetic properties of cobalt thin films by electrical bias across thin films of Gd2O3 was demonstrated. The reversible switching was found to be assisted by electro-migration of oxygen ions to and away from the Co/Gd2O3 interface. This novel process called “magneto-ionic control” creates new opportunities for nonvolatile information storage. In this study, the properties of Gd2O3 and related oxides are being examined systematically to establish how their defect and nano structures impact oxygen ion transport and in turn magneto-ionic device properties.