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Interface chemistry between complex oxides and semiconductors: where chemistry and physics meet

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Even though heavily based on semiconductors, microelectronics CMOS technology would not exist without the integration of thin oxide films which enable the exploitation of the semiconductor properties. Indeed, working principle of the metal-oxide-semiconductor field-effect transistor, the main building block of such a technology, is the modulation of charges at the oxide/semiconductor interface. The quality of this interface is of fundamental importance for device performance. For over four decades, SiO_2 was the gate dielectric of choice and device scaling meant improving performance while lowering production costs. However, as scaling is approaching fundamental limits, direct tunneling across the dielectric becomes unacceptable. At this point, the integration of more complex and higher dielectric constant oxides - "high-K dielectrics"- with Si or even more complex semiconductors (Ge, III-V) is the key enabler of performance gain. I will review critical issues related to the oxide/semiconductor interfaces, starting with SiO_2/Si. Then, I will discuss how the level of complexity increases with the introduction of high-K dielectrics and other semiconductors in the stack. Among the issues to be addressed to fabricate high-performance devices, I will discuss the role played by: 1) interfacial chemistry and thermodynamical stability, 2) band alignment and surface band bending, 3) presence of defects at the interface and in the oxide bulk, 4) evolution of the gate stack properties upon post-deposition treatments. The impact of these parameters on electrical performance of devices will be discussed in detail. Finally, epitaxial oxide on Si will be explored as a promising approach for ultimate EOT scaling and the parameters governing the epitaxial growth of complex crystalline oxides on Si will be addressed. I will show that the development performed in this area might enable the integration of epitaxial oxides for monolithic integration, paving the way to technological developments that go beyond the simple Moore's scaling law