

# Atomic jewelry: Exploring epitaxial technologies for silicon's future

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Since a few thousand years, crystalline order has contributed to women and men happiness, made jewelers rich and, more recently, kept semiconductor manufacturers R&D organizations extremely busy. Although oxides do represent a major part of the most interesting gems, oxygen has been kept out of the crystalline lattices in most devices developed for the IT industry. This situation is about to change. At the heart of any computing system today are circuits based on complimentary metal-oxide semiconductor (CMOS) devices. In the coming years, the current silicon-based CMOS materials set will be profoundly renewed. Starting from an unavoidable silicon platform, crystalline oxides, semiconductors and metallic thin films will be stacked to combine their specific properties: high mobility channel, Silicon-On-Insulator structure, high-k dielectric, metal gate, etc. As in jewelry, the challenge for scientists today is to optimize materials performances through a delicate control of their crystalline state: composition, defects, surface structure, etc. Of course, the characteristic length scale at which we need to understand these aspects is not more than a few inter-atomic distances.

Because it is the ground plane of these heterostructures, our effort is today focused on the epitaxial growth of oxides directly on silicon surfaces, our primary goal being to develop high-k dielectrics for field effect transistors. The latest development in the field have been done following five complementary approaches: (1) materials selection guided by bulk thermodynamics; (2) interface thermodynamics; (3) structural matching of the silicon and epitaxial oxide lattices; (4) oxidation kinetic control during all process stages and (5) development of process-specific tools. The aim of this talk is to prove that deposition processes can be developed with an appropriate combination of these five cornerstones. It allowed materials scientists to control the transition from silicon to a crystalline oxide layer, using perovskite- or fluorite-related oxides. We will then present recent advances in materials, tools and growth processes, extracted from our work or from the open literature.

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