Building materials one layer at a time: Technological challenges as scientific opportunities

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Controlling interfaces at the atomic level during thin film growth is one of the most difficult and important aspects of device fabrication in areas as diverse as microelectronics and biotechnology. For semiconductor devices in particular, interface control requires the development of both surface cleaning/chemical functionalization and film deposition methods, together with appropriate surface characterization. In this talk, we describe novel wet chemical procedures to chemically functionalize Si surfaces and the use of atomic layer deposition (ALD) to perform highly conformal growth of high-κ gate dielectrics. In all cases, infrared absorption spectroscopy provides the essential information to identify the surface chemistry involved in all processes (including side reactions) and to provide a basic understanding of the chemical attachment, growth process and interface formation.

To illustrate the issues and methods, we discuss alkylation of Si surfaces and growth of Al_2O_3 and HfO_2 using atomic layer deposition on a variety of functionalized Si surface. Surface alkylation constitutes an interesting model system because alkyl chains with various head groups can be attached either through Si-O-C or Si-C bonds, making it possible to tailor the stability, properties and functionality of these self-assembled monolayers. We also discuss the role of surface functionalization for ALD growth of high-κ dielectrics and the impact on the interfacial layer between the Si and the dielectric.

Yves Chabal received the AB in Physics from Princeton (1974) and PhD in Physics from Cornell (1980). After a potdoc with Jack Rowe at Bell Labs, he joined the Surface Physics department and developed surface infrared spectroscopy methods to probe the structure and dynamics of semiconductor surfaces and interfaces. He remained at Bells Labs (AT&T, Lucent, Agere) as a Distinguished Member of Staff and later a Consulting Member of Staff until 2002 working on surface phase transitions, H_2 inclusion in amorphous Si, H-induced Si film exfoliation and silicon-on-insulator, direct wafer bonding, and a host of issues in front end micro- and opto-electronics. He joined Rugers in 2003 as a Professor in Chemistry and Chemical Biology, Biomedical Engineering, and Physics and Astronomy. He became director of the Laboratory for Surface Modification in 2004. His current interests are centered on surface chemical functionalization of semiconductor and oxide surfaces, atomic layer deposition, organic electronics, biosensors and H_2 storage materials. He has played a key role in forming the newly created Institute for Advanced Materials & Devices, and Nanotechnology at Rutgers and was recently awarded the Rutgers Board of Trustees Award for Excellence in Research.