Advanced chemical deposition and nanostructuration methods will be available in the energy research laboratory building

From Catherine Dubourdieu

Research at IFOX is conducted on new materials for energy-efficient information technologies (e.g. data storage and processing, energy conversion...). Metal oxides exhibit a wide range of electrical, magnetic, optical, mechanical properties, which may even be coupled. This extraordinary wealth of physical properties offers an enormous potential for developing low-power devices as well as new functionalities, addressing societal needs. We particularly focus on strongly correlated electronic systems such as ferroics, with fascinating intricate properties resulting from interactions between spin, charge, orbital and lattice. We aim at reaching with oxides a level comparable with that achieved today with semiconductor heterostructures, be it from material to application standpoints.

In the new energy research laboratory building, advanced chemical deposition and nanostructuration methods will be developed for the synthesis of thin films, multilayers and nanostructures combining oxides and semiconductors. Metal organic chemical vapor deposition, in which the solid film is formed from heterogeneous reactions (chemical reactions of gaseous reactants on a surface) will be used to design functional heterostructures. Using a liquid-injection delivery system for the gas phase formation, a precise control of the thickness (at the monolayer level of 0.4 nm), as well as the composition can be achieved, insuring high quality interfaces.

This method will be combined in a cluster tool with an atomic layer deposition chamber, another gas phase deposition method, which offers complementary capabilities. Both CVD and ALD offer advantages such as a conformal coverage on complex pre-structured substrates and large area deposition suitable for transfer to industry. In addition to gas phase techniques, liquid deposition methods using dip coating will be used to design composition-gradient materials and to prepare nanostructured substrates for further processing.

Advanced characterization techniques of the materials will include spectroscopic ellipsometry, Raman, PL and XPS, the latter being connected to the cluster tool. With such infrastructure, we will address questions such as deciphering the role of oxygen vacancies, cationic stoichiometry and extended defects on the electrical, magnetic and optical properties of oxides and of semiconductor/oxide heterostructures. With control of the deposition methods, we will be able to finely engineer strain, composition and defects to reach e.g. mutual control of electric and magnetic properties or, as another example, modulation of light through a metal to insulator transition or a piezoelectric strain.

Prototype devices will be tested for nanoelectronic and silicon integrated-photonic applications. In addition to fundamental studies that will be conducted in this new energy material building, we also plan to develop strong ties with industry throughout collaborative projects.

In a longer term, we believe that the development of new materials for energy efficient information technology will impact not only computation but also many areas where sensing/communicating is needed (transportation, smart grid, health…) or where metal oxides are used as catalysts, hence opening new research avenues.