Epitaxial growth of insulating oxides on germanium substrates (001) by pulsed laser deposition

Garcia-PrietoA[1,2]*, Sebastiani-Tofano E[1,2], Rubio-Zuazo J[1,2]
*lead presenter: ana.garcia-prieto@esrf.fr
1 BM25-SpLine The Spanish CRG Beamline at the European Synchrotron Radiation Facility, CS40220 38043 Grenoble Cedex 9 France
2 ICMM-CSIC Materials Science Institute of Madrid, Sor Juana Ines de la Cruz Cantoblanco 28049 Madrid España

Semiconductor spintronics utilizing the spin degree of freedom as a new functionality in semiconductor has received considerable interest as one of the possible candidates to solve the physical limit of complementary metal-oxide-semiconductor (CMOS) technologies in the near future [1,2]. Group-IV semiconductors are of particular interest due to the potential compatibility with established silicon technologies, and specially germanium (Ge) has shown favourable characteristics for high frequency operation and permits the design of faster devices with respect to silicon (Si). Furthermore, its low bandgap (0.66 eV) allows the operation at lower voltage, even if the thermal noise must be correctly handled and minimized. These exceptional characteristics are related to its advantageous properties, such as its high carrier mobility (1900 cm^2 /Vs and 3600 cm^2 /Vs for holes and electrons, respectively), with a hole mobility value that is one of the highest of all the commonly used semiconductors [3].

The mayor technological drawback to the use of Ge in microelectronics is the difficulty of passivating its surface, in order to minimize the interface trap density. Deposition of oxide epitaxial thin films may solve this issue besides crystalline oxides have a much wider range of functional properties than semiconductors. In this regard, epitaxial growth of oxides on germanium has been studied by different research groups. Nevertheless, there are very limited studies on pulsed laser deposition (PLD) growth of oxide films on Ge. In the present work the oxide materials of interest span from established binary oxides, for example MgO, to the diverse families of complex oxides, dominated by the ABO_3 perovskite oxide materials such as $SrTiO_3$ (STO), $BaTiO_3$ (BTO) and $LaAlO_3$ (LAO). We report the epitaxial growth of MgO, STO, BTO and LAO on Ge (001) substrates using pulsed laser deposition. An exhaustive characterization of these heterostructures has been performed using different synchrotron-based techniques-X-Ray Photoelectron Spectroscopy (XPS), Grazing Incidence X-Ray Diffraction (GIXRD) and X-Ray Reflectivity (XRR)- in order to determine some important aspects as crystallinity, interface properties, morphology, composition, degree of oxygen vacancies and thickness of the films. The results obtained have important implications for the integration of functional oxide materials with established semiconductor based technologies.

References

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