Integrated Perovskites oxides on Silicon: from Optical to Quantum applications

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With the slowing down of Moore's law, related to conventional scaling of integrated circuits, alternative technologies will require research effort for pushing the limits of new generations of electronic or photonic devices. Perovskite oxides with the ABO_3 chemical formula have a very wide range of interesting intrinsic properties such as metal-insulator transition, ferroelectricity, pyroelectricity, piezoelectricity, ferromagnetic and superconductivity. For the integration of such oxides, it is of great interest to combine their properties with traditional electronic, memory and optical devices on the same silicon-based platform.

In the context of high-speed chip-to-chip optical interconnects, compact high-resolution beam steering and video-rate RGB hologram generation require the integration of fast and efficient optical modulators on top of silicon CMOS devices. For these applications the integration of high quality electro-optical materials A defect-free material-stack deposition on silicon wafers is hence required. Among the possible materials options, barium titanate ($BaTiO_3$) is one promising candidate due to its large intrinsic Pockels coefficients that can be obtained. In a first part of the talk, we will review the different options to integrate $BaTiO_3$ on Silicon substrate though different templates to control the polarization direction and discuss the influence on the physical, electrical and optical properties.

Then in the second section we will discuss the use of perovskites oxide in the field of topological based qubits which is one of the promising methods for realizing fault-tolerant computations. It is recognized that superconductor/topological insulator heterostructure interfaces may be a perfect host for the exotic "Majorana" particles. These have relevant topological protection nature as required for processing information. Therefore, the physics at the superconductor/topological insulator heterostructure interface need to be studied further, starting at the material level. In this work, a candidate material Barium Bismuthate (BBO) is studied utilizing the Oxide Molecular Beam Epitaxy (MBE) process. The perovskite structure provides opportunity for easily tailored functionality through substitutional doping. Incorporation of potassium into the lattice of BBO results in a superconducting phase with Curie temperature as high as ~ 30K. In addition, BBO is according to DFT based studies, predicted to form topological surface states when doped with Fluorine. In our work, we integrate BBO perovskite on Si(001) substrate, using an epitaxially grown strontium titanate (STO) single-crystalline buffer layer and discuss the structural and chemical properties of the heterostructure will be established by utilizing physical characterization techniques such as AFM, and TEM in later stages. This will go hand in hand with the understanding of the ARPES studies and related surface reconstruction of BBO observed by RHEED as a criterion for the high-quality films.

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