Title:	CARRIER DYNAMICS OF THE TWO- DIMENSIONAL ELECTRON GAS FORMED IN THE OXIDE HETEROSTRUCTURE
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Abstract:	"The number of transistors on a microchip doubled about every year": Gordon Moore predicted about transistors in 1965- called “Moore’s Law”. However, semiconductor chips will very soon be reaching their limit and will be unable to hold any additional transistors, implying future innovations will require a replacement material. Transition metal oxides (TMOs) are one of the potential candidates to replace conventional semiconductor devices. Due to electron correlation, the TMO displays an array of functionalities. The electron correlation in TMO constrains the number of electrons at a given lattice site and induces local entanglement of charge, spin, and orbital degree of freedom. This entanglement gives rise to various emerging phenomena like metal-insulator transition, ferroelectricity, spin-orbit coupling, superconductivity, etc. By making a heterostructure of such TMOs we can manipulate these functionalities along with creating new ones. The finding of highly mobile two-dimensional electron gas (2DEG) at the interface of two wide gap insulators LaAlO 3 - SrTiO 3 (LAO/STO) marked a significant advancement in the field of TMO interfaces. The origin of conductivity at such oxide interfaces is still a topic of debate. The polar catastrophe, oxygen vacancy, cation intermixing, and cation off-stoichiometry are among the many models put out to explain conductivity. In this thesis, we mainly tried to investigate the nature and the shape of the conducting channel at the interface of two insulating oxides namely LaVO 3 and SrTiO 3 along with the dynamics of these carriers. In the later part, we have presented an entirely new type of quantum oscillation in the resistivity arising from the non-trivial spin texture in the momentum space as a consequence of the strong spin-orbit coupling present in the conduction channel at the interface of LaVO 3 and KTaO 3 . The research on perovskite oxide thin films, interfaces, and super-lattices demands the need for the atomically flat surface of the substrate to realize high-quality epitaxial thin films and atomically well-defined interfaces. In this thesis, we report the time exposure and pH dependence of Buffered NH 4 F-HF (BHF) etching as well as the concentration dependence of ACID (HCl+HNO3 in 3:1 ratio) etching of the STO substrate. This study was performed for different orientations [(001), (110), and (111)] of STO single crystals. To study the depth profile of the conducting channel at the interface of two perovskite oxides, we have grown LaVO 3 (LVO) thin film on TiO 2 terminated STO substrate in (001) orientation. We vihave proposed a scheme, that combines the photoluminescence and time-correlated single-photon counting with transport measurements of resistivity to unravel the carrier distribution, the shape of the quantum well, energy subbands, and Fermi surfaces of the conducting interface of LVO and STO. The measurements further show that the conductivity at the interface of LVO/STO is arising because of a polar catastrophe. Electronic parameters, such as the carrier density, and the mobility, estimated from the electrical measurements, are in remarkably good agreement with those extracted from the spectroscopy with theoretical modelling providing a bridge between the two sets of data analysis. A similar analysis has been done for the conducting interface of LVO and KTaO 3 (KTO). For both interfaces, the full-width half maxima of the depth of the conducting channel at the interface are estimated to be around 10 nm by using spectroscopy techniques of photoluminescence and time-correlated single-photon counting: suggesting a quasi-2-dimensional nature of the conducting electrons. To unravel the shape of the Fermi surface and its evolution with an applied magnetic field of an interface having strong spin-orbit coupling we have done temperature-dependent magnetotransport measurements at the LVO/KTO interface. In a quantum material when a charge carrier undergoes adiabatic evolution on a closed path, it captures signatures of non-trivial features present either in real or momentum space. We have observed Shubnikov-de Haas oscillation at the conducting interface of LVO/KTO in both perpendicular and in-plane configurations (B□E and B//E). This indicates the 3D nature of the Fermi surface at the interface. The oscillations produce a non-linear Landau fan diagram. This oscillation carries the signature of zero-field susceptibility arising from the non-trivial spin texture in the momentum space. In addition, we have observed a surprising dependence on quantum mobility when the electric field (E) and magnetic field (B) are applied in the plane of the interface. Quantum mobility depends on the relative orientation of E and B. The quantum mobility in the B//E configuration was four times larger compared to the mobility in the B□E configuration. These observations may open up new directions in the field of quantum oscillation observed in systems with non-trivial electronic and magnetic textures in the momentum space.
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