Quantum and field effects of oxide heterostructures

The interface between two materials can show radically different properties than either of the bulk parent materials. This is not the least true for oxide interfaces, which can display multiple physical functionalities thus making them ideal for the realisation of so-called multi-plexed devices. In these multi-plexed devices, several inputs are translated into several outputs through the multiple physical functionalities. A highly prominent example of such an oxide interface is the one between LaAlO$_3$ and SrTiO$_3$. Although both LaAlO$_3$ and SrTiO$_3$ in the bulk are electrically insulating and non-magnetic, their interface nonetheless shows attractive properties such as metallic conductivity, superconductivity and ferromagnetism.

This thesis will provide an extensive review of the literature concerning the interface metal found in LaAlO$_3$/SrTiO$_3$ as well as in other SrTiO$_3$-based heterostructures. Through this review, several open questions will be revealed, which constitute the scientific aims of this thesis. These open questions will subsequently be addressed through the work presented in the articles that were published during the course of this Ph.D. study. In the review of these published articles, the important aspects of sample preparation will initially be covered. Here, the growth of amorphous-LaAlO$_3$ on SrTiO$_3$ will be addressed in a modified pulsed laser deposition setup. This is followed by an investigation of two high-electron mobility interfaces in SrTiO$_3$-based heterostructures. Specifically, these interfaces are the ones between CaZrO$_3$/SrTiO$_3$ and amorphous-LaAlO$_3$/(La, Sr)MnO$_3$/SrTiO$_3$. The sample preparation section is ended by outlining a patterning strategy for the high-electron mobility interface at amorphous-LaAlO$_3$/(La, Sr)MnO$_3$/SrTiO$_3$. Subsequently, the effects of electrostatic gating are studied in two different SrTiO$_3$-based heterostructures. Here, it is shown that the interface between amorphous-LaAlO$_3$ and SrTiO$_3$ is superconducting with a larger critical transition temperature than that in LaAlO$_3$/SrTiO$_3$. For γ-Al$_2$O$_3$/SrTiO$_3$ it is shown that non-volatile bipolar resistance switching is possible with a gradual tuning of the interface conductivity. Finally, the so-called quantum Hall effect is demonstrated at the interface between amorphous-LaAlO$_3$/(La, Sr)MnO$_3$/SrTiO$_3$. The manifestation of the quantum Hall effect reveals that the interface conductivity is comprised of several subbands conducting in parallel.

An outlook will be provided at the end of the thesis judging the research as well as development of oxide electronics and multi-plexed devices.