ABSTRACT

The interest in improving MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) devices is driven by the need of more balanced and faster CMOS circuits. In addition to the current relentless device miniaturization, which brought the CMOS technology into the nanometer regime and offered outstanding improvements, the emerging SiGe technology has provided further enhancement in several applications and there is a great potentiality for more gains.

In this thesis, we investigate and address some of the engineering possibilities to boost the performance of the conventional Si MOSFET by exploiting the favorable electrical properties of the $Si_{1-x}Ge_x$ material and its compatibility with standard CMOS technology. We have used this material in three parts of the MOSFET device, as a quantum well to engineer the channel of the p-type MOSFET, as a polycrystalline thin film to engineer the gate of the transistor, and as a virtual substrate for tensile-strained Si MOSFETs as well as for integrating III-V semiconductor devices with Si-based devices.

Regarding channel engineering, we have proposed and analyzed different structures of $Si/Si_{1-x}Ge_x/Si$ double quantum well (DQW) p-MOSFETs to extend the engineering possibilities of these devices. Threshold voltage, charge control, and short-channel effects have been studied theoretically for some of the structures. For gate engineering, MOS capacitors with *in-situ* boron-doped polycrystalline thin films of $Si_{1-x}Ge_x$ and ultra-thin (2.0 – 3.0 nm) gate oxides have been fabricated and electrically characterized in different ways. Finally, substrate engineering has been addressed through some material characterization of different $Si_{1-x}Ge_x$ (x=0-1) relaxed buffers layers grown on Si (001) substrates. We have used the state-of-the-art x-ray diffractometer (Philips Extended Platform X-pert Material Research Diffractometer), as the main tool to assess the relaxation and defect propagation in these materials.

KEYWORDS:

MOSFET, semiconductor devices, strained $Si_{1-x}Ge_x$, channel engineering, short-channel effects, gate engineering, poly-$Si_{1-x}Ge_x$, high-κ dielectrics, ultra-thin oxide, gate depletion, boron penetration, Nitridation, electrical stress, substrate engineering, relaxed buffer layers.