In this thesis, by means of STM we study all the stages that occur during stepwise annealing of the SiC(0001) substrate, and lead to the formation of buffer layer and to the single layer graphene. It is demonstrated that the buffer layer growth is initiated by merging of graphene nanobubbles arising due to Si depletion and that this process competes with formation of a largely neglected phase, the 5ã3x5ã3, for which we develop an atomistic model.

We studied the single-layer graphene using a simultaneous nc-AFM/STM. By this technique we are able to separate the topographic and electronic contributions from the overall landscape. The analysis reveal that graphene roughness evaluated from the atomic force maps is very low, in accord with theoretical simulations.

Furthermore, we report a method for preparation of high-quality B- and N-doped graphene on SiC(0001). We combine experimental (nc-AFM, STM, XPS, NEXAFS) and theoretical (total energy DFT simulated STM) studies to analyze the structural, chemical and electronic properties of the single-atom substitutional dopants in graphene. We show that chemical identification of B and N substitutional dopants can be achieved only with the STM due to the quantum interference effect, arising from the specific electronic structure of N dopant sites. Chemical reactivity of the single B and N dopants is analyzed using force-distance spectroscopy by means of nc-AFM.