Introduction

Nanotechnology is one of the key technologies of the 21st century. In this context, the challenge for surface science is to create regular structures on the scale of a few nanometers or less. This is not only important in view of device miniaturization, but it also enables to change physical properties of matter by confining electrons to dimensions comparable to their wavelength. The fabrication of quantum dots and quantum wires with atomic dimensions is one of the ultimate goals of nanotechnology.

To realize these nanoscopic structures, different methods can be used, like e.g. the lateral manipulation of atoms or molecules with a Low-Temperature Scanning Tunneling Microscope (LT-STM) or self-organized ordering processes which take place while growing a material of choice on a suitable substrate. The first method is capable of creating small arrangements (less than one thousand units) of atoms or molecules with atomic precision [ES90, SE91, CLEH96, BR02]. The second method is able to modify large areas (bigger than one μm) into well ordered structures whose units have dimensions from several nanometers up to one hundred nanometers. The fabrication of nanomagnet arrays on a semiconductor substrate [TBL98, TBOK99] and the design of supramolecular nanostructures [WVB$^+$01] are some recent example for this method.

To understand the physics on the atomic scale, it is useful and more convenient to have a small number of atoms and molecules, but for technological implementation it is necessary to create a regular structure of quantum dots or wires with the size of at least several micrometers. Another aspect for technological use is the electronic decoupling of the template onto which the structure is built and the nanostructure itself. This is for instance possible with insulating layers as a spacer between the nanostructure and the conducting template, or with metallic and/or magnetic arrays which are separated by insulating arrays. For this purpose, a new material system with an interesting growth characteristics was found and recently studied in our group: The interfacial stability between ultrathin ionic insulator layers, especially alkali halides, and vicinal metal surfaces is significantly enhanced due to strong electrostatic interactions between the layer and the substrate [RFMR01]. The vicinal surfaces under consideration in this work are vicinal to the (111) plane, and the template materials are the noble metals copper and silver.

The goal of this work is a systematic investigation of the growth behavior of different ionic insulators on regularly stepped and kinked metal surfaces (i) to create highly ordered ultrathin insulator layers as the basis for the decoupling of metallic or molecular nanostructures, and (ii) to fabricate regular surface patterns on the nanometer scale by means of adsorbate-induced faceting and selective growth.

This growth study was carried out with two complimentary surface science techniques, namely Scanning Tunneling Microscopy (STM) and High-Resolution Low-Energy Electron Diffraction (SPA-LEED). With STM it is possible to investigate the growth mechanism at the atomic scale, whereas SPA-LEED gives information on the surface-crystallographic properties and on the growth mode at a mesoscopic length scale.

In the first chapter I will explain the basics of the experimental methods STM and SPA-LEED. In the next chapter, theoretical aspects concerning growth modes and the Smoluchowski effect – which plays an important role for the growth systems studied here – will be elucidated. The third chapter gives a description of the relevant substrate surfaces with their respective orientations and the alkali halide deposits.

In the first chapter concerning the experimental results three combinations of alkali halide deposits and stepped metal substrates will be studied, which are characterized by layer growth. Here, the separation of the intrinsic substrate surface steps is comparable with one and two Cl-Cl ion distances in the alkali halide film. This geometrical matching is decisive for the stability of the interface between the ionic film and the metallic substrate. The stabilization effect is mediated by the charge modulation of the substrate which results from the Smoluchowski smoothing effect of the electron charge at a corrugated metal surface. The investigated systems are **NaCl on Cu(311)**, **KCl on Cu(311)**, and **NaCl on Cu(221)**.

The next chapter discusses the results for a system, where stripe-like surface patterns consisting of alkali halide-covered facets and bare metal facets are created. Here, the original intrinsic step separation of the substrate does not fit with the Cl-Cl distance in the alkali halide film. As a consequence, a faceting process occurs to achieve a geometrical matching between the ionic film and the metallic facets formed. This faceting process is found for the system **KCl on Ag(211)**.

As demonstrated in the third chapter about experimental results, a pyramidal facet structure can be fabricated by depositing the alkali halide **NaCl** on the kinked **Cu(532)** surface. In this case, a regular structure consisting of three-sided nanopyramids is formed where two facet types are covered by the chemically inert NaCl deposit, whereas the third facet type is still bare copper. The resulting modulation in surface-chemical behavior was verified by the exclusive adsorption of carbon monoxide on the bare metal facets. Furthermore, the subsurface growth of silver on the NaCl-covered facets was investigated by using the prestructured surface.