# Abstract

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Title: *Growth of Galliumnitrid-based devices on Silicon(001) substrates by metalorganic vapor phase epitaxy*

The main topic of this thesis is to investigate GaN-based layer systems grown by metalorganic vapor phase epitaxy on Si(001) substrates. A successful implementation of such compound semiconductor structures on silicon substrates having this special surface orientation might pave the way for an easier integration of GaN-based electronics as well as optoelectronics with the main silicon semiconductor market. The proof of a possible fabrication of GaN-based devices on Si(001) has to be aspired.

Additionally, a curvature and reflectivity prototype should be optimized to allow for standard in-situ measurements as a matter of routine during the growth process. By means of a combination of the simultaneous determination of curvature, reflectivity, and surface temperature, the influence of the wafer bowing on the growth temperature could be proved. A temperature shift up to 45 K is measured for a complete device structure on a 2-inch silicon substrate.

By using a 40 nm thin LT-AlN-seed layer (680°C), the GaN crystallites on Si(001) substrates are almost oriented with their GaN($10\bar{1}2$)-planes parallel to the Si(001)-plane. A four-fold azimuthal symmetry occurs for these layers, with the GaN[$10\bar{1}1$]-direction is aligned parallel to one of the four equivalent Si$\langle 110 \rangle$-directions, respectively. This result can be explained by the formation of an approximate coincidence site lattice of the Si(001) surface and the epitaxial grown AlN/GaN-layers. However, a mono-crystalline and fully coalesced GaN-layer with this crystallographic orientation could not yet been obtained.

If a deposition temperature of more than 1100°C is used for the AlN-seed layer, solely the GaN[0001]-growth direction of crystallites occurs in the main GaN layer on Si(001) substrates. These c-axis oriented GaN columns feature two opposite azimuthal alignments that are rotated by 90° with respect to each other and with GaN[$11\bar{2}0$]||Si[110] and GaN[$10\bar{1}0$]||Si[110], respectively. This behavior can be explained by the epitaxial relation of the Si(001) surface, which exhibits two types of surface reconstruction with perpendicularly aligned dimer-rows. By using 4° off-oriented substrates towards the Si[110]-direction, one certain azimuthal texture component can be selected. The critical value of the miscut angle corresponds to theoretical calculations predicting the occurrence of atomic double steps on the Si(001) surface. The achieved crystallographic quality of the GaN layers on Si(001) is characterized by having a tilt of FWHM = 0,27° and a twist of FWHM = 0,8° of the crystallites, determined by x-ray diffraction.

A completely crack-free, up to 2.5 µm thick, and mono-crystalline GaN-template can be realized on Si(001), integrating 4 or 5 LT-AlN-interlayers in the GaN buffer structure. Based on this structure, the first successful implementation of an (InGaN/GaN)-LED on Si(001) is achieved. Furthermore, the possible fabrication of GaN-based FET-structures is demonstrated with a fully processed and operating device on Si(001). Moreover, the developed approach for the MOVPE growth of GaN on Si(001) is successfully adapted to large area 150 mm Si(001) substrates, proving the possible scalability to industrial circuits.