Semipolar GaN was successfully used for the realization of the green laser diode and is also a promising material for LEDs, due to the changed symmetry and binding configuration on the surface. However, growth on large area low cost substrates like sapphire typically leads to the formation of a high density of extended defects, especially stacking faults and threading dislocations. These defects can be also formed by strain relaxation of heterostructures grown on GaN substrates with low defect density. This focus session aims to explain the mechanism for formation, methods of identification and growth methods for reduction of such defects as well as optoelectronic devices grown defect reduced GaN. (Organizers: Ulrich Schwarz, Fraunhofer IAF Freiburg, Tim Wernicke, TU Berlin)

Morning session: Origin and identification and reduction of defects in semipolar GaN / Semipolar heterostructures and devices

Time: Thursday 9:30–13:15
Location: H13

Topical Talk
HL 72.1 Thu 9:30 H13
Defect reduction methods for GaN heteroepitaxial films grown along semipolar orientations — PHILIPPE VENNÉGUES — Centre de Recherche sur l’Hétéroépitaxie et ses Applications, rue Bernard Gregory 06560 VALBONNE FRANCE

Heteroepitaxially-grown semipolar GaN films contain a high density of extended structural defects, mainly basal stacking faults, which prohibit their use for the fabrication of efficient optoelectronic devices. After a short description of the microstructure and of the origin of the crystalline defects, this presentation will focus on a few methods which have been developed to improve the crystalline quality. Thanks to transmission electron microscopy, the behavior of the defects and the mechanisms resulting in the reduction of their density are investigated. Two main efficient defect reduction techniques will be presented: epitaxial lateral overgrowth and growth on inclined facets. Problems encountered in the implementation of such growth techniques and the perspective towards the developments of high quality heteroepitaxial GaN templates will be presented.

Topical Talk
HL 72.2 Thu 10:00 H13
Identification of defects in semipolar GaN and (Al,Ga,In)N by cathodoluminescence spectroscopy — KLAUS THONKE1, INGO TSCHER1, MATTHIAS HOCKER1, MANUEL FREV1, and FERDINAND SCHOLZ2 — 1Institute of Quantum Matter / Semiconductor Physics Group, Ulm University, 89081 Ulm, Germany — 2Institute of Optoelectronics, Ulm University, 89081 Ulm, Germany

The growth of nitride semiconductor layers on semipolar planes typically introduces specific crystalline defects in relatively high concentrations. These defects create local strain, deteriorate the electrical properties, and act as nonradiative recombination centers. Mainly basal plane stacking faults of I1 and I2 type are introduced, terminated eventually by prismatic stacking defects or dislocations. To correlate specific types of defects with the commonly observed multiple mostly broad sub-bandgap luminescence emission bands, optical methods with very high spatial resolution in the range of few 10 nm are required. Here, either transmission electron microscope (TEM) or low-energy scanning electron microscope (SEM) based cathodoluminescence (CL) setups yield valuable information. By spatial correlation of CL maps with high-resolution TEM micrographs recorded on exactly the same sample cross section, direct correlation can be obtained. These defects also affect the incorporation of dopant atoms like Mg, or of In and Al atoms when quantum well structures are grown. We discuss the most prominent cases, and look also into the characteristic shift of the emission bands with changes in the (Al,Ga,In) composition.

Topical Talk
HL 72.3 Thu 10:30 H13
Stacking fault elimination in heteroepitaxial semipolar GaN — ARMIN DAGGARD — Institut für Experimentelle Physik, Otto-von Guericke-Universität Magdeburg, Universitätplatz 2, 39106 Magdeburg

Heteroepitaxially grown semi- and non-polar GaN layers typically suffer from high densities of stacking faults or require elaborate growth techniques as epitaxial lateral overgrowth. Recently a simple method to eliminate stacking faults of the dominant I1 type by the insertion of AlN interlayers in GaN has been demonstrated for GaN layers inclined towards the m-plane. For semipolar GaN layers with different inclination angles X-ray diffraction and TEM studies of GaN / AlN layer stacks show in detail the annihilation of stacking faults, but also the generation of short segments of I2 type stacking faults.
the c-plane. It was revealed that the reduction rate of the dislocation density could be controlled by the proper selection of the growth plane. We obtained a freestanding GaN of 2 inch diameter. Thick GaN growth led to the self-separation of the GaN layer from the PSS during cooling process. The separation plane formed at the interface between GaN and PSS, which is different from the case of a conventional c-plane GaN/sapphire. The separation ability of the GaN layer from the PSS depended on the selective growth area of the sapphire sidewall. A freestanding semi-polar GaN substrates were then obtained.

**HL 72.7 Thu 12:30 H13**

Optical properties of MBE grown cubic AlGaN/GaN double quantum well structures — **Tobias Wucker**, Christian Mietze, Dirk Reuter, and Donat J. As — Department of Physics, University of Paderborn, Warburger Str. 100, 33098 Paderborn, Germany

The spatial separation of electrons and holes in Al<sub>x</sub>Ga<sub>1-x</sub>N/GaN quantum well structures due to polarization effects can be avoided by growing cubic quantum well samples in the (001) direction. Therefore, the optical recombination efficiency in quantum well structures resulting from strain relaxation during the semipolar InGaN/GaN QWs is reduced in a large leakage current. It is reduced from ~5mA to ~0.3mA at a reverse bias of 5V by including a 50nm p-GaN layer before the p-AlGaN electron blocking layer (EBL). Mg doping induces lateral growth in the ~50nm p-GaN layer leading to a plateau at the tip. Under a suitable epitaxial condition, AlGaN EBL grows more vertically recovering the sharp tip with an AlGaN triangle to block the leakage current there. The growth of the undoped GaN between the QWs and p-(Al)GaN was controlled to avoid any plateau or current crowding at the tip.

**HL 72.8 Thu 12:45 H13**

InGaN/GaN based semipolar light emitting diodes — **Junjun Wang**<sup>1</sup>, Matthias Hocker<sup>2</sup>, Robert Leute<sup>1</sup>, and Ferdinand Scholz<sup>1</sup> — 1Institute of Optoelectronics, Ulm University, Germany — 2Institute of Quantum Matter, Ulm University, Germany

Non- and semi-polar III-nitrides are promising to fabricate highly efficient light-emitting devices due to a reduced piezoelectric field leading to an increased overlap of electron and hole wavefunctions. In our research, three-dimensional stripes are realized by selective area growth on patterned masks providing semipolar surfaces. We focused on improving the electrical and optical performance of the stripe light emitting diodes with the semi-polar InGaN/GaN quantum wells (QWs). Defects are generated at the tip via strain relaxation during the semi-polar InGaN/GaN QWs resulting in a large leakage current. It is reduced from ~5mA to ~0.3mA at a reverse bias of 5V by including a 50nm p-GaN layer before the p-AlGaN electron blocking layer (EBL). Mg doping induces lateral growth in the ~50nm p-GaN layer leading to a plateau at the tip. Under a suitable epitaxial condition, AlGaN EBL grows more vertically recovering the sharp tip with an AlGaN triangle to block the leakage current there. The growth of the undoped GaN between the QWs and p-(Al)GaN was controlled to avoid any plateau or current crowding at the tip.