HL 47: GaN on Si

Time: Wednesday 10:15–11:30 Location: POT 51

HL 47.1 Wed 10:15 POT 51

Kathodolumineszenzuntersuchungen an GaN auf Si(211)- und Si(311)-Substraten — •Mathias Müller, Anja Dempewolf, Frank Bertram, Thomas Hempel, Jürgen Christen, Roghaiyeh Ravash, Armin Dadgar und Alois Krost — Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Deutschland

Mittels spektral aufgelöster Kathodolumineszenzmikroskopie (KL) wurden die Lumineszenzeigenschaften von GaN-Schichten auf Si(211) und Si(311)-Substraten bei Heliumtemperatur untersucht. Nicht-c-Achsen orientiertes GaN Wachstum ermöglicht eine Reduktion der Polarisationsfelder und somit des quantum confined Stark effect (QCSE), welcher die Effizienz von optoelektronischen Bauelementen herabsetzt. Hierzu wurden systematisch geeignete hoch indizierte Si(h11)-Substrate benutzt, auf denen mittels MOVPE jeweils eine AlN-Keimschicht sowie eine AlGaN-Pufferschicht gewachsen wurde, gefolgt von zwei dicken GaN-Schichten, welche durch eine AlN-Zwischenschicht unterbrochen sind. Ortsintegrale Spektren zeigen bei tiefen Temperaturen drei dominante Lumineszenzkanäle: das gebundene Exziton (D^0,X), Donator-Akzeptor-Paarbande DAP sowie Basalflächenstapelfehlerlumineszenz BSF. Auf Si(211) ist die Stapelfehlerlumineszenz im Vergleich zum GaN auf Si(311) stark reduziert. An der Bruchkante zeigt sich mit zunehmender Schichtdicke die Entwicklung der dominanten Lumineszenzkanäle der Proben, welche auf Si(311) eine starke Inhomogenität im Vergleich zu Si(211) aufweist.

HL 47.2 Wed 10:30 POT 51

Semi-polar GaN heteroepitaxy an high index Si-surfaces — •Roghaiyeh Ravash, Jürgen Bläsing, Thomas Hempel, Armin Dadgar, Jürgen Christen, and Alois Krost — Otto-von-Guericke-University Magdeburg, FNW/IEP/AHE, Postfach 4120, 39016 Magdeburg, Germany

Due to the lack of GaN homosubstrates, the growth of GaN-based devices is usually performed on heterosubstrates as sapphire or SiC. These substrates are either insulating or expensive, and both unavailable in large diameters. Meanwhile, silicon can meet the requirements for a low price and thermally well conducting substrate and also enabling the integration of optoelectronic devices with Si-based electronics. Up to now, the good matching of hexagonal GaN with the threefold symmetry of Si(111) greatly promotes the c-axis orientated growth of GaN on this surface plane. A large spontaneous and piezoelectric polarization oriented along the c-axis exists in such hexagonal structure leading to low efficiencies for thick quantum wells. The attention to the growth of non-polar or semi-polar GaN based epitaxial structures has been increased recently because of reducing the effect of the polarization fields in these growth directions. Therefore we studied semi-polar GaN epilayers grown by metalorganic vapor phase epitaxy on silicon substrates with different orientations from Si(211) to Si(711). We observed that AlN seeding layer growth time play a significant role in obtaining the different GaN texture.

HL 47.3 Wed 10:45 POT 51

Spatially resolved cathodoluminescence spectroscopy of InGaN/GaN heterostructures on m-plane GaN grown on patterned Si (112) substrates — •Christopher Karbaum[1], Frank Bertram[1], Sebastian Metzner[1], Jürgen Christen[1], Xianfeng Ni[2], Natalia Izyumskaya[2], Vitaliy Avrutin[2], Ümit Özgür[2], and Hadis Morkoç[2] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Depart. of Electrical and Computer Engineering, VCU, Richmond, USA

The optical properties of GaN/InGaN heterostructures grown by MOVPE on pre-patterned Si substrate have been studied using cathodoluminescence (CL) at low temperatures (T=5.4 K). A stripe mask pattern was produced on the Si (112) substrate using photolithography and ICP-RIE. Anisotropic wet etching resulted in (-1-11) Si sidewalls and (112) Si terraces connected by (111) Si facets. After the growth of an AlN layer the (111) and (112) Si facets were masked with SiO_2. The lateral and vertical epitaxial growth of GaN was initiated at the (-1-11) Si sidewalls resulting in a partially coalesced m-plane surface. Finally, an InGaN layer capped with p-GaN was deposited. The GaN (D^0,X) emission observed from the +c-wing is red-shifted possibly due to tensile strain and the incorporation of impurities. Homogeneous and intense CL from InGaN is emitted from nearly the entire m-plane surface at about 3.2 eV with a FWHM of 98 meV. Just above the -c-wing the CL intensity from InGaN is reduced due to the presence of stacking faults and defects. The influence of BSFs on lifetimes of (D^0,X) and InGaN emissions will be discussed.

HL 47.4 Wed 11:00 POT 51

Monitoring the influence of interlayer thickness and Si doping on the stress behaviour of GaN grown on Si(111) — •S. Fritze[1], J. Bläsing[1], P. Drechsel[2], A. Dadgar[1], and A. Krost[1] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Universitätsplatz 2, 39106 Magdeburg — [2]OSRAM Opto Semiconductors, Leibnizstraße 4, 93055 Regensburg

GaN growth on Si substrates is a cost-effective alternative to replace conventional substrates like sapphire and SiC. Especially the large diameter availability of Si substrates up to 300 mm can increase chip yield and reduce production costs. To accomplish thick, crack free GaN layers of high crystalline quality an exact control of tensile thermal stress between GaN and Si and the reduction of high dislocation densities are essential. By inserting thin AlN interlayers during growth compressive stress is induced in the subsequent GaN layer and compensates part of the tensile stress. Here the influence of interlayer thickness and Si doping on wafer bow, crystal quality and vertical strain profile of MOVPE grown GaN structures on Si(111) has been studied. In symmetric and grazing incidence high resolution X-ray diffraction measurements we observe higher compressive stress in the GaN toplayer with increasing interlayer thickness. Additional X-ray transmission scattering measurements also show the stress state of the underlying GaN layers. Optical bow measurements demonstrate an increasing convex curvature with increasing interlayer thickness. With a Si doping level between $1 \cdot 10^{18} cm^{-3}$ and $4 \cdot 10^{18} cm^{-3}$ a wafer bow as low as 2.9 μm can be achieved using an optimized interlayer thickness.

HL 47.5 Wed 11:15 POT 51

Investigations of pn-junctions based on AlGaN / AlN structures for LEDs on Si(111) — •Antje Rohrbeck, Hartmut Witte, Phannee Saengkaew, Thomas Fey, Armin Dadgar, Jürgen Christen, and Alois Krost — nstitute of Experimental Physics, Otto-von-Guericke- University Magdeburg, Magdeburg, Germany

AlGaN/AlN - ultraviolet LEDs grown on Si(111) substrates are of high interest for many applications and have the advantages to easily be integrated within the silicon electronic. However, the large misfit between the AlGaN layers and the Si substrate introduces many defects in the layers. The most important part of the AlGaN/AlN-LED structure is the p- AlGaN / n-AlGaN junction involving the AlGaN/GaN multi-quantum well. We have investigated these pn-junctions within the LED structure grown by MOVPE in detail and n-type AlGaN layers as well as p-type AlGaN/p-type GaN multilayer which were grown separately. All AlGaN layers have an Al content of 10 % and the Si(111) substrates were highly n-type doped. For these investigations Hall-effect measurements, CV- and IV-characteristics, impedance spectroscopy, surface scanning potential and scanning capacitance microscopy were used. The p-type doping of the AlGaN/GaN multilayer structure shows a Mg-accumulation at the AlGaN/GaN interfaces. Furthermore, there are negative differential capacitances and currents within the CV- and IV-characteristics whose origins will be discussed considering the impact of surface defects or the AlGaN/GaN interfaces. Additionally, electroluminescence spectra of the whole LED structure give further indications that defects are located within or close to the pn-junctions.