HL 93: III-V semiconductors (other than nitrides)

Time: Thursday 15:45–17:45 Location: EW 203

HL 93.1 Thu 15:45 EW 203

Bond stretching force constants in (In,Ga)P — •Stefanie Eckner[1], Martin Gnauck[1], Andreas Johannes[1], Tobias Steinbach[1], Helena Kämmer[1], Mark C. Ridgway[2], and Claudia S. Schnohr[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Department of Electronic Materials Engineering, Research School of Physics and Engineering, The Australian National University, Canberra ACT 0200, Australia

In order to exploit the full potential of mixed III-V-semiconductors for electronic and opto-electronic applications, a deeper understanding of their atomic scale structure and its relation to relevant properties such as the bandgap is necessary. The local atomic arrangement, which is crucial especially for strained thin films and nanostructures, strongly depends on the bond stretching force constants of the atomic pairs present in the material. In this study, (In,Ga)P grown by metal organic chemical vapour deposition was investigated using extended X-ray absorption fine structure spectroscopy. Measurements at the In- and Ga-K-edge were performed at ten different temperatures to determine the bond length variation as a function of temperature. As a result, bond stretching force constants of Ga-P- and In-P-bonds were determined in (In,Ga)P for varying indium content. These bond stretching force constants can be used in analyses of Raman spectra and in theoretical models of strained III-V thin films and nanostructures.

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Capture cross sections from first-principles total energy calculations for oxygen in GaP as benchmark case — •Ying Cui, Christoph Freysoldt, and Jörg Neugebauer — Max-Planck-Institut für Eisenforschung, Max-Planck-Str. 1, 40627 Düsseldorf

Non-radiative recombination is of particular technological importance for optoelectronic devices. The mechanism is however far from well understood. The Shockley-Read-Hall model is usually applied to explain thermally activated recombination at deep defects. Capture cross sections are key parameters in this model. We present a theoretical approach to compute the capture cross sections by using density functional theory with hybrid functional (HSE). In our approach the transition state in the capture process is located by using defect level occupation as a natural reaction coordinate. To benchmark theory against experiment, we apply our method to substitutional oxygen in GaP for which accurate DLTS data is available. We find a good agreement for capture cross sections as well as optical transition energies. Our method to determine capture cross sections is universal and can be applied to materials beyond GaP.

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Effect of localized boron states on the conduction band transport in n-type (B,Ga)P — •Lars Ostheim[1], Steve Petznick[1], Sven Liebich[2], Kerstin Volz[2], Wolfgang Stolz[2], and Peter J. Klar[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universtität Gießen, Germany — [2]Department of Physics and Material Sciences Center, Phillips-Universität Marburg, Germany

(B,Ga)P:Te and GaP:Te samples are grown by MOVPE on a 300 nm GaP buffer layer under a Te-partial pressure of Te/Ga=5*10-4. While the incorporation of Te results in n-type doping of the samples, the incorporation of B into GaP leads to the formation of localized electronic states resonant with the conduction band. In order to investigate the influence of these localized states on the transport properties, magnetotransport measurements were performed in a temperature range from 1.5 K to 300 K and as a function of applied hydrostatic pressure up to 17 kbar using a non-magnetic pressure cell. The results obtained indicate that a boron-related density of localized states exists in the vicinity of the conduction band edge of the alloy, which act as electron traps as well as efficient scattering centers. By applying hydrostatic pressure the energetic positions of conduction band edge at the X-point and the localized boron states are shifted apart reducing the impact of boron on the electronic transport parameters of the alloy.

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HR-XRD analysis on GaP rotational twin domains on Si(111) substrates — •Christian Koppka, Agnieszka Paszuk, Matthias Steidl, Katja Tonisch, and Thomas Hannappel — Technische Universität Ilmenau, FG Photovoltaik, 98693 Ilmenau, Deutschland

The combination of todays silicon technology with tunable III-V semiconductors is of great interest for future high-efficiency optoelectronic devices. Due to the small lattice mismatch GaP/Si is a suitable quasi-substrate to link non-polar silicon substrates and polar III/V layers. For the growth of nanowire-based semiconductor structures {111} oriented substrates are commonly used. Here, rotational twin domains are a major defect, which cannot easily be suppressed by the substrate surface structure. Low defect densities, however, are required for further III/V integration. A reliable quantification of the rotational domain ratio is essential in order to adjust the MOCVD process for growth of single crystal GaP epilayers on Si(111). Here, we use high-resolution x-ray diffraction analysis for quantification and investigate the influence of various parameters, such as growth temperature, III:V ratio and surface terminations, on the twin domain ratio. We find that growth temperature and Si surface termination prior nucleation highly impact the GaP(111) epilayer growth.

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Growth of (Ga,In)(As,Bi) layers on GaAs, InP and GaSb substrates by Molecular Beam Epitaxy — •Wolfgang Bennarndt, Gerhard Böhm, and Markus-Christian Amann — Walter Schottky Institut, Garching

The incorporation of Bi in III/V semiconductor alloys results in a strong band gap reduction and therefore has attracted considerable interest for long-wavelength optoelectronic applications. Theoretical calculations even revealed a negative band gap for the binary materials GaBi and InBi, which means that layers with metallic character could be epitaxially grown and can in principal act as a waveguide for lasers emitting in the THz wavelength range. In this work we present incorporation studies of Bi into (Ga,In)As grown on GaAs, InP and GaSb by molecular beam epitaxy. Smooth layers with Bi-contents as high as 20% were successfully grown and characterized by XRD and PL-measurements. The influence of growth parameters on Bi-incorporation such as In content, strain, temperature and the flux ratio of the Group V elements will be discussed.

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Luminescence properties of green (InGaAl)P-GaP LED grown on different orientated GaAs substrates — •Sarah Schlichting[1], Nikolay N. Ledentsov[2], Vitaly A. Shukin[2], Jari Lyytikäinen[3], Oleg Okhotnikov[4], Yurri M. Shernyakov[4], Alexey S. Payusov[4], Nikita Gordeev[4], Michail V. Maximov[4], Felix Nippert[1], and Axel Hoffmann[1] — [1]TU Berlin, Germany — [2]VIS GmbH, Germany — [3]Tampere University of Technology, Finland — [4]Russian Academy of Science, Russia

$(Al_{0.5}Ga_{0.5})_{0.5}In_{0.5}P - (Al_{0.8}Ga_{0.2})_{0.5}In_{0.5}P$ LED with GaP barriers were investigated by means of EL and PL techniques. The structures were grown by MBE side-by-side on differently-oriented GaAs substrates: (100), (211) and (311). Through studies of the luminescence properties of the structures it was found that at room temperature at current densities of $\sim 500 A/cm^2$ and below the EL intensity is similar for all substrates. A shift towards shorter wavelengths is observed for the structures grown on high-index GaAs substrates. For higher current densities ($>1\ kA/cm^2$) the (211) and (311)-orientated substrates show a much higher EL intensity compared to the GaAs(100) substrate. A gradually saturation of integrated intensity of the (311)-grown structure occurs at current densities above 4 kA/cm^2, such saturation is not visible for the (211)-grown structure even for current densities up to 14 kA/cm^2. This effect is attributed to self-organized superlattice formation[1] and the GaP insertion-induced engineering of the conduction band structure on high-index surfaces[2]. [1] N. Cherkashin et al., to be published [2] Appl. Phys. Lett. 105, 181902 (2014)

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Impact of growth temperature on structural and optical properties of GaAs quantum structures grown on GaP (100) substrate — •S. Dadgostar[1], J. Schmidtbauer[2], T. Boeck[2], M. Rodríguez[3], A. Torres[3], J. Jiménez[3], O. Martínez[3], W. T. Masselink[1], and F. Hatami[1] — [1]Department of Physics, Humboldt-Universität zu Berlin, Newton-Str. 15, D-12489 Berlin, Germany

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We describe impact of growth temperature on structural and optical properties of self-assembled GaAs/GaP quantum structures grown using GS-MBE. Formation of quantum structures is driven by the 3.6% lattice mismatch between GaAs and GaP. 2.7-ML of GaAs was deposited at temperatures between 450 and 530C on GaP(100) and capped by 50 nm GaP. Then, GaAs layer was grown again at the same conditions for AFM measurements. Morphology of deposited GaAs changes with increasing growth temperature from quantum dots to dashes. The dots have a density of e11 cm-2, diameter and height of 19, and 1.1 nm, while the dashes have a density of 7.0 e10 cm-2, length, width, and height of 58, 18, and 2.1 nm. Cathodeluminescence measurements indicate that the emission spectra of all samples contain two peaks between 1.99 and 1.84 eV, which we attribute to the recombination in wetting layer and in dot/dash structures. The peak position changes for samples due to different geometry of quantum structures.

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High-power 1060-mn photonic band crystal lasers with narrow beam divergence and low astigmatism — •Md. Jarez Miah[1], Thorsten Kettler[1,2], Kristijan Posilovic[1,2], Vladimir P. Kalosha[1], Danilo Skoczowsky[2], Dieter Bimberg[1], Johannes Pohl[3], and Markus Weyers[3] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]PBC Lasers GmbH, Hardenbergstr. 36, 10623 Berlin, Germany — [3]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

High-power edge-emitting lasers are efficient and indispensable light sources for a wide range of scientific and commercial applications such as pump sources for solid-state lasers, frequency conversion, material processing, and medicine. High-power edge-emitting photonic band crystal lasers emitting in the commercially important 1060 nm wavelength range are investigated. Highest to date single transverse mode output power of 1.9 W is obtained from ridge waveguide lasers with 9 μm ridge width and 2.64 mm cavity length. Extended vertical waveguides result in a very narrow vertical far-field divergence below 14° (full width at half maximum) across full single mode operating regime. The corresponding lateral beam divergence is 9°. The lasers provide excellent beam quality with beam quality factor M^2 below 1.9 up to 1.9 W output power. A brightness as high as 72 $MWcm^{-2}sr^{-1}$ is achieved. The measured astigmatism varies only from 5 μm to 14 μm over the entire operating range, which means almost astigmatism-free.