HL 15 III-V semiconductors II

Time: Tuesday 11:00–13:15 Room: POT 51

HL 15.1 Tue 11:00 POT 51

Incorporation of N at GaAs and InAs Surfaces — •Hazem Abu-Farsakh[1,2], Alexey Dick [1], and Jörg Neugebauer[1,2] — [1]Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Straße 1, 40237 Düsseldorf, Germany — [2]Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Recently, GaAsN and GaInNAs alloys with low N content have attracted a remarkable interest for making laser diodes operating in the 1.3-1.6 μm region which is interesting for optical fiber communications. A specific problem for practical applications is the extremely low bulk equilibrium solubility of N in GaAs at typical growth temperatures. An interesting option to increase the concentration of N is the use of surface kinetics by (i) identifying GaAs and InAs surfaces with a large N solubility, and (ii) identifying conditions which prevent/reduce surface aggregation of N. We have therefore calculated the surface phase diagrams of N at GaAs and InAs surfaces using density functional theory in the GGA approximation. Based on these results, we have estimated the maximum N equilibrium concentration at various surface orientations ((110), (001)) for given temperature and chemical potentials, and compared them with recent experimental results. In addition, STM simulation of selected structures have been made and compared with available experimental images.

HL 15.2 Tue 11:15 POT 51

Combining quasiparticle energy calculations with exact-exchange density-functional theory: the bandgap of InN — •Patrick Rinke[1], Abdallah Qteish[2], Jörg Neugebauer[1,3], and Matthias Scheffler[1] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Department of Physics, Yarmouk University, Irbid - Jordan — [3]MPI für Eisenforschung, Düsseldorf

Amongst the group-III-nitrides InN assumes a special place because the magnitude of its bandgap is still controversial. If one believes density-functional theory (DFT) calculations in the local-density approximation (LDA) or LDA based quasiparticle energy calculations in the G_0W_0 approximation InN should be metallic. Recent experiments [1,2], however, place the band gap between 0.7 and 1.0 eV, significantly lower than previously thought. For GaN and II-VI compounds we have shown that DFT in the exact-exchange (EXX) approach gives an improved description of the d-electron hybridization compared to the LDA. In combination with G_0W_0 calculations we achieve very good agreement with experiment for the band gaps of these compounds [3]. For InN the EXX calculations yield a semiconductor with a band gap of 0.8 eV in the zincblend phase [4] and 1.0 eV for wurtzite. In contrast to GaN the G_0W_0 corrections are negative and lower the band gap to 0.5 eV and 0.7 eV, respectively - in very good agreement with the new experimental data.

[1] J. Wu *et al.*, Appl. Phys. Lett. **80**, 3967 (2002)
[2] T. Takachi *et al.*, Appl. Phys. Lett. **81**, 1246 (2002)
[3] P. Rinke *et al.*, New J. Phys. **7**, 126 (2005)
[4] A. Qteish *et al.*, Phys. Rev. B **72**, 155317 (2005)

HL 15.3 Tue 11:30 POT 51

RARE-EARTH DOPANT IMPLANTATION INTO GAN AND ZNO — •R. Nédélec[1], R. Vianden[1], and ISOLDE Collaboration[2] — [1]HISKP, Nußallee 14-16, D-53115 Bonn, Germany — [2]CERN, CH-1211 Genève, Switzerland

In the past, wide band-gap semiconductors for optical, high-power and high-temperature application have been intensively investigated. The observation of room temperature luminescence for various Rare Earth dopants in GaN has stimulated further interest in the incorporation these impurities in appropriate host lattices. A convenient way of introducing impurities into semiconductors is ion implantation. In order to study the implantation induced damage and its recovery by annealing we used the perturbed angular correlation technique (PAC). Our samples were implanted at the ISOLDE facility at CERN and then treated in a rapid thermal annealing furnace.

We have studied the annealing behaviour and the temperature dependence of the electric field gradient (EFG) using the Rare Earth PAC probe 172-Lu. The temperature dependence was investigated for temperatures below and above room temperature. The results will be discussed and compared to results obtained with the PAC probe 181-Hf.

HL 15.4 Tue 11:45 POT 51

Evolution of N Defect States and Optical Transitions in Ordered and Disordered $GaP_{1-x}N_x$ Alloys — •Eoin OReilly, Clive Harris, and Andrew Lindsay — Tyndall National Institute, Lee Maltings, Cork, Ireland

We show using an sp^3s^* tight-binding model that the band anti-crossing (BAC) model describes well the evolution of the lowest N-related conduction states in ordered $GaP_{1-x}N_x$ alloys, including the evolution of the Γ character with increasing x. We obtain a good description of the lowest conduction states in disordered GaPN structures by explicitly treating the interaction between the GaP host Γ conduction band minimum and defect states associated with a random distribution of N atoms. We find a very similar value for the total Γ character mixed into the N levels in the ordered and disordered cases but a wider distribution of states with Γ character in the disordered case. We show that in the very dilute limit ($< 0.1\%$) inhomogeneous broadening of the N state energies prevents the band-gap reduction predicted by the BAC model, while the band-gap reduction at higher composition is determined by the increasing formation of N cluster states. Overall key features of the band structure can be well described using a modified BAC model which explicitly includes the broad distribution of N levels in disordered GaPN alloys.

HL 15.5 Tue 12:00 POT 51

Magneto-excitons in GaInNAs / GaAs quantum well structures — •M. Hetterich, A. Grau, W. Löffler, and H. Kalt — Institut für Angewandte Physik and Center for Functional Nanostructures (CFN), Universität Karlsruhe, D-76131 Karlsruhe, Germany

In recent years, GaInNAs-based quantum wells have attracted considerable interest due to their possible utilization in near-infrared optoelectronic devices. From a band structure point of view, Ga(In)NAs is quite unusual, because the interaction of N-related states with the conduction band leads to a strong non-parabolicity of the latter, which can be described within the so-called band anti-crossing (BAC) model.

In this contribution we investigate the influence of a magnetic field (up to $B = 14$ T) on the excitonic states in GaInNAs / GaAs quantum wells with various compositions and well widths. Magneto-photoluminescence has been used to measure the diamagnetic shift of the exciton ground state. In addition, absorption measurements have been carried out to investigate the field dependence of excited magneto-exciton states. The theoretical approach we use to fit our data is based on the BAC model for the conduction band and a 4-band Luttinger Hamiltonian for the valence bands. The coupling between the valence and conduction bands is taken into account perturbatively using a semi-empirical approach. The in-plane part of the exciton wavefunction is expanded in a Gaussian basis set and the resulting generalized eigenvalue problem is solved numerically on a parallel computer. From a comparison between theory and experiment we can extract data for the exciton binding energy as well as the conduction band dispersion in GaInNAs / GaAs quantum wells.

HL 15.6 Tue 12:15 POT 51

The influence of defects on the recomination dynamics in InGaN quantum wells grown on sapphire and GaN substrates — •T. Stempel Pereira[1], M. Dworzak[1], A Hoffmann[1], G. Franssen[2], T. Suski[2], S. Grzanka[2], R. Czernecki[2], M. Leszczynski[2], and I. Grzegory[2] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Institut of High Pressure Physics 'Unipress', Polish Academy of Sciences, Sokołowska 29/37, 01-142 Warsaw, Poland

We studied the influence of localization and defects on the recombination in single InGaN quantum wells on sapphire- and GaN-substrates, respectively. Time-integrated and time-resolved PL measurements were performed. Temperature dependent radiative and non-radiative lifetimes and the depth of the localization potentials could be determined. It appears on both substrates, that due to the high density of defects, localization is a crucial condition for radiative recombination. When carriers leave their localization potential due to thermal activation, they recombine non-radiatively at defects.

Intensity dependent time-resolved PL measurements cast new light on the significance of defects. At 10 K we observe an increasing influence of non-radiative recombination via defects with growing excitation intensity due to the filling of the localized states. However, at room temperature

the decay decelerates with increasing excitation intensity. This decreasing significance of the defects can be explained with a saturation of defect states.

HL 15.7 Tue 12:30 POT 51

Electronic Transport Studies of Single InAs Nanowhiskers — •Quoc Thai Do — University Duisburg-Essen, Solid-State Electronics Dept., Lotharstr. 55 / ZHO, D-47057 Duisburg

InAs nanowhiskers were grown in the vapour-liquid-solid growth mode using low-pressure metal-organic vapor phase epitaxy. Electrical characterization of single nanowhiskers was done by conductive scanning force microscopy directly of the wafer. Contacting the whiskers scratched from the wafer and deposited on an insulator-covered conductive substrate using e-beam lithography allowed to realize the field-effect transistor consisting of single nanowhisker only. We observed the n-type conductivity of the nominally undoped whisker material. The nanowhisker-based transistors showed with well-defined linear regimes and pronounced switching behaviour at room temperature. Using the data of I-Vg measurements on the nanowhiskers with different n-doping concentration, the electron density and the electron mobility within investigated nanowhiskers could be estimated. Mechanism of electron transport through the nanowhisker in dependence on the nanowhisker dimensions are discussed. Our work demonstrate the feasibility of nanoelectronic and nanosensor applications for III-V nanowhiskers.

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HL 15.8 Tue 12:45 POT 51

Segregation of Antimony in InP in MOVPE — •Martin Leyer[1], S. Weeke[1], M. Pristovsek[1], and Prof. Dr. W. Richter[2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Università di Roma "Tor Vergata", Dipartimento di Fisica, Via della Ricerca Scientifica 1, I-00133 Roma, Italy

The optimization of $GaAs_{0.5}Sb_{0.5}$/InP interfaces in semiconductor devices is a critical point since antimony segregation is a well known phenomenon. We investigated this segregation in MOVPE in-situ with Reflectance Anisotropy Spectroscopy. InP layers were exposed to different amounts of TMSb and afterwards overgrown with InP. An unexpected second antimony containing layer developed in a distance between 50 – 200nm. This double layer structure was confirmed by SIMS and X-Ray diffraction measurements. We systematically studied the position of the second Sb layer as a function of temperature, precursor partial pressure and amount of antimony on the semiconductor surface. The existence of a second Sb layer could be explained by a quasi liquid surface phase above InSb melting point of 527°C.

HL 15.9 Tue 13:00 POT 51

Spectroscopic investigations of GaAsSb/GaAs based structures for 1.3 μm VCSELs — •G. Blume[1], T.J.C. Hosea[1], S.J. Sweeney[1], P.J. Klar[2], G. Weiser[2], A. Thränhardt[2], S.W. Koch[2], S.R. Johnson[3], and Y.-H. Zhang[3] — [1]ATI, University of Surrey, Guildford, UK — [2]Dept. Physics and WZMW, Philipps-University Marburg, Germany — [3]MBE research group, Arizona State University, Tempe, USA

Metro-area communication (fibre to the home) requires lasers emitting at 1.3 μm due to the zero dispersion and low loss of silica fibres at this wavelength. Vertical-cavity surface-emitting lasers (VCSELs) grown on GaAs offer the best performance and temperature stability at low cost. Amongst the different approaches to realise a GaAs based VCSEL, the GaAsSb/GaAs material system shows great potential and VCSEL operation at 1.3 μm has recently been demonstrated. The band alignment (type I or II) of the GaAsSb/GaAs interface is still a matter of discussion and of significant importance for the further development of devices. We employ electro-absorption spectroscopy on GaAsSb/GaAs structures. The spectra obtained are compared with those calculated for different offset situations using a sophisticated microscopic model accounting for Coulomb effects. The comparison indicates that our GaAsSb/GaAs quantum wells have an almost flat alignment of the conduction band.