HL 1: III-V semiconductors I

Time: Monday 10:15–12:45 Location: BEY 81

HL 1.1 Mon 10:15 BEY 81

Epitaxy of self-assembled quantum dots on AlGaInAs lattice matched to InP for long wavelength emission using molecular beam epitaxy — •Mario Bareiss, Roland Enzmann, Marion Kraus, Daniela Baierl, Gerhard Böhm, Ralf Meyer, Jonathan Finley, and Markus-Christian Amann — Walter Schottky Institut, Technische Universität München, D-85748 Garching, Germany

We present the formation of InAs quantum dots with a low surface density on AlGaInAs lattice matched to InP(001) substrates using molecular beam epitaxy. Usually the deposition of self assembled quantum structures on InP results in the form of elongated quantum dashes. Only within a narrow regime of growth parameters the formation of circular shaped quantum dots is favoured as our study shows. Aiming for a low quantum dot density requires a high migration length of the Indium atoms. Therefore we used low growth rates down to 0.003 monolayers per second. To tailor furthermore the emission wavelength of the quantum dots to 1.5 micrometers the Aluminium to Gallium ratio in the barrier material was adjusted. Achieving very low quantum dot densities of approximatly one per square micrometer makes these quantum dots promising candidates for single photon generation in the telecommunication regime.

HL 1.2 Mon 10:30 BEY 81

Minority carrier lifetime of MOCVD grown InGaAsP and InGaAs absorbers for low bandgap tandem solar cells — •Nadine Szabo, Erol Sagol, Marinus Kunst, Klaus Schwarzburg, and Thomas Hannappel — Helmholtz Zentrum Berlin Glienicker Str. 100 14109 Germany

MOVPE-grown III-V semiconductor compounds are implemented in today's state-of-the-art third generation multi-junction solar cells. Conventional triple-junction solar cells grown on germanium, having Ge, Ga(In)As and GaInP as subcells, reached a record efficiency of 40.7%. This could be improved further if the Ge subcell is replaced by a double junction solar cell. The best bandgap combination was found out to be 0.7 eV and 1 eV. These bandgaps could easily be realized with materials such as InGaAs and InGaAsP which are lattice-matched to InP. The lifetime of minority charge carriers in these absorber materials is essential for the performance of solar cells. Time resolved photoluminescence (TRPL) and transient microwave conductivity (TRMC) measurements were used to evaluate the lifetime of the absorber materials grown in a double hetero-structure. To get meaningful results, a precise knowledge of the excess carrier density created by the pump pulse is necessary. With our single photon counting TRPL setup a carrier density regime between 10E9 cm-3 and 10E16 cm-3 in the VIS (λ<1000 nm) and 10E13 cm-3 and 10E16 cm-3 in the NIR (λ<1700 nm) can be assessed. We will present the lifetime of minority carriers in p-InGaAs and p-InGaAsP layers for different thicknesses as a function of excitation density.

HL 1.3 Mon 10:45 BEY 81

Investigation of the Bir-Aronov-Pikus spin relaxation mechanism in (110) GaAs quantum wells — •Stefan Oertel[1], Jens Hübner[1], Dieter Schuh[2], Werner Wegscheider[2], and Michael Oestreich[1] — [1]Universität Hannover, Institut für Festkörperphysik, Abteilung Nanostrukturen, Appelstr. 2, D-30167 Hannover — [2]Universität Regensburg, Institut für Experimentelle und Angewandte Physik, D-93040 Regensburg

We determine the spin relaxation time τ_s in (110)-oriented GaAs quantum wells by time- and polarization resolved photoluminescence spectroscopy. The major spin relaxation channel in III-V compounds, the D'yakonov-Perel' mechansim, is suppressed in growth direction of (110)-oriented heterostructures and the most prominent remaining spin relaxation mechanism in these quantum wells is the Bir-Aronov-Pikus (BAP) mechanism via interaction with unpolarized holes. By variation of the excitation density, we are able to directly control the electron hole density and thus determine the efficiency of the BAP spin relaxation mechanism. The electron hole interaction also depends strongly on temperature and hence the temperature dependence of τ_s^{BAP} directly yields a measure for the electron hole interaction strength.

HL 1.4 Mon 11:00 BEY 81

Intrinsic Spin Lifetimes in GaAs (110) Quantum Wells — •Georg Müller[1], Michael Römer[1], Dieter Schuh[2], Werner Wegscheider[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institut für Festkörperphysik, Gottfried Wilhelm Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

GaAs (110) quantum wells attract great attention due to the long spin lifetime for electron spins along the growth axis and are, therefore, of interest for future spin based optoelectronic devices.

At low temperatures, optical injection of a finite spin polarization yields strongly enhanced spin dephasing due to the Bir Aronov Pikus mechanism that arises from the exchange interaction between electrons and holes. Thus, the intrinsic spin lifetime in GaAs (110) quantum wells has been unknown. In this work, the non-demolition technique of spin noise spectroscopy, which only relies on statistical spin flucutations, is applied to GaAs (110) quantum wells in order to measure the intrinsic spin lifetimes. Furthermore, the Brownian motion of the electrons modifies the linewidth of the measured spin noise spectra due to time of flight broadening. This effect uniquely allows to study electronic motion at thermal equilibrium.

[1] G. Müller, M. Römer, D. Schuh, W. Wegscheider, J. Hübner, and M. Oestreich, Phys. Rev. Lett. **101**, 206601 (2008).

HL 1.5 Mon 11:15 BEY 81

Temperature and Concentration Dependent Spin Noise Measurements in GaAs — •Michael Römer, Georg Müller, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Gottfried Wilhelm Leibniz University Hannover, Appelstr. 2, 30167 Hannover, Germany

Spin noise spectroscopy is an elegant method to access electron properties of direct gap semiconductors in thermal equilibrium while avoiding carrier heating and excitation of electron hole pairs [1]. This technique is used to examine the electron spin lifetime and noise power in GaAs in dependence of electron doping concentration, sample temperature, and the probe laser wavelength. The measured power of the spin noise signal is used to extract information about the electron statistics and the position of the electrons in the conduction band. The measured data can be well explained using a model based on the change of the index of refraction due to the ever present thermal fluctuations of the electron spin.

[1] M. Römer, J. Hübner and M. Oestreich "Spin Noise Spectroscopy in Semiconductors", Rev. Sci. Instrum. **78**, 103903 (2007).

15 min. break

HL 1.6 Mon 11:45 BEY 81

Analysis of segregation profiles in InGaAs quantum wells via TEM and STEM — •Thorsten Mehrtens[1], Marco Schowalter[1], Knut Müller[1], Andreas Rosenauer[1], Dongzhi Hu[2], and Daniel M. Schaadt[2] — [1]Institut für Festkörperphysik, Universität Bremen, Otto-Hahn-Allee 1, 28359 Bremen — [2]Institut für Angewandte Physik/DFG-Center für funktionelle Nanostrukturen, Universität Karlsruhe (TH), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe

Knowledge of the composition distribution in epitaxially grown semiconductor nanostructures is essential to understand the growth process, where segregation plays an important role. We report on InGaAs heterostructures grown by molecular beam epitaxy (MBE). Before the growth of the InGaAs layer the specimen was heated up briefly to remove Ga from a possible Ga floating layer. The temperature has been varied for different wells to study the influence on segregation. Composition profiles were measured by scanning transmission electron microscopy (STEM) with a high-angle annular dark field (HAADF) detector. This setup exploits the Z-dependence of the thermal diffuse high angle scattering. Simulations were performed with the frozen lattice approach in dependence on sample thickness and concentration. Comparing the measurement with the simulations leads to the concentration profile. Segregation coefficients have been calculated and compared to coefficients obtained with the composition evaluation by lattice fringe analysis (CELFA), which uses the chemical sensitive (002) and the undiffracted (000) beam. Both methods do not reveal a significant influence of the specimen heating on the segregation coefficient.

HL 1.7 Mon 12:00 BEY 81

Properties of of GaAs/GaMnAs core-shell nanowires — •Elisabeth Reiger[1], Andreas Rudolph[1], Marcello Soda[1], Matthias Kiessling[1], Benedikt Bauer[1], Dieter Schuh[1], Tomasz Wojtowicz[2], and Werner Wegscheider[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Institute of Physics, PAS, Al. Lotników 32/46, 02-668 Warszawa, Poland

Combining GaMnAs growth with nanowires would open a whole new field of spintronics application. For 2D GaMnAs/GaAs systems efficient spin injection into GaAs has been experimentally achieved. We investigate the possibilities to combine GaMnAs growth with the typical growth of nanowires. As GaMnAs has to be grown at low temperatures, it is not compatible to the typical axial growth conditions for nanowires. However, this does not apply for core-shell nanowires. Here, in a first step, GaAs core nanowires are grown using the gold catalyst technique on GaAs(111)B substrates. In a second growth step the GaMnAs shell is deposited on the side facets of the core nanowire using typical GaMnAs growth conditions as used for 2D film growth. We characterize the core-shell nanowires with scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The core nanowires show a zinc blend crystal structure with very few stacking faults. The GaMnAs shell - depending on the growth conditions - is uniformly deposited around the core or shows a very rough, 3D surface. Employing SQUID measurements we determine the Curie-Temperature and study the magnetic anisotropy of the nanowires.

HL 1.8 Mon 12:15 BEY 81

III/V surface channel devices: substrate preparation, interface passivation and growth — •Mirja Richter[1], Chiara Marchiori[1], David J. Webb[1], Christian Gerl[1], Marilyne Sousa[1], Christophe Rossel[1], Caroline Andersson[1], Roland Germann[1], Heinz Siegwart[1], Edward Kiewra[2], Yanning Sun[2], Joel De Souza[2], Devendra Sadana[2], Thanasis Dimoulas[3], and Jean Fompeyrine[1] — [1]IBM Zurich Research Laboratory, Rueschlikon, Switzerland — [2]IBM Watson Research Center, Yorktown Heights, NY, USA — [3]National Center for Scientific Research Demokritos, Athens, Greece

III/V-based metal-oxide-semiconductor field effect transistors (MOSFET) are considered as promising candidates for replacing Si-based devices at and beyond the 22 nm CMOS technology node. For their fabrication, it is essential to develop an effective surface passivation. Indeed, the presence of defects at the III/V-oxide interface introduces energy states in the gap which can pin the Fermi level. In addition, to profit from their intrinsic higher charge carrier mobility, high quality III/V channel deposition as well as surface preparation procedures are indispensable.

We will discuss MBE grown gate stacks with HfO2 dielectric and Si passivation layers. Structural characterization is accomplished by RHEED and in-situ X-ray photoelectron spectroscopy. Electrical properties of the stacks are studied by measurements performed on capacitors. By this means a minimum Si passivation layer thickness is determined. Data on long channel GaAs nFETs will also be presented.

HL 1.9 Mon 12:30 BEY 81

Electrostatic force microscopy measurement of carbon nanotube field-effect transistors — •Imad Ibrahim, Nitesh Ranjan, Juliane Posseckardt, Michael Mertig, and Gianaurelio Cuniberti — Institute for Materials Science and Max Bergmann Center of Biomaterials, Technische Universität Dresden, 01062 Dresden, Germany

Multi-tube field-effect transistors (FETs) are assembled between two metallic electrodes using dielectrophoresis, in which a solution of dispersed single-walled carbon nanotubes (SWCNTs) is put between the electrodes, and an AC voltage with an amplitude of 5-8 V and a frequency of 300 kHz is applied [1,2]. After depositing the SWCNTs between the electrodes, the solution is blotted with a filter paper and the sample is dried with air. Room temperature I-V measurements are performed for such multi-tube devices which are found to have transistor-like behaviour in most cases. Further on, the devices are characterized with Atomic force microscopy (AFM) and electrostatic force microscopy (EFM). By applying a voltage to the AFM tip in lift mode [3], we are able to detect changes of the potential along the deposited SWCNT interconnects, and thus, to identify local defects in the transistor channels.

[1] S. Taeger, M. Mertig, Int. J. Mat. Res. 98, 742 (2007). [2] N. Ranjan, M. Mertig, phys. stat. sol. (b) 245, 2311 (2008). [3] T. P. Gotszalk, P. Grabiec, I. W. Rangelow, Materials Science 21, 333 (2003).