HL 6: Quantum dots and wires: preparation and characterization I

Time: Monday 11:00–13:00 Location: H15

HL 6.1 Mon 11:00 H15

Morphology and properties of silicon nanowires grown by thermal evaporation — •Wilma Dewald[1], Daniel Stichtenoth[1], Sven Müller[1], Tore Niermann[2], Sebastian Geburt[1], and Carsten Ronning[1] — [1]II. Institute of Physics, University of Göttingen, Germany — [2]IV. Institute of Physics, University of Göttingen, Germany

Silicon nanowires of different morphology were grown by thermal evaporation. SiO was placed into the centre of a horizontal tube furnace, which was heated up to 1200°C. The vapour was transported to colder regions by a regulated Argon/Hydrogen gas flow, where it could condense onto Si substrates coated with a thin Au layer. Here, Au acts as a catalyst in the so called vapour-liquid-solid (VLS) growth process. In general, the obtained nanowires show a Si-SiO core-shell structure. Different morphologies occurred due to changed parameters including pressure, temperature, gas flow etc. The correlation between these parameters and the observed morphologies (SEM/TEM) has been studied. Long and straight nanowires grown under optimised parameters were dispersed on a second substrate and contacted by a FIB-system or e-beam lithography. First results on the electrical properties will be presented.

HL 6.2 Mon 11:15 H15

Templated Selforganization of SiGe Quantumdots — •Christian Dais, Harun Solak, Hans Sigg, Elisabeth Müller, and Detlev Grützmacher — Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, Villigen-PSI, Switzerland

Templated self-organization has been used to prepare samples with regimented arrays of Ge quantum dots. For prepatterning of Si (001) substrates we used extreme ultra-violet interference lithography (EUV-IL) which was performed at the Swiss Light Source (SLS) at the PSI. The EUV-IL technique is based on multiple beam interference to form an interference pattern which is projected onto PMMA resist. EUV-IL allows the definition of patterns of various symmetries with a periodicity smaller than 30 nm over areas as large as 2x2 mm. After the pattern had been transferred into the Si (100) substrate by reactive ion etching, molecular beam epitaxy was employed to grow Si/Ge quantum dot layers on the prepatterned substrates. By choosing appropriate growth conditions, dense packed 2D dot arrays, quantum dot molecule arrays, as well as 3D quantum dot crystals have been realized. AFM surface scans as well as cross-sectional TEM micrographs exhibit a remarkably narrow size distribution of the dots. This is confirmed by X-ray diffraction experiments at symmetric and asymmetric diffraction peaks. Moreover, photoluminescence measurements have been performed giving insights into the bandstructure of the 2-d and 3-d quantum dot crystals. Our results on the fabrication and properties of 2- and 3-dimensional Ge quantum dot crystals may open new routes towards the realization of nanoelectronic and spintronic devices.

HL 6.3 Mon 11:30 H15

Transferring achievements of quantum dot test structures to laser devices — •Tim David Germann, André Strittmatter, Thorsten Kettler, Kristijan Posilovic, Udo W. Pohl, and Dieter Bimberg — Institute of Solid State Physics, Sekr. PN 5-2, Hardenbergstr. 36, Technical University of Berlin, D-10623 Berlin, Germany

Fabrication of quantum dot (QD) based lasers for 1.3 μm emission and beyond requires a better understanding of epitaxial processes of the active QD region. The lasing wavelength of QD layers grown by MOCVD is typically blue shifted with respect to the ground state photoluminescence of test structures. We identified mechanisms driving the blue shift and developed techniques to reduce or even suppress this shift. A crucial parameter is the V/III ratio during the process of overgrowing the QDs with GaAs. High V/III ratios promote the blue shift due to a preferential formation of group-III vacancies at the surface. This increases group-III diffusion, leading to smaller QDs with less In content. In contrast, by using low V/III ratios, negligible blue shift of the photoluminescence is observed for laser structures.

However, laser diodes grown with low V/III ratios showing QD ground state emission at 1270-1280 nm still exhibit lasing at only 1220-1240 nm. This shift is shown to originate from gain saturation of the ground state emission and contributions of excited states emission. The growth of the p-doped AlGaAs cladding layer and the highly p-doped GaAs contact layer may affect the luminescence properties of the active region and induce fast saturation. Strategies and achievements to overcome this limit are discussed.

HL 6.4 Mon 11:45 H15

positioning of self-assembled InAs quantum dots by focused ion beam implantation — •minisha mehta, dirk reuter, alexander melnikov, and andreas d. wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätstraße 150, D-44780, Bochum

We present results on the positioning of InAs quantum dots (QDs) by a combined focused ion beam (FIB) and molecular beam epitaxy (MBE) process. First, a layer of GaAs was grown by MBE before a square lattice of holes was fabricated by FIB implantation. Thereafter, before overgrowth with InAs an in-situ annealing step was performed. The QDs were preferentially formed in the holes generated by FIB implantation. We have studied the influence of ion dose, the annealing parameters and the In amount. With an optimized process one can achieve one QD per hole without QDs between the holes. Photoluminescence studies on GaAs-capped QDs confirmed the optical quality of the QDs.

Financial support by GRK384 and the BMBF via the NanoQuit program is gratefully acknowledged.

HL 6.5 Mon 12:00 H15

Horizontal arrangement of alumina nanopores on a silicon chip — •Ying Xiang[1], Woo Lee[2], Kornelius Nielsch[2], Gerhard Abstreiter[1], and Anna Fontcuberta i Morral[1] — [1]Walter Schottky Institut, TU München, Am Coulombwall 3, 85748 Garching, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

Template growth of nanowires has been extensively studied over the past few years, since it provides compactness and uniformity which are necessary for reproducible device fabrication based on arrays of individual nanoobjects. Especially porous anodic alumina (PAA) film has attracted much interest due to the high aspect ratio, high level of ordering, high pore density, and uniformity. PAA templates are commonly obtained with the pores oriented perpendicular to the substrate plane[MAS,LEE]. Unfortunately this method is not compatible with mainstream Si planar processing technology. Here, we present horizontally aligned, well-defined nanopores fabricated by two-step anodic oxidation of aluminum. To characterize different pore diameters obtained by different electrolytes and different anodization voltages, SEM measurements were performed. We obtained pore diameters between 15 nm and 110 nm, and interpore distances between 45 nm and 250 nm. The pore diameter is linearly dependent on the anodization voltage, but slightly different from that of typical vertical anodization. As a result of horizontal alignment, our approach is promising for nanoelectronic applications. Reference: [LEE] W. Lee et al., Nature Materials 5, 741-747 [MAS] H. Masuda et al., Science 268, 1466 (1995)

HL 6.6 Mon 12:15 H15

Self-organised growth of InN-nanocolumns by MBE — •Christian Denker[1], Joerg Malindretos[1], Henning Schuhmann[1], Michael Seibt[1], Angela Rizzi[1], Núria Garro[2], and Andrés Cantarero[2] — [1]IV. Physikalisches Institut and Virtual Institute of Spin Electronics (VISel), Georg-August Universität Göttingen, 37077 Göttingen, Germany — [2]Material Science Institute, University of Valencia, PO Box 22085, 46071 Valencia, Spain

InN nanocolumns (NCs) are an attractive system for light harvesting applications. Our aim is to investigate the optical and electrical properties of nanorod ensembles and of single objects. An electron accumulation layer is known to be formed at the surface of epitaxial thin layers due to Fermi level pinning and should therefore facilitate the electrical contacting of the nanorods. InN-NCs were grown on p-Si(111) by plasma assisted MBE. In dependence on the growth parameters four different growth regimes were identified, according to the final shape of the NCs: broadened, tapered, uniform, tapered as well as long uniform rods. The early stages of nucleation have been analysed and correlated to the final shape distribution of the NCs. Nanorods with diameters of 20-250 nm and lengths up to 1.75 μm have been grown. The aspect ratio (length-to-diameter) reaches values of 45. HR-TEM images show a perfect crystal quality. Additionally we will present I-U-characteristics of a single NC contacted by Focused Ion Beam and e-beam lithography. First results show a resistance of a single object in the order of $k\Omega$. Micro-Raman and micro-PL measurements will provide an insight into the optical properties of InN-NC-ensembles and single objects.

HL 6.7 Mon 12:30 H15

Guided self assembly of mono- and bi- chain of InAs quantum dots on a cleaved facet — •Emanuele Uccelli[1], Dieter Schuh[2], Jochen Bauer[1], Max Bichler[1], Gerhard Abstreiter[1], and Anna Fontcuberta i Morral[1] — [1]Walter Schottky Institute, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany — [2]Institut für Angewandte und Experimentelle Physik II, Universität Regensburg, 93040 Regensburg, Germany

Recently, we were able to fabricate long range ordered chains of InAs QDs by combining selective growth with self-assembly (APL 85, 4750 (2004)). InAs growth was realized on a (110) facet consisting of AlAs nanostripes embedded in GaAs, that was obtained by *in situ* cleaving of a previuosly MBE grown AlAs/GaAs (001) heterostructure. Here, we present an extended phase diagram for the fabrication of QDs arrays, showing under which conditions preferential growth of QDs on the AlAs stripes occurs. We found that the lateral dimensions of the QDs directly reflect the thickness of the underlying AlAs layer, with an onset for the QDs nucleation at AlAs stripe thickness of about 14 nm. The volume and the height of the QDs increases linearly with the stripe thickness. For AlAs stripes thicker than 40 nm, we also observed the formation of double QDs chain on the same stripe depending by the amount of the InAs deposited material. Finally, a comprehensive model is presented, for the understanding of the mechanism of selective nucleation of the single and double QDs chain on the AlAs stripes as a function of the growth conditions. The model gives insight for the mastering of the density and uniformity of the dots arrays.

HL 6.8 Mon 12:45 H15

Herstellung von InAs/GaAs-Quantenpunktstrukturen zur Ladungsträgerspeicherung — David Feise, •Konstantin Pötschke, Andreas Marent, Martin Geller, Udo Pohl und Dieter Bimberg — Institut für Festkörperphysik, TU Berlin, Hardenbergstr. 36, 10623 Berlin

Aufgrund der steigenden Verbreitung portabler IT-Geräte sind insbesondere nicht-flüchtige Festkörperspeicher hoher Kapazität stark nachgefragt. Diese Flash-Speicher benötigen zur Ladungsträgerspeicherung allerdings ein Barrierenmaterial, dessen Haltbarkeit durch den Betrieb des Bauelements limitiert ist.

Quantenpunkte sind ideal als Speicherort für Ladungsträger, da sie ausschließlich diskrete Energiezustände enthalten und sich gezielt mit einzelnen Ladungsträgern beladen lassen. Theoretisch ist für Quantenpunkt-Speicher eine Schreibzeit von unter einer Nanosekunde möglich, so daß ein solches Speicherbauelement auch als Arbeitsspeicher verwendbar wäre.

In diesem Vortrag wird das Konzept und die Herstellung einer InAs/GaAs-Quantenpunktstruktur zur Ladungsträgerspeicherung mittels metallorganischer Gasphasenepitaxie vorgestellt. Der Speicherzustand der Quantenpunkte kann mit Hilfe eines 2D-Elektronengases (2DEG) ausgelesen werden. Zur Verlängerung der Speicherzeit wird eine AlGaAs-Barriere eingesetzt. Die Wachstumsbedingungen für das 2DEG und der Einfluß des InGaAs-Quantenfilms auf die optimalen Wachstumsbedingungen der Quantenpunkte werden diskutiert.