Cleanroom Vienna

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This annual report contains a summary of the major research activities represented by national and international projects carried out in the MISZ TU Wien (Mikrostrukturzentrum der Technischen Universität Wien) during the year 2002. In this year an important step in the direction of future technologies was taken by implanting new equipment into the MISZ to fabricate nanodevices. To keep the mission of the MISZ TU Wien alive (state of the art growth, processing and structuring of novel devices) new downscaling processes for nanoscale and ultrafast devices have to be developed. High-risk projects as well as the improvement of standard devices are running in the framework of the cleanroom and the available technologies within. Top down and bottom up approaches are investigated in parallel, making partly intensive use of the cleanroom and the existing technologies. After a short introduction an overview of the main research efforts with a high need of technological input is presented.

Introduction

The cleanroom of the MISZ TU Wien holds a variety of technologies capable to fabricate and characterize novel artificial materials and devices. These technologies include growth of III-V nanostructures, silicon processing, structuring techniques like contact lithography, the production of patterned masks, ion milling, dry etching, plasma enhanced chemical vapor deposition, electron beam writing, focused ion beam etching and depositing, metallization techniques, transport measurements, spectroscopic techniques for optoelectronic devices, scanning tunneling microscopy, and atomic force microscopy.

Within the last year new equipment as well as upgrades of existing one was installed in the MISZ. These systems are a spectroscopic ellipsometer, a high resolution x-ray diffraction (HRXRD) system, a reactive ion etching with inductive coupled plasma, rapid thermal annealers, a wafer bonder, a spray coater, an upgraded surface profiler, MBE pumping and cell upgrades, and a scanning probe microscope. It takes some time to take full advantage of new equipment and although the additional technologies started to pay off already, we expect a peak in the productivity within the next 18 months.

To satisfy the mission of the MISZ and demonstrate novel materials and devices for semiconductor industries all the technologies implemented in the cleanroom have to be kept at state of the art performance. This includes an operable cleanroom environment (purified air, constant temperature and humidity, cooling, purified water, various inert gases) as well as periodic maintenance of the equipment and the cleanroom itself, e.g. pumping systems (rotary pumps, turbo pumps), exhaust filtering, liquid nitrogen, and cleaning and repair. Testing of the cleanroom quality and adjustment (laminar airflow, filters, cooling, humidity, and temperature) is done periodically. A detailed project information naming all the people making use the cleanroom, scientific publications resulting from samples processed in the cleanroom, talks presented at international conferences, finished diploma and PhD works and national and international cooperations are listed below. The listed projects and the attached publication list may give more insides on the broad range of activities in our facility and offer a more general overview.

This scientific report wants to highlight projects with a high need of technological input carried out within the cleanroom of the MISZ TU Wien during the last twelve months. A selected number of projects describe the achieved results in detail to show some of the major research activities and offer a deeper inside in the scientific work. All projects described below in detail take full advantage of the technologies installed in our cleanroom.

Research Activities

Opto-Electronics

J. Darmo et al.: New Generation of Photoconductive Terahertz Emitters

W. Schrenk et al.: Quantum Cascade Lasers

F.F. Schrey et al.: Modification of the Photoresponse by Energy Level Engineering in InAs Quantum Dot Nanostructures

P. Schwaha et al.: Electrically Pumped Quantum Cascade Ring Lasers

Transport Phenomena

M. Kast et al.: Transport through Wannier-Stark States in Biased Finite Superlattices

T. Müller et al.: Time-Resolved Measurement of Intersubband Population Dynamics

Power Devices

M. Blaho et al.: Study of Internal Behavior of BCD ESD Protection Devices under TLP and Very-Fast TLP Stress

D. Pogany: Local Thermal and Current Imaging in Power Devices

Direct Write Processes

W. Brezna et al.: Scanning Capacitance Microscopy Investigations of Focused Ion Beam Damage in Silicon

A. Lugstein et al.: Post-Process CMOS Channel Profile Tailoring With Focused Ion Beams

H.D. Wanzenboeck et al.: Deposition Mechanism of Direct-write Processes – An Application-Oriented Approach to Custom-Tailored Material Properties

Insulating Films

S. Harasek et al.: Zirconium Dioxide Thin Films for Microelectronics Deposited by Metal Organic Chemical Vapor Deposition

Project Information

Project Manager

Reinraum MISZ TU Wien, G. Strasser

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Project Group

Last Name	First Name	Status	Remarks
Anders	Solveig	postdoc	
Auer	Erwin	student	
Basnar	Bernhard	postdoc	
Beiter	Klaus	student	
Bertagnolli	Emmerich	o. prof.	
Blaho	Matej	dissertation	
Boxleitner	Winfried	postdoc	
Bychikhin	Sergey	postdoc	
Bratschitsch	Rudolf	dissertation	
Brezna	Wolfgang	dissertation	
Coquelin	Michael	student	
Darmo	juraj	postdoc	
Dubec	Viktor	dissertant	
Dzigal	Elvira	technician	
Fasching	Gernot	dissertant	
Fürnhammer	Felix	dissertant	
Gornik	Erich	o. prof.	
Gruber	Karl	student	
Harasek	Stefan	dissertation	
Hobler	Gerhard	ao. prof.	
Kamvar	Parvis	student	
Kast	Michael	dissertation	
Kröll	Josef	student	
Kröll	Peter	technician	
Kreuter	Johann	student	
Kuzmik	Ian	postdoc	
Langfischer	Helmut	dissertation	GMe
Litzenberger	Martin	dissertation	
Lugstein	Alois	univ. ass.	
Müller	Thomas	dissertation	

Last Name	First Name	Status	Remarks
Otto	Gustav	dissertation	
Pacher	Christoph	dissertation	
Pogany	Dionyz	univ. ass.	
Prinzinger	Johannes	technician	
Pflügl	Christian	dissertation	
Rebohle	Lars	postdoc	
Rakoczy	Doris	dissertation	
Riegler	Erich	technician	
Roch	Tomas	postdoc	
Schinnerl	Markus	technician	
Schenold	Helmut	technician	
Schrenk	Werner	cleanroom director	
Schrey	Frederik	dissertation	
Schwaha	Philipp	student	
Smoliner	Jürgen	ao. prof.	
Steinesberger	Gernot	dissertant	
Strasser	Gottfried	ao. prof.	
Tamosiunas	Vincas	postdoc	
Ulrich	Jochen	dissertation	
Unterrainer	Karl	ao. prof.	
Wanzenböck	Heinz	univ. ass.	
Zobl	Reinhard	dissertation	

Books and Contributions to Books

1. R. Bratschitsch and K. Unterrainer, “Terahertz physics of semiconductor heterostructures”; Encyclopedia of Modern Optics, Academic Press, to be published February 2002
2. C. Kranz, B. Mizaikoff, A. Lugstein, E. Bertagnolli, “Integrating an Ultramicroelectrode in an AFM Cantilever: Towards the Development of Combined Microsensing Imaging Tools”, Enviromental Electrochemistry, Analysis of Trace Element Biogeochemistry, American Chemical Society (ISBN 0-8412-3774-3), pp. 320, (2002)

Patents

1. E. Gornik, D. Pogany, Innovationsagentur, “Verfahren und Einrichtung zum optischem Testen von Halbleiterbauelementen”, submitted Jan 2002.
2. T. Le, A. Stingl, G. Tempea, J. Darmo, G. Strasser, and K. Unterrainer, “Einrichtung zur Erzeugung von Terahertz-Strahlung sowie Halbleiterbauelement” (A312/2002 H01S).

Publications in Reviewed Journals

1. D. Rakoczy, G. Strasser, J. Smoliner, “Ballistic electron emission microscopy of ‘on-surface’ self assembled InAs dots and wetting layers”, J. Vac. Sci. Technol. B **20**, 373 (2002), Selected for the *Virtual Journal of Nanoscale Science & Technology **5**(8) 2002*
2. S. Anders, W. Schrenk, E. Gornik, G. Strasser, “Room-temperature emission of GaAs/AlGaAs superlattice quantum cascade lasers at 12.6 μm”, Appl. Phys. Lett. 80, 1864 (2002), Selected for the Virtual Journal of Nanoscale Science & Technology 5(12) 2002
3. A. Lugstein, E. Bertagnolli, C. Kranz, B. Mizaikoff, Fabrication of a ring nanoelectrode in an AFM tip: novel approach towards simultaneous electrochemical and topographical imaging, Surf. Interface Analysis 33, 146 (2002)
4. R. Bratschitsch, T. Müller, G. Strasser, K. Unterrainer; “Intersubband relaxation dynamics in semiconductor quantum structures”; Physica E 13, 908 (2002).
5. J. Ulrich, G. Strasser, K. Unterrainer; “Terahertz quantum cascade emitters based on AlAs/GaAs”; Physica E 13, 900 (2002).
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7. M. Kast, C. Pacher, M. Coquelin, G. Fasching, G. Strasser, E. Gornik; “Narrow electron injector for hot electron spectroscopy”; Physica E 13, 728 (2002).
8. S. Hofer, H. Hirner, R. Bratschitsch, G. Strasser, K. Unterrainer; “Photoconductive Response of InAs/GaAs quantum dot stacks”; Physica **E 13**, 190 (2002).
9. M. Kast, C. Pacher, M. Coquelin, G. Fasching, G. Strasser, E. Gornik; “LO-phonon assisted hot electron transport in biased superlattices”; Physica B **314**, 409 (2002).
10. D. Rakoczy, G. Strasser, J. Smoliner; “Ballistic Electron Emission Microscopy for Local Measurements of Barrier Heights on InAs Self-assembled Quantum Dots on GaAs”; Physica **B 314**, 81 (2002)
11. C. Pacher, G. Strasser, E. Gornik, F. Elsholz, G. Kießlich, A. Wacker, and E. Schöll, “Optics with ballistic electrons: antireflection coatings for GaAs/AlGaAs superlattices”, Physica E **12**, 285 (2002).
12. T. Müller, R. Bratschitsch, G. Strasser, K. Unterrainer, “Direct measurement of intersubband dynamics”, Physica **B 314**, 259 (2002).
13. G. Strasser, W. Schrenk, S. Anders, E. Gornik; “Single mode GaAs Quantum Cascade Laser”; Microelectronic Engineering **63**, 179 (2002)
14. D.Rakoczy, R.Heer, G.Strasser, J.Smoliner, High Energy Ballistic Transport in Hetero- and Nanostructures, to be published in Physica E (2002)
15. J. Ulrich, J. Kreuter, W. Schrenk, G. Strasser, K. Unterrainer, “Long wavelength (15 and 23 μm) GaAs/AlGaAs quantum cascade lasers”, Appl. Phys. Lett. **80**, 3691 (2002), Selected for the *Virtual Journal of Nanoscale Science & Technology **5**(12) 2002*
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19. W. Brezna, S. Harasek, H. Enichlmair, E. Bertagnolli, E. Gornik, J. Smoliner, “Scanning Capacitance Microscopy With ZrO_2 as Dielectric Material”, J. Appl. Phys. **92**, 2144 (2002)

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21. D. Pogany, S. Bychikhin, M. Litzenberger, E. Gornik, G. Groos and M. Stecher, “Extraction of spatio-temporal distribution of power dissipation in semiconductor devices using nanosecond interferometric mapping technique”, Appl. Phys. Lett, **81**, 2881-2883 (2002).

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41. R. Colombelli, F. Capasso, K. Unterrainer, C. Gmachl, A. M. Sergent, D. L. Sivco, A.Y. Cho, “Quantum Cascade Lasers and Metal Waveguides at λ>20μm”, SPIE Proceedings, **4651**, .146-156 (2002).

42. D.Rakoczy, G.Strasser, J.Smoliner Measuring the Energetic Distribution of Ballistic Electrons after their Refraction at an Au-GaAs Interface, to be published in Appl-Phys. Lett. (2003)

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45. M. Lackner, C. Forsuch, F. Winter, S. Anders, and G. Strasser, “Investigation of biomass steam gasification gas using a GaAs based quantum cascade laser emitting at 11 μm”, to be published in Optics Communications.

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47. A. Lugstein, B. Basnar, and E. Bertagnolli, “FIB processing of silicon in the nanoscale regime”, Appl. Physics A. (accepted for publication)

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Presentations & Conference Proceedings

1. K. Unterrainer (invited), “Ultrafast Spectroscopy of Intersubband Transitions”, “Workshop on Quantum Heterostructures and THz Electronics”, 17.1. 2002, Univ. Regensburg, Regensburg
2. G. Strasser (invited); “Prospects of intersubband laser action in GaAs cascaded quantum dots”; Photonics West, San Jose, USA, 19.-25.1.2002
3. W. Schrenk, E. Gornik, G. Strasser; “Room temperature DFB GaAs quantum cascade lasers”; Photonics West, San Jose, USA, 19.-25.1.2002
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5. R. Colombelli, F. Capasso, K. Unterrainer, C. Gmachl, A. M. Sergent, D. L. Sivco, A.Y. Cho, “Quantum Cascade Lasers and Metal Waveguides at λ>20μm”, Photonics West, San Jose, USA, 19.-25.1.2002, *in SPIE Proceedings, Photonics West (to be published)*.
6. W. Schrenk (invited), “GaAs-based quantum cascade lasers”, Workshop Light Emitters Based on Intersubband Transitions, Berlin, Germany, February 2002.
7. J.Smoliner (invited), High Energy Ballistic Transport in Hetero- and Nanostructures, 12th International Winterschool on New Developments in Solid State Physics, Mauterndorf (Feb. 2002)
8. G. Steinlesberger, M. Engelhardt, G. Schindler, J. Kretz, W. Steinhögl, E. Bertagnolli, “Processing Technology for the Investigation of Sub-50 Nanometer Copper Damascene Interconnects”, 3rd European Workshop on **UI**timate **I**ntegration of **S**ilicon, ULIS´3, Munich, March 2002.
9. G. Schindler, G. Steinlesberger, M. Engelhardt, Steinhögl, “Electrical Characterization of Copper Interconnects with End of Roadmap Feature Sizes”, 3rd European Workshop on **UI**timate **I**ntegration of **S**ilicon, ULIS´3, Munich, March 2002.
10. C. Kranz, E. L. Heinz, B. Mizaikoff, A. Lugstein, E. Bertagnolli,” Simultaneous Surface Modification and Imaging with Integrated Scanning Electrochemical/Atomic Force Microscopy, Pittcon , Pittsburgh, 17-22.3. 2002.

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13. T. Müller, R. Bratschitsch, G. Strasser, and K. Unterrainer, “Population dynamics in quantum structures”, 13th International Conference on Ultrafast Phenomena, Vancouver, Canada, 12.-17. 5. 2002, *T. Müller, R. Bratschitsch, G. Strasser, and K. Unterrainer, “Population dynamics in quantum structures”, in OSA Trends in Optics and Photonics Vol.72, The Thirteenth International Conference on Ultrafast Phenomena, OSA Technical Digest, Postconference Edition (Optical Society of America, Washington DC, 2002), pp. 334-335.*
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Doctor's Theses

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2. Dipl. Phys. Jochen Ulrich, "Longwavelength Quantum Cascade Lasers", March 2002

3. Mag. Wolfgang Fischler, “Zeitaufgelöste Pump-Probe-Spektroskopie an GaAs/AlGaAs-Halbleiterstrukturen”, Dezember 2002

Diploma works

1. Gernot Fasching, “Untersuchung der Elektron-Phonon-Wechselwirkung mittels ballistischer Elektronenspektroskopie”, Jänner 2002
2. Wolfgang Parz, “Intersubband Relaxation Dynamics in Quantum Structures”, September 2002
3. Johann Kreuter, “Long wavelength GaAs/AlGaAs quantum cascade lasers with low-loss waveguide”, Dezember 2002

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