

Cleanroom Vienna

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In this report a summary of the main activities in the MISZ TU Wien (Mikrostrukturzentrum der Technischen Universität Wien) during the year 2001 will be given. We will focus on projects taking intensive use of the cleanroom and the available technologies within. Part of the mission of the MISZ is the development and production of optoelectronic and microelectronic prototype devices. This includes state of the art growth of III-V nanostructures and silicon processing, structuring techniques utilizing standard contact lithography, the production of patterned masks, ion milling as well as dry etching and plasma enhanced chemical vapor deposition, electron beam writing, focused ion beam etching and depositing, and different metallization techniques. A variety of device characterization techniques like transport measurements, spectroscopic techniques for optoelectronic devices and surface probing like scanning tunneling microscopy and atomic force microscopy are available.

1. Introduction

An overview of the main research efforts with a high need of technological input are presented within this scientific report. This summary includes the majority of experimental projects of the solid state electronics institute (Festkörperelektronik TU Wien) during the last twelve months. All the projects described below like transport studies in low dimensional semiconductor nanostructures, scanning probe spectroscopy, realization of new and improved optoelectronic devices, quantum cascade lasers, THz sources, and the characterization of microelectronic devices take full advantage of the technologies installed in the cleanroom of the MISZ (Reinraum Mikrostrukturzentrum der TU Wien).

To structure this yearly increasing number of various activities four research areas are introduced, namely:

- Optoelectronics
- Transport in III-V Semiconductors
- Silicon Device Testing
- Focused Ion Beam Developments

To satisfy this variety of topics and demonstrate e.g. optoelectronic devices as well as basic research and the development of new tools for semiconductor industries, various technologies have to be kept at state of the art performance.

This includes growth of semiconductor nanostructures (molecular beam epitaxy), as well as a complete process line including structure definition (lithography), structure transfer (reactive ion etching, focussed ion beam etching, ion milling, wet chemical etching techniques) and coating with metals and/or dielectrics (plasma-enhanced chemical vapor deposition, sputtering, electron gun evaporation, focussed ion beam deposi-

tion). Surface morphology as well as local carrier concentrations probing is done with a conventional Atomic Force Microscope (AFM) in combination with a Scanning Capacitance Microscopy (SCM) extension.

All the equipment necessary for the above mentioned technologies needs the cleanroom environment (cooling, filtered air, constant temperature and humidity, high quality water, different 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.

For a more general overview the listed projects and the attached publication list may give more insides on the broad range of activities in our facility.

2. Research Activities

The research activities are described in detail in the subsequent part of this report:

2.1 Optoelectronics

E. Gornik, G. Strasser, R. Zobl, M. Kast, C. Pacher:

Search for Plasma Instability Driven THz Radiation Sources

J. Darmo, G. Strasser, T. Müller, K. Unterrainer:

THz Plasmon Emission from an LT-GaAs/GaAs Homojunction

J. Darmo, G. Strasser, T. Müller, K. Unterrainer, Tuan Le, A. Stingl:
Voltage Controlled Intracavity Emitter of Terahertz Radiation

T. Müller, R. Bratschitsch, G. Strasser, K. Unterrainer:

Direct Measurement of Intersubband Population Dynamics

J. Ulrich, J. Kreuter, W. Schrenk, G. Strasser, K. Unterrainer:

Long Wavelength (15 and 23 μm) GaAs/AlGaAs Quantum Cascade Lasers

W. Schrenk, S. Anders, E. Gornik, G. Strasser:

Room Temperature Operation of Distributed Feedback GaAs/AlGaAs Quantum-Cascade Lasers

S. Anders, W. Schrenk, G. Strasser:

Room Temperature Lasing of Electrically Pumped Quantum Cascade Micro-Cylinders

R. Zobl, E. Gornik, I.V. Altukhov, M.S. Kagan:

Spectrum of Low-Voltage THz Emission of Strained p-Ge Resonant-State Laser

2.2 Transport in III-V Semiconductors

M. Coquelin, C. Pacher, M. Kast, G. Strasser, E. Gornik:

Transport Studies on Double Period Superlattices Utilizing Hot Electron Spectroscopy

M. Kast, C. Pacher, G. Strasser, E. Gornik:

Transport Through Wannier-Stark States in Biased Finite Superlattices

C. Pacher, G. Fasching, M. Kast, G. Strasser, E. Gornik:
Study of Electron-LO Phonon Scattering in Wide GaAs Quantum Wells Utilizing Hot Electron Spectroscopy

J. Smoliner, D. Racoszy, G. Strasser:
Electron Transport in Kinetic Heterostructures

2.3 Silicon Device Testing

W. Brezna, S. Harasek, H. Enichlmair, E. Bertagnolli, E. Gornik, J. Smoliner:
Scanning Capacitance Microscopy with Zirconium Oxide as High-k Dielectric Material

M. Litzenberger, D. Pogany, E. Gornik, K. Esmark:
Effect of Pulse Risetime on Trigger Homogeneity in Grounded Gate nMOSFET Electrostatic Discharge Protection Devices

M. Blaho, D. Pogany, E. Gornik, W. Wilkening, J. Hieber:
Backside Interferometric Investigations of a DMOS Clamp Under ESD Stress

D. Pogany, C. Fürböck, M. Litzenberger, P. Kamvar, S. Bychikhin, E. Gornik:
Study of Trigger Instabilities in ESD Protection Devices Using Backside Laser Interferometry

S. Bychikhin, M. Litzenberger, P. Kamvar, D. Pogany, E. Gornik, G. Groos, M. Stecher:
Laser Interferometric Mapping of Smart Power ESD Protection Devices with Different Blocking Capabilities

V. Dubec, S. Bychikhin, M. Litzenberger, D. Pogany, E. Gornik, K. Esmark, W. Stadler:
An Optical Setup for Investigation of Internal Device Behavior Under CDM-Like ESD Stress

S. Harasek, B. Basnar, J. Smoliner, E. Bertagnolli:
Ultrathin Zirconium Dioxide for future MOS Technology

G. Otto, G. Hobler:
Molecular Dynamic Simulations of Ion Induced Damage in Silicon

2.4 Focused Ion Beam Developments

H.D. Wanzenboeck:
Fabrication Technology for Sub-100 nm Semiconductor Devices

H. Langfischer:
Evolution of Tungsten Film Deposition Induced by Focused Ion Beam

A. Lugstein, E. Bertagnolli, C. Krantz, B. Mizaikoff:
Integrating Micro- and Nanoelectrodes into Atomic Force Microscopy Cantilevers using Focused Ion Beam Techniques

A. Lugstein, W. Brezna, E. Bertagnolli:
Impact of Focused Ion Beam Assisted Front End Processing on n-MOSFET Degradation

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	
Bertagnolli	Emmerich	o. prof.	
Blaho	Matej	dissertation	
Boxleitner	Winfried	postdoc	
Bychikhin	Sergey	postdoc	
Bratschitsch	Rudolf	dissertation	
Coquelin	Michael	student	
Darmo	juraj	postdoc	
Dzagal	Elvira	technician	
Fasching	Gernot	student	
Fehlmann	Gerhard	student	
Fürböck	Christoph	dissertation	
Gornik	Erich	o. prof.	
Harasek	Stefan	dissertation	
Hobler	Gerhard	ao. prof.	
Kamvar	Parvis	student	
Kast	Michael	dissertation	
Kellermann	Peer	dissertation	
Kröll	Peter	technician	
Langfischer	Helmut	dissertation	GMe
Litzenberger	Martin	dissertation	
Lugstein	Alois	univ. ass.	
Maier	Harald	student	
Müller	Thomas	dissertation	
Otto	Gustav	dissertation	
Pacher	Christoph	dissertation	
Pogany	Dionyz	univ. ass.	

Last Name	First Name	Status	Remarks
Prinzinger	Johannes	technician	
Rakoczy	Doris	dissertation	
Riegler	Erich	technician	
Schinnerl	Markus	technician	
Schenold	Helmut	technician	
Schrenk	Werner	dissertation	
Smoliner	Jürgen	ao. prof.	
Strasser	Gottfried	univ. ass.	
Ulrich	Jochen	dissertation	
Unterrainer	Karl	ao. prof.	
Wanzenböck	Heinz	univ. ass.	
Zobl	Reinhard	dissertation	

Books and Contributions to Books

1. E.Gornik, R.Kersting, “*Coherent THz Emission in Semiconductors*”, Semiconductors and Semimetals, 67, 389, Academic Press (2001)
2. R. Bratschitsch and K. Unterrainer, “*Terahertz physics of semiconductor heterostructures*”; Encyclopedia of Modern Optics, Academic Press, to be published February 2002.

Publications in Reviewed Journals

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3. J. Smoliner, R. Heer, G. Strasser, C. Strahberger, “*Magnetic field effects and k_{\parallel} -filtering in BEEM on GaAs-AlGaAs resonant tunneling structures*”, Applied Physics **A72**, 233, (2001)
4. G. Strasser; “*Monomodige GaAs/AlAs Quantenkaskadenlaser im Dauerstrichbetrieb – Continuous wave operation of single mode GaAs/AlAs quantum cascade lasers*”; LaserOpto **33**, 30 (2001)
5. H. Bachhofer, H. Reisinger, E. Bertagnolli, H. von Philipsborn, “*Transient conduction in multielectric silicon-oxide-nitride-oxide-semiconductor structures*”, J. Appl. Phys **89**, 2791 (2001).
6. C. Strahberger, J. Smoliner, R. Heer, G. Strasser, “*Enhanced k_{\parallel} filtering effects in ballistic electron emission experiments*”, Phys. Rev. **B63**, 205306 (2001)

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10. D. Pogany, J.A. Chroboczek, G. Ghibaudo, “*Random telegraph signal noise mechanisms in reverse base current of hot carrier degraded submicron bipolar transistors: Effect of carrier trapping during stress on noise characteristics*”, J. Appl. Phys., **89**, 4049 (2001).
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12. B. Goebel, D. Schumann, and E. Bertagnolli, “*Vertical MOSFETs for Extremely High Density Memories: The Impact of Interface Orientation on Device Performance*”, IEEE Trans. El. Devices **48**, 897 (2001).
13. J.N. Heyman, P. Neocleous, D. Herbert, P.A. Crowell, T. Müller, K. Unterrainer, “*Terahertz emission from GaAs and InAs in a magnetic field*”, Phys. Rev. B **64**, 085202 (2001).
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17. J. Smoliner, B. Basnar, S. Golka, E. Gornik, B. Löffler, M. Schatzmayer, H. Enichlmair, “*Mechanism of bias dependent contrast in Scanning Capacitance Microscopy images*”, Appl. Phys. Lett. **79**, 3182 (2001)
18. M. Leicht, G. Fritzer, B. Basnar, S. Golka, J. Smoliner, “*A reliable course of Scanning Capacitance Microscopy analysis applied for 2D-Dopant Profilings of Power MOSFET Devices*”, Microelectronics Reliability **41**, 1535 (2001)
19. A. Edelmann, C. Ruzicka, J. Frank, B. Lendl, W. Schrenk, E. Gornik, G. Strasser; “*Towards functional group specific detection in high-performance liquid chromatography using mid infrared quantum cascade lasers*”; J. Chromatogr. A **934**, 123 (2001)
20. L. Palmetshofer, M. Gritsch, and G. Hobler, “*Range of ion-implanted rare earth elements in Si and SiO₂*”, Mater. Sci. Eng. B **81**, 83 (2001).

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23. G. Hobler and G. Betz, “*On the useful range of application of molecular dynamics simulations in the recoil interaction approximation*”, Nucl. Instr. Meth. B **180**, 203 (2001).
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“*Influence of Layout parameters on Triggering Behaviour in 0.35 μ m and 0.18 μ m Process gg-nMOS ESD Protection Devices*”, *Proc. ESSDERC 2001*, Sept. 11.-13. 2001, Nürnberg, Germany, pp. 335-338.
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“*Infrared Quantum Cascade Laser*”, ISBN: 3-901578-07-2, *Proceedings GMe Forum 2001*, 67 (2001)
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 55. H. Wanzenboeck, A. Lugstein, H. Langfischer, S. Harasek, E. Bertagnolli; U. Grabner, P. Pongratz, B. Basnar, J. Smoliner, E. Gornik; "*Effects of Ga-ion irradiation on chemical and electrical properties of materials processed by a Focused Ion Beam (FIB)*", MRS Proceedings Volume 647, O6.6 (2001)
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64. W. Schrenk, E. Gornik, H. Page, C. Sirtori, V. Ortiz, G. Strasser; “*High performance single mode GaAs quantum cascade lasers*”; accepted for publication in Physica E
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73. G. Strasser, W. Schrenk, S. Anders, E. Gornik; “*Single mode GaAs Quantum Cascade Laser*”; accepted for publication in Microelectronic Engineering (NPMS-5)

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Presentations

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2. K. Unterrainer (invited), “*THz emission from semiconductor quantum structures*”, Workshop on Quantum Heterostructures and THz Electronics, Regensburg, Germany, 1.2.2001.
3. G. Strasser (invited); “*Nanostructures in Photonics*”; Optoelectronics & Photonics Winter School, Trento, Italy, 4-11.3.2001
4. G. Strasser (invited); “*Single mode continuous wave GaAs quantum cascade lasers*”; APS March Meeting, 12-16.3.01, Seattle, USA
5. R. Bratschitsch, T. Müller, N. Finger, G. Strasser, K. Unterrainer, C. Sirtori; “*Non-instantaneous response of a plasma Bragg mirror*”; APS March Meeting, 12-16.3.01, Seattle, USA

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7. W. Schrenk, N. Finger, S. Gianordoli, L. Hvozdar, E. Gornik, G. Strasser, “*Infrarot-Quantenkaskadenlaser*”, GMe-Forum 2001, Wien, 5.-6.4.2001
8. R. Bratschitsch, T. Müller, G. Strasser, K. Unterrainer; “*Coherent Terahertz Emission from Optically Pumped Parabolic Quantum Wells*”; GMe-Forum 2001, Wien, Austria, 5.-6.4.2001
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13. T. Berer, G. Pillwein, G. Brunthaler, G. Strasser; “*Fabrication of AlGaAs Nanostructures*”; GMe-Forum 2001, Wien, Austria, 5.-6.4.2001
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16. M. Litzenberger, R. Pichler, C. Fürböck, S. Bychikhin, D. Pogany, E. Gornik, K. Esmark, G. Groos, H. Gossner, and M. Stecher, “*Laser-interferometric investigation of triggering behavior in CMOS and smart power technology electrostatic discharge (ESD) protection structures*”, Proceedings GMe Forum 2001, 5.-6. April 2001, ISBN 3-901578-07-2, p.129-132.
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19. T. Müller, R. Bratschitsch, N. Finger, G. Strasser, K. Unterrainer, C. Sirtori; “*Ultrafast response of a plasma Bragg mirror*”, CLEO2001, Baltimore, USA, May 6-8 2001
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Habilitations

1. Gottfried Strasser, “*Quantum Cascade Semiconductor Laser*”, January 2001.

Doctor’s Theses

1. Christoph Fürböck, “*Characterization of Semiconductor Power Devices: Laser Interferometry and Failure Analysis*”, February 2001
2. Bernd Goebel, “*Vertical n-channel MOSFETs for extremely high density integration*”, June 2001
3. P.O. Kellermann, “*Entwicklung von Halbleiterlasers mit postepitaktischer Adjustierung der Wellenlänge*”, June 2001
4. Rudolf Bratschitsch, “*Time-resolved THz-Spectroscopy of Semiconductor Nanostructures*”, November 2001
5. Werner Schrenk, “*Distributed Feedback Quantum Cascade Lasers*”, November 2001

Cooperations

1. Universität Linz, W. Heiss, F. Schäffler, H. Thiem, L. Palmetshofer, W. Jantsch
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