# Cleanroom Vienna

**G. Strasser**

**Center for Micro- and Nanostructures**
**of the Vienna University of Technology,**
**Floragasse 7, A-1040 Vienna, Austria**

In this annual report a summary of the main activities in the ZMNS TU Wien (*Zentrum für Mikro- und Nanostrukturen der Technischen Universität Wien*) during the year 2004 will be given. Within this report we describe projects making intensive use of the cleanroom and the available technologies within. 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 various metallization techniques. A major part of the mission of the ZMNS is the development and production of microelectronic, optoelectronic, and nanoelectronic prototype devices. A list of the people involved in the cleanroom activities is added. The list of scientific publications published last year is a direct measure of the activities within the ZMNS cleanroom.

## Introduction

An overview of the main research efforts with a high need of technological input is 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 ZMNS (*Reinraum des Zentrums für Mikro-und Nanostrukturen der TU Wien*). A detailed up-to-date list of the existing cleanroom equipment including benchmark data are given on the actual webpage of the cleanroom (http://zmns.tuwien.ac.at/).

To structure the yearly increasing number of various activities within the cleanroom of the ZMNS, six research areas are introduced, namely:

- Optoelectronics & THz technology
- Quantum Dots
- Transport in III-V Semiconductors
- Silicon Device Testing
- Focused Ion Beam Developments
- Novel Characterization Techniques and Devices

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, different 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, focused ion beam etching, ion milling, wet chemical etch-

ing techniques) and coating with metals and/or dielectrics (plasma-enhanced chemical vapor deposition, sputtering, electron gun evaporation, focused ion beam deposition). 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.

# Research Activities

### Optoelectronics and THz technology

G. FASCHING *et al.* (TU Vienna): "*Terahertz Quantum Cascade Lasers Operating in Magnetic Fields*"

M. AUSTERER *et al.* (TU Vienna): "*Surface-Emitting Single-Mode Quantum Cascade Lasers*"

### Quantum Dots

W. BREZNA *et al.* (TU Vienna): "*Quantitative Scanning Capacitance Spectroscopy on GaAs and InAs Quantum Dots*"

G. FASCHING *et al.* (TU Vienna): "*Photocurrent Spectroscopy of Single InAs/GaAs Quantum Dots*"

T. MÜLLER *et al.*: "*Carrier Dynamics in Quantum Dots*"

F.F. SCHREY *et al.* (TU Vienna): "*Ultrafast Intersublevel Spectroscopy of a Single Quantum Dot*"

### Transport in III-V Semiconductors

D. RAKOCZY *et al*. (TU Vienna): "*Cross Sectional Ballistic Electron Emission Microscopy for Schottky Barrier Height Profiling on Heterostructures*"

### Silicon Device Testing

V. DUBEC *et al*. (TU Vienna): "*Thermal Imaging at Multiple Time Instants for Study of Self-Heating and ESD Phenomena*"

J. KUZMÍK *et al*. (TU Vienna): "*Degradation Mechanisms in AlGaN/GaN HEMTs under Electrostatic Discharge*"

## Focused Ion Beam Developments

M. FISCHER *et al*. (TU Vienna): "*Direct-Write Deposition Utilizing a Focused Electron Beam*"

A. LUGSTEIN *et al*. (TU Vienna): "*A New Approach for the Formation of Size and Site Controlled Metallic Nano Dots Seeded by Focused Ion Beams*"

## Novel Characterization Techniques and Devices

S. GOLKA et al. (TU Vienna): "*Inductively Coupled Plasma Reactive Ion Etching of GaN*"

# Project Information

## Project Manager

**Associate Prof. Dr. G. Strasser**

Institute of Solid State Electronics,
Floragasse 7, A-1040 Vienna

## Project Group

| Last Name | First Name | Status | Remarks |
|---|---|---|---|
| Andrews | A. Maxwell | postdoc | |
| Auer | Erwin | dissertation | |
| Austerer | Maximilian | dissertation | |
| Bae | Kim Heung | dissertation | |
| Bertagnolli | Emmerich | o. prof. | |
| Blaho | Matej | dissertation | |
| Bychikhin | Sergey | postdoc | |
| Brezna | Wolfgang | dissertation | |
| Coquelin | Michael | dissertation | |
| Dalibor | Kovac | dissertation | |
| Darmo | juraj | postdoc | |
| Dominizi | Karl | student | |
| Dubec | Viktor | dissertant | |
| Dzigal | Elvira | technician | |
| Fasching | Gernot | dissertation | |
| Fischer | Markus | dissertation | |
| Golka | Sebastian | dissertation | |
| Gornik | Erich | o. prof. | |
| Gottsbachner | Josef | student | |
| Gruber | Karl | student | |
| Hagl | Peter | student | |
| Harasek | Stefan | dissertation | |
| Hobler | Gerhard | ao. prof. | |
| Kast | Michael | dissertation | |
| Kröll | Josef | student | |
| Kröll | Peter | technician | |
| Kuzmik | Ian | postdoc | |
| Langfischer | Helmut | dissertation | |
| Lugstein | Alois | univ. ass. | |

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

## Books and Contributions to Books

1. S Anders, G. Strasser, E. Gornik:
   "*Long wavelength laser diodes*";
   in: "Handbook of Laser Technology and Applications", IoP Publishing, Bristol. UK, 2004, S. 271 - 286.

## Publications in Reviewed Journals

2. S. Anders, W. Schrenk, T. Roch, C. Pflügl, G. Strasser:
   "*Tuning quantum-cascade lasers by postgrowtz rapid thermal processing*";
   Applied Physics Letters, **84** (2004), 2; S. 164 - 166.
3. S. Anders, V. Tamosiunas, W. Schrenk, G. Strasser:
   "*Optical modes in mesoscopic quantum cascade ring lasers*";
   Physical Review B, **69** (2004), S. 0733091 - 0733093.
4. Y. Baryshnikov, P. Heider, W. Parz, V. Zharnitsky:
   "*Whispering Gallery Modes Inside Aymmetric Resonant Cavities*";
   Physical Review Letters, **93** (2004), 13; S. 1339021 - 1339024.

5. B. Basnar, H. Hirner, E. Gornik, G. Strasser:
"*Fast characterisation of InAs quantum dot structures using AFM*";
Journal of Crystal Growth, **264** (2004), S. 26 - 30.

6. B. Basnar, A. Lugstein, E. Bertagnolli, E. Gornik:
"*Spectroscopic ellipsometry study of focused ion beam induced GaAs surface modification*";
Thin Solid Films, **1** (2004), S. 540 - 544.

7. M. Blaho, L. Zullino, H. Wolf, R. Stella, A. Andreini, H. Gieser, D. Pogany, E. Gornik:
"*Internal Behavior of BCD ESD Protection Devices Under TLP and Very-Fast TLP Stress*";
IEEE Transactions on Device and Materials Reliability, **4** (2004), 3; S. 535 - 541.

8. S. Bychikhin, V. Dubec, D. Pogany, E. Gornik, M. Graf, V. Dudek, W. Soppa:
"*Transient interferometric mapping of smart power SOI ESD protection devices under TLP and vf-TLP stress*";
Microelectronics Reliability, **44** (2004), S. 1687 - 1692.

9. J. Darmo, T. Müller, W. Parz, J. Kröll, G. Strasser, K. Unterrainer:
"*Few-cycle terahertz generation and spectroscopy of nanostruture*";
Philosophical Transactions of the Royal Society of London A, **362** (2004), S. 251 - 262.

10. J. Darmo, V. Tamosiunas, G. Fasching, J. Kröll, K. Unterrainer, M. Beck, M. Giovannini, J. Faist, C. Kremser, P. Debbage:
"*Imaging with a Terahertz quantum cascade laser*";
Optics Express, **12** (2004), 9; S. 1879 - 1884.

11. M. Denison, M. Blaho, P. Rodin, V. Dubec, D. Pogany, D Silber, E. Gornik, M. Stecher:
"*Moving Current Filaments in Integrated DMOS Transistors Under Short-Duration Current Stress*";
IEEE Transactions on Electron Devices, **51** (2004), 10; S. 1695 - 1703.

12. V. Dubec, S. Bychikhin, M. Blaho, M. Heer, D. Pogany, M. Denison, N. Jensen, M. Stecher, G. Groos, E. Gornik:
"*Multiple-time-instant 2D thermal mapping during a single ESD event*";
Microelectronics Reliability, **44** (2004), S. 1793 - 1798.

13. M. Eckhardt, A. Schwanhäußer, L. Robledo, S. Malzer, G. Döhler, M. Betz, S. Trumm, A. Leitenstorfer, T. Müller, K. Unterrainer:
"*Exotic transport regime in GaAs: absence of intervalley scattering leading to quasi-ballistic, real-space THz oscillations*";
Semiconductor Science and Technology, **19** (2004), S. 195 - 198.

14. P. Green, L.R. Wilson, E.A. Zibik, D.G. Revin, J.W. Cockburn, C. Pflügl, W. Schrenk, G. Strasser, A.B. Krysa, J.S. Roberts, C.M. Tey, A.G. Cullis:
"*High-performance distributed feedback quantum cascade lasers grown by metalorganic vapor phase epitaxy*";
Applied Physics Letters, **83** (2004), 23; S. 5529 - 5531.

15. R. Heer, J. Smoliner, J. Bornemeier, H. Brückl:
"*Ballistic electron emission microscopy on spin valve structures*";
Applied Physics Letters, **85** (2004), 19; S. 4388 - 4390.

16. C. Kranz, A. Kueng, A. Lugstein, E. Bertagnolli, B. Mizaikoff:
"Mapping of enzyme activity by detection of enzymatic products during AFM imaging with integrated SECM-AFM probes";
Ultramicroscopy, **100** (2004), S. 127 - 134.

17. J. Kröll, J. Darmo, K. Unterrainer:
"*High-performance terahertz electro-optic detector*";
Electronics Letters, **40** (2004), 12; S. 763 - 764.

18. J. Kuzmik, G. Konstantinidis, S. Harasek, S. Hascik, E. Bertagnolli, A. Georgakilas, D. Pogany:
"*ZrO2/(Al)GaN metal-oxide-semiconductor structures: characterization and application*";
Semiconductor Science and Technology, **19** (2004), S. 1364 - 1368.

19. J. Kuzmik, D. Pogany, E. Gornik, P. Javorka, P. Kordos:
"*Electrical overstress in AlGaN/GaN HEMTs: study of degradation processes*";
Solid-State Electronics, **48** (2004), S. 271 - 276.

20. A. Lugstein, B. Basnar, E. Bertagnolli:
"*Metallic nano dots realized by a subtractive self organization process*";
Superlattices and Microstructures, **36** (2004), S. 107 - 111.

21. A. Lugstein, B. Basnar, E. Bertagnolli:
"*Size and site controlled Ga nano dots on GaAs seeded by focused ion beams*";
Virtual Journal of Nanoscale Science & Technology, **9** (2004), 16.

22. A. Lugstein, B. Basnar, E. Bertagnolli:
"*Size and site controlled Ga nanodots on GaAs seeded by focused ion beams*";
Journal of Vacuum Science and Technology, **22** (2004), S. 888 - 892.

23. A. Lugstein, B. Basnar, E. Bertagnolli:
"Study of the chemical and morphological evolution of the GaAs surface after high fluence focused ion beam exposure";
Nuclear Instruments & Methods B, **217** (2004), S. 402 - 408.

24. A. Lugstein, M. Weil, B. Basnar, C. Tomastik, E. Bertagnolli:
"*A novel fabrication technique for crystallite growth on a (100) InAs surface utilizing focused ion beams*";
Nuclear Instruments & Methods B, **222** (2004), S. 91 - 95.

25. T. Müller, W. Parz, F. Schrey, G. Strasser, K. Unterrainer:
"*Intraband relaxation of photoexcited electrons in GaAs/AlGaAs quantum wells and InAs/GaAs self-assembled quantum dots*";
Semiconductor Science and Technology, **19** (2004), S. 287 - 289.

26. T. Müller, W. Parz, G. Strasser, K. Unterrainer:
"Influence of carrier-carrier interaction on time-dependent intersubband absorption in a semiconductor quantum well";
Physical Review B, **70** (2004), S. 155324-1 - 155324-5.

27. T. Müller, W. Parz, G. Strasser, K. Unterrainer:
"*Pulse-induced quantum interference of intersubband transitions in coupled quantum wells*";
Applied Physics Letters, **84** (2004), 1; S. 64 - 66.

28. C. Pacher, E. Gornik:
"Tunning of transmission function and tunneling time in finite periodic potentials";
Physica E, **21** (2004), S. 783 - 786.

29. C. Pacher, M. Kast, T. Roch, G. Strasser, E. Gornik:
"*Hot electron spectroscopy of the GaAs/AlAs/GaAs band structure*";
Semiconductor Science and Technology, **19** (2004), S. 102 - 103.

30. C. Pflügl, M. Austerer, W. Schrenk, S. Golka, G. Strasser:
"*Surface emitting quantum cascade lasers*";
Opto-Electronics Review (invited), **12** (2004), 4; S. 361 - 363.

31. C. Pflügl, W. Schrenk, S. Anders, G. Strasser:
"*Spectral dynamics of distributed feedback quantum cascade lasers*";
Semiconductor, Science and Technology, **19** (2004), S. 336 - 338.

32. D. Rakoczy, G. Strasser, C. Pacher, J. Smoliner:
"*Ballistic electron microscopy on doped AlAs barriers in the regime of the Mott transition*";
Semiconductor Science and Technology, **19** (2004), S. 8 - 10.

33. F. Rizzi, G. Scamarcio, G. Strasser:
"Three-terminal mid-IR tunable emitters based on Wannier-Stark ladder transitions in semiconductor superlattices";
Semiconductor Science and Technology, **19** (2004), S. 87 - 88.

34. D Schneider, C Brink, A. Schlachetzki, G. Ploner, G. Strasser, E. Gornik:
"*Tuned transition from a quantum well to a quantum wire investigated by magnetophonon resonance*";
Japanese Journal of Applied Physics, **95** (2004), S. 2509 - 2517.

35. F. F. Schrey, G. Fasching, T. Müller, G. Strasser, K. Unterrainer:
"*Optically induced intraband electron transfer in self-assembled InAs quantum dots*";
Physica Status Solidi (c), **1** (2004), S. 434 - 437.

36. F. Schrey, T. Müller, G. Fasching, S. Anders, C. Pflügl, W. Schrenk, G. Strasser, K. Unterrainer:
"*Intersublevel dynamics of semiconductor nanostructures*";
Physica E, **25** (2004), S. 271 - 279.

37. A. Schröder, S. Harasek, M. Kupnik, M. Wiesinger, E. Gornik, E. Benes, M. Gröschl:
"*A Capacitance Ultrasonic Transducer for High-Temperature Applications*";
IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, **51** (2004), 7; S. 896 - 907.

38. J. Smoliner, D. Rakoczy, M. Kast:
"*Hot electron spectroscopy and microscopy*";
Reports on Progress in Physics, **67** (2004), S. 1863 - 1914.

39. V. Spagnolo, G. Scamarcio, W. Schrenk, G. Strasser:
"*Influence of the band-offset on the electronic temperature of GaAs/Al(Ga)As superlattice quantum cascade lasers*";
Semiconductor Science and Technology, **19** (2004), S. 110 - 112.

40. V. Tamosiunas, R. Zobl, G. Fasching, J. Ulrich, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, K. West, L. Pfeiffer, F. Capasso:
"*Magnetic field effects in terahertz quantum-cascade lasers*";
Semiconductor, Science and Technology, **19** (2004), S. 348 - 350.

## Conference Publications

1. M. Austerer, C. Pflügl, W. Schrenk, T. Roch, G. Strasser:
"*Surface Emitting Quantum Cascade Laser*";
in: "*GMe Annual Report 2003*", Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 31.

2. M. Coquelin, R. Zobl, G. Strasser, E. Gornik:
"Plasmon Enhanced THz Emission";

in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 49.

3. M. Coquelin, R. Zobl, G. Strasser, E. Gornik:
“Recent Structures for Plasma Instability Search”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 117 - 119.

4. J. Darmo, G. Strasser, J. Kröll, K. Unterrainer:
“Heterostructure-Based Photoconductive Terahertz Emitters”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 53.

5. G. Fasching, F. Schrey, G. Strasser, K. Unterrainer:
“Photocurrent and Photoluminescence Measurements of InAs Quantum Dots”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 65.

6. S. Golka, W. Schrenk, G. Strasser:
“Fabrication of Dry Etched Planar Photonic Crystals for THz Regime”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 45.

7. M. Kast, C Pacher, M. Coquelin, W Boxleitner, G. Strasser, E. Gornik:
“High-Resolution Hot -Electron Spectroscopy in Parallel Magnetic Fields”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 71.

8. T. Müller, F. Schrey, G. Fasching, G. Strasser, K. Unterrainer:
“Ultrafast Intraband Dynamics in InAs/GaAs Quantum Dots”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 59.

9. C. Pflügl, M. Litzenberger, W. Schrenk, D. Pogany, E. Gornik, G. Strasser:
“Interferometric Temperature Mapping of GaAs-based Quantum Cascade Laser”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 33.

10. G. Pillwein, G. Brunthaler, G. Strasser:
“Fabrication and Characterization of Lateral Quantum Dots in GaAs Heterostructures”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, S. 67.

11. D. Rakoczy, G. Strasser, J. Smoliner:
“BEEM/BEES Investigations on AlAs/GaAs Single Barriers and RTDs”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 75.

12. T. Roch, W. Schrenk, S Anders, C. Pflügl, G. Strasser:
“X-Ray Investigatin of Interface Broadening by Rapid Thermal Processing”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 109.

13. W. Schrenk, S Anders, T. Roch, C. Pflügl, G. Strasser:
“Tuning Quantum-Cascade Lasers by Postgrowth Rapid Thermal Processing”;
in: “GMe Annual Report 2003”, Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 37.

14. F. Schrey, G. Fasching, T. Müller, G. Strasser, K. Unterrainer:
“Confocal Micro-Photoluminescence and Micro-Photoluminescence Excitation

Spectroscopy on Single Self Assembled InAs Quantum Dots";
in: "GMe Annual Report 2003", Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 61.

15. P Schwaha, S Anders, V Tamosiunas, W. Schrenk, G. Strasser:
"Light Field in Quantum Cascade Ring Lasers";
in: "GMe Annual Report 2003", Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 39.
16. V Tamosiunas, R. Zobl, G. Fasching, J. Ulrich, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, L. Pfeiffer, K. West, F. Capasso:
"Terahertz Quantum-Cascade Lasers in a Magnetic Field";
in: "GMe Annual Report 2003", Gesellschaft für Mikro- und Nanoelektronik, 2004, 3-901578-12-9, S. 41.

## Presentations with Proceedings

1. M. Austerer, C. Pflügl, W. Schrenk, T. Roch, G. Strasser:
"*Surface emitting quantum cascade laser*";
Talk: Workshop on Compound Semiconductor Devices and Integrated Circuits (WOCSDICE), Smolinice Castle, Slovakia; 17.05.2004 - 19.05.2004; in: "*Proceedings of WOCSDICE 2004*", (2004), S. 63 - 64.
2. S. Bychikhin, L.K.J. Vandamme, J. Kuzmik, G. Meneghesso, D. Pogany:
"*Low frequency noise characterization of the GaN LEDs*";
Talk: 5th International Conference on Advanced Semiconductor Devices and Microsystems, Smolenice Castle, Slovakia; 17.10.2004 - 21.10.2004; in: "*IEEE Proceedings of ASDAM 2004*", (2004), S. 85 - 86.
3. J. Darmo, J. Kröll, M. Hulman, K. Unterrainer, H. Kuzmany:
"*Terahertz time-domain linear spectroscopy of single-walled carbon nanotube film*";
Talk: International Conference on Advanced Semiconductor Devices and Microsystems (ASDAM), Smolenice, Slovakia; 17.10.2004 - 21.10.2004; in: "*IEEE Conference Proceedings of the 5th International Conference on Advanced Semiconductor Devices and Microsystems 2004 04 EX876*", (2004), ISBN 0-7803-8535-7; S. 239 - 242.
4. J. Darmo, J. Kröll, K. Unterrainer:
"*Time and frequency resolved THz spectroscopy of micro- and nano-systems*";
Talk: 12th International Symposium on Ultrafast Phenomena in Semiconductors, Vilnius, Lithuania (invited); 22.08.2004 - 25.08.2004; in: "*Book of Abstracts*", (2004), ISBN 9986-9284-4-3; S. 13.
5. J. Darmo, J. Kröll, K. Unterrainer, M. Hulman, H. Kuzmany:
"*Terahertz time-resolved linear spectroscopy of single-wall carbon nanotube films*";
Talk: CLEO/IQEC 2004, San Franisco, USA; 16.05.2004 - 21.05.2004; in: "*Technical Digest*", (2004), Paper-Nr. JMB7, 2 S.
6. J. Darmo, J. Kröll, K. Unterrainer, M. Hulman, H. Kuzmany:
"*Absorption of single-wall carbon nanotubes at Terahertz frequencies*";
Poster: 12th International Conference on Terahertz Electronics, Karlsruhe, Deutschland; 27.09.2004 - 01.10.2004; in: "*IEEE Conference Digest of the 2004 IRMMW 2004/THz 2004 04EX857*", (2004), ISBN 0-7803-8490-3; S. 409 - 410.
7. J. Darmo, V. Tamosiunas, J. Kröll, T. Müller, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, K. West, L. Pfeiffer:
"*THz quantum cascade lasers: magnetic field effects and waveguide properties*";

Talk: 2004 MRS Fall Meeting, Boston, USA; 29.11.2004 - 03.12.2004; in: "*Abstracts*", (2004), S. 46.

8. V. Dubec, S. Bychikhin, D. Pogany, E. Gornik, N. Jensen, M. Stecher, G. Groos: "*Error Analysis in Phase Extracton in a 2D Hologrphic Imaging of Semiconductor Devices*";
   Talk: SPIE Conference, San Jose, California, USA; 18.01.2004 - 21.01.2004; in: "*Proceedings of the SPIE Vol.5290*", (2004), S. 233 - 241.
9. G. Fasching, W. Brezna, J. Smoliner, G. Strasser, K. Unterrainer: "*Photocurrent spectroscopy of single InAs/GaAs quantum dots*";
   Talk: Int. Conf. on Superlattices, Nanostructures and Nanodevices (ICSNN), Cancun, Mexico; 19.07.2004 - 23.07.2004; in: "*Programm & Abstracts*", (2004), S. 119 - 120.
10. S. Golka, M. Austerer, C. Pflügl, W. Schrenk, G. Strasser: "*Processing of Deeply etched GaAs/AlGaAs quantum casdade lasers with grating structures*";
    Talk: 2004 MRS Fall Meeting, Boston, USA; 29.11.2004 - 03.12.2004; in: "*Mater. Res. Soc: Symp. Proc. Vol 829*", (2004), S. 1 - 5.
11. S. Golka, W. Schrenk, G. Strasser: "*High aspect ratio etching with SiCl4 plasma for THz Photonic Crystals in GaAs*";
    Talk: Workshop on Compound Semiconductor Devices and Integrated Circuits (WOCSDICE), Smolenice Castle, Slovakia; 17.05.2004 - 19.05.2004; in: "*Proceeding of WOCSDICE 2004*", (2004), S. 127 - 128.
12. G. Hobler: "*Simulation of Focused Ion Beam Milling*";
    Talk: SEM X Int. Congress & Exposition on Experimental and Applied Mechanics, Costa Mesa, CA; 07.06.2004 - 10.06.2004; in: "*Proc. 5th Int. Symp. MEMS and Nanotechnology*", (2004), S. 46 - 51.
13. G. Hobler, A. Lugstein, W. Brezna, E. Bertagnolli: "*Simulation of focused ion beam induced damage formation in crystalline silicon*";
    Poster: Materials Research Society Fall Meeting (MRS), Boston/MA, USA; 01.12.2003 - 05.12.2003; in: "*Proceedings of MRS Fall Meeting 2003*", (2004), 6 S.
14. J. Kröll, J. Darmo, K. Unterrainer: "*Properties of ultra thin metal layers in the THz region*";
    Poster: Terahertz Workshop 2004 Technology and Application, Freiburg, Germany; 17.02.2004; in: "*Book of Abstracts*", (2004), S. 16.
15. J. Kröll, J. Darmo, K. Unterrainer: "*Terahertz electrodynaics of ultra thin Cr layers*";
    Talk: The 28th Workshop on Compound Semiconductor Devices and Integrated Circuits held in Europe, Smolenice, Slovakia; 17.05.2004 - 19.05.2004; in: "*WOCSDICE 2004*", (2004), ISBN 80-227-2050-X; S. 125 - 126.
16. J. Kröll, J. Darmo, K. Unterrainer: "*Terahertz spectroscopy of vibrational modes of molecular crystal of sucrose*";
    Talk: 11th International Conference of Terahertz Electronics, Karlsruhe, Deutschland; 27.09.2004 - 01.10.2004; in: "*IEEE Conference Digest of the 2004 IRMMW 2004/THz 2004 04EX857*", (2004), ISBN 0-7803-8490-3; S. 89 - 90.
17. J. Kröll, J. Darmo, K. Unterrainer: "*Ultra-thin metallic layers studied by broadband Terahertz time-domain spectroscopy*";
    Talk: 12th International Conference on Terahertz Electronics, Karlsruhe, Deutschland; 27.09.2004 - 01.10.2004; in: "*Conference Digest of the 2004 Joint*

*29th International Conference on Terahertz Electronics*", (2004), ISBN 0-7803-8490-3; S. 465 - 466.

18. J. Kröll, J. Darmo, K. Unterrainer:
"*High resolution Terahertz time-domain spectroscopy*";
Talk: CLEO/IQEC 2004, San Francisco, USA; 16.05.2004 - 21.05.2004; in:
"*Technical Digest*", (2004), Paper-Nr. JMB5, 2 S.

19. J. Kuzmik, S. Harasek, G. Constantinidis, S. Hascik, D. Pogany, E. Bertagnolli, A. Georgakilas:
"*Zr02/GaN metal oxide semiconductor structures characterization and application*";
Talk: Workshop on Compound Semiconductor Devices and Integrated Circuits (WOCSDICE), Smolenice Castle, Slovakia; 17.05.2004 - 19.05.2004; in:
"*Wocsdice 2004*", (2004), S. 35 - 36.

20. P Moens, S. Bychikhin, K Reynders, D. Pogany, M Zubeidat:
"*Effects of Hot Spot Hopping and Drain Ballasting in Integrated Vertical DMOS Devices under TLP Stress*";
Talk: International Reliability Physics Symposium (IRPS), Phoenix, USA; 25.04.2004 - 29.04.2004; in: "*Proceedings of the IRPS 2004*", (2004), S. 241 - 246.

21. P Moens, K Reynders, S. Bychikhin, D. Pogany, M Zubeidat:
"Optimization of Integrated Vertical DMOS Transistors for ESD Robustness";
Talk: ISPSD, Kitakyushu, Japan; 24.05.2004 - 27.05.2004; in: "Proceeding of 2004 International Symposium on Power Semiconductor Devices & ICs", (2004), S. 221 - 224.

22. T. Müller, F. Schrey, C. Pflügl, G. Strasser, K. Unterrainer:
"*Ultrafast intraband dynamics in quantum dots*";
Talk: CLEO/IQEC 2004, San Francisco, USA; 16.05.2004 - 21.05.2004; in:
"*Technical Digest*", (2004), Paper-Nr. IThJ4, 2 S.

23. G. Otto, G. Hobler:
"Coupled kinetic Monte Carlo and molecular dynamics simulations of implant damage accumulation in silicon";
Poster: Materials Research Society Fall Meeting (MRS), Boston/MA, USA; 01.12.2003 - 05.12.2003; in: "Proceedings of MRS Fall Meeting 2003", (2004), S. 1 - 6.

24. C. Pflügl, S. Golka, M. Austerer, W. Schrenk, A. M. Andrews, G. Strasser:
"*Surface Emitting Quantum Cascade Lasers*";
Talk: International Conference on Infrared and Millimeter Waves, Karlsruhe, Deutschland (invited); 27.09.2004 - 01.10.2004; in: "*Conference Digest of the IRMMW 2004*", (2004), S. 157 - 158.

25. C. Pflügl, S. Golka, M. Austerer, W. Schrenk, G. Strasser:
"*High power surface emitting quantum cascade lasers*";
Talk: Int. Conf. on Superlattices, Nanostructures and Nanodevices (ICSNN), Cancun, Mexico; 19.07.2004 - 23.07.2004; in: "*Programm and Abstracts*", (2004), S. 33 - 34.

26. C. Pflügl, T. Müller, W. Schrenk, T. Roch, M. Kast, F. Schrey, K. Unterrainer, G. Strasser:
"*Intraband dynamics and transitions in quantum dot structures*";
Talk: Workshop on Compound Semiconductor Devices and Integrated Circuits (WOCSDICE), Smolenice Castle, Slovakia; 17.05.2004 - 19.05.2004; in:
"*Proceeding of the WOCSDICE 2004*", (2004), S. 59 - 61.

27. W. Schrenk, C. Pflügl, S. Golka, T. Roch, G. Strasser:
"*GaAs/AlGaAs based Quantum Cascade Lasers*";

Talk: International Conference on Infrared and Millimeter Waves, Karlsruhe, Deutschland; 27.09.2004 - 01.10.2004; in: "*Confernce Digest of the IRMMW 2004*", (2004), S. 281 - 282.

28. F. F. Schrey, T. Müller, G. Fasching, G. Strasser, K. Unterrainer:
"*Ultrafast intersublevel spectroscopy on InAs/GaAs Quantum dots*";
Talk: Quantum Dots 2004, Banff, Canada; 10.05.2004 - 13.05.2004; in: "*Program and Book of Abstracts*", (2004), S. 135.

29. F. Schrey, G. Fasching, T. Müller, C. Pflügl, T. Roch, K. Unterrainer, G. Strasser:
"*Quantum dot inter-sublevel devices*";
Poster: 13th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Salzburg, Austria; 15.02.2004 - 20.02.2004; in: "*Book of Abstracts*", (2004), S. 119.

30. F. Schrey, D. Nguyen, T. Müller, L. Rebohle, N. Regnault, R. Ferreira, G. Bastard, G. Strasser, K. Unterrainer:
"*IR quantum dot detectors with miniband tunnel extraction*";
Talk: 12th International Conference on Terahertz Electronics, Karlsruhe, Deutschland; 27.09.2004 - 01.10.2004; in: "*IEEE Conference Digest of the 2004 IRMMW 2004/THz 2004 04EX857*", (2004), ISBN 0-7803-8490-3; S. 245 - 246.

31. V. Tamosiunas, S. Anders, T. Müller, W. Schrenk, G. Strasser, K. Unterrainer:
"*THz quantum cascade lasers: From quantum wells to quantum boxes*";
Talk: Colorado Meeting on Fundamental Optical Processes in Semiconductors (FOBS), Colorado, USA (invited); 08.08.2004 - 13.08.2004; in: "*Proceedings for the Colorado Meeting on Fundamental Optical Processes in Semiconductors*", (2004), S. 1.

32. V. Tamosiunas, G. Fasching, J. Darmo, J. Kröll, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, K. West, L. Pfeiffer, F. Capasso:
"*Magnetic quantization in terahertz Quantum cascade lasers*";
Poster: 13th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria; 15.02.2004 - 20.02.2004; in: "*Book of Abstracts*", (2004), S. 120.

33. V. Tamosiunas, Z. Kancleris, M. Dagys, R. Simniskis, M. Tamosiuniene, G. Valusis, G. Strasser, K. Unterrainer:
"*Finite-difference time-domain simulation of mid- and far-infrared quantum cascade lasers*";
Talk: 12th International Symposium on Ultrafast Phenomena in Semiconductors, Vilnius, Lithuania; 22.08.2004 - 25.08.2004; in: "*Book of Abstracts*", (2004), ISBN 9986-9284-4-3; S. 24.

34. V. Tamosiunas, R. Zobl, G. Fasching, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, L. Pfeiffer, K. West, F. Capasso:
"*Magnetic modulation of THz quantum cascade lasers*";
Talk: 12th International Conference on Terahertz Electronics, Karlsruhe, Deutschland; 27.09.2004 - 01.10.2004; in: "*IEEE Conference Digest of the 2004 IRMMW 2004/THz 2004 04EX857*", (2004), ISBN 0-7803-8490-3; S. 541 - 542.

35. K. Unterrainer:
"*Few-cycle terahertz generation and spectroscopy of nanostructures*";
Talk: 12th International Symposium on Ultrafast Phenomena in Semiconductors, Vilinius, Lithuania (invited); 22.08.2004 - 25.08.2004; in: "*Book of Abstracts*", (2004), ISBN 9986-9284-4-3; S. 3.

36. K. Unterrainer:
"*Field control of quantum cascade lasers*";
Talk: 3rd Akasaki Research Center Symposium: 2004 International (To the New

Horizon of the Nitride Research), Nagoya, Japan; 05.03.2004; in: "*Book of Abstracts*", (2004), S. 28.

37. K. Unterrainer:
"*Field control of THz quantum cascade lasers*";
Talk: International Workshop on Quantum Cascade Lasers, Seville, Spain (invited); 04.01.2004 - 08.01.2004; in: "*Abstract Book*", (2004), S. 55.

38. K. Unterrainer, J. Darmo, J. Kröll, T. Müller, G. Strasser, T. Le, A. Stingl:
"*Cavity enhanced THz generation*";
Talk: Photonics West, San Jose, CAL, USA (invited); 24.01.2004 - 29.01.2004; in: "*Technical Summary Digest*", (2004), S. 401.

39. K. Unterrainer, T. Müller, J. Darmo, G. Strasser:
"*Few-cycle THz generation and spectroscopy of nanostructures*";
Talk: The 28th Workshop on Compound Semiconductor Devices and Integrated Circuits held in Europe, Smolenice, Slovakia (invited); 17.05.2004 - 19.05.2004; in: "*WOCSDICE 2004*", (2004), ISBN 80-227-2050-X; S. 117.

40. K. Unterrainer, T. Müller, F. Schrey, G. Fasching, C. Pflügl, G. Strasser:
"*Interlevel dynamics in semiconductor nanostructures*";
Talk: 13th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria (invited); 15.02.2004 - 20.02.2004; in: "*Book of Abstracts*", (2004), S. 40.

41. L.R. Wilson, P. Green, A.B. Krysa, J.S. Roberts, H. Ng, D.G. Revin, C. Pflügl, W. Schrenk, G. Strasser, J.W. Cockburn:
"*High-performance quantum cascade lasers grown by metal-orgnic vapor phase epitaxy*";
Talk: SPIE Conference, Denver, USA; 01.08.2004 - 06.08.2004; in: "*Proc. SPIE Int. Soc. Opt. Eng.*", 5564 (2004), S. 156.

42. M. Wörner, F. Eickemeyer, K. Reimann, T. Elsaesser, S. Barbieri, C. Sirtori, T. Müller, R. Bratschitsch, K. Unterrainer, G. Strasser:
"*Coherent vs. incoherent charge transport in semiconductor quantum cascade structures*";
Talk: SPIE Conference, Denver, USA; 01.08.2004 - 06.08.2004; in: "*Proc. SPIE Int. Soc. Opt. Eng.*", 5352 (2004), S. 333.

43. R. Zobl, V. Tamosiunas, G. Fasching, J. Ulrich, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, L. Pfeiffer, K. West, F. Capasso:
"*Terahertz quantum cascade lasers operating in magnetic fields*";
Talk: The 16th International Conference on High Magnetic Fields in Semiconductor Physics, Tallahassee, Florida; 02.08.2004 - 06.08.2004; in: "*SemiMag- 16*", (2004), S. 7.

## Presentations without Proceedings

1. A. M. Andrews, C. Pflügl, M. Austerer, T. Roch, W. Schrenk, M. Kast, G. Strasser:
"*High performance GaAs-based Quantum Cascade Lasers*";
Talk: North American Conf. on Molecular Beam Epitaxy (NAMBE), Banff, Canada; 10.10.2004 - 14.10.2004.

2. W. Brezna, S. Harasek, A. Lugstein, T Leitner, H Hoffmann, E. Bertagnolli, J. Smoliner:
"*Quantitative Scanning Capacitanc Spectroscopy*";
Talk: International Conference on Physics of Semiconductor (ICPS), Flagstaff, Arizona, USA (invited); 26.07.2004 - 30.07.2004.

3. W. Brezna, M. Schramböck, A. Lugstein, S. Harasek, H. Enichlmair, E. Bertagnolli, E. Gornik, J. Smoliner:
"*Quantitative Scanning Capacitance Sppecroscopy*";
Talk: 8th Int. Conference on Nanometer Scale Science and Technology, Venice, Italy; 29.06.2004 - 01.07.2004.

4. S. Bychikhin, V. Dubec, D. Pogany, E. Gornik, M. Graf, V. Dudek, W. Soppa:
"*Transient interferometric mapping of smart power SOI ESD protection devices under TLP and vf-TLP stress*";
Talk: European Symposium on Reliability of Electron Devices, Failure Physics and Analysis (ESREF), Zürich, Schweiz; 04.10.2004 - 08.10.2004.

5. M. Coquelin, C Pacher, M. Kast, G. Strasser, E. Gornik:
"*Interlevel crossing in double period superlattices*";
Poster: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

6. J. Darmo, J. Kröll, T. Müller, G. Strasser, K. Unterrainer:
"*Cavity enhanced THz generation*";
Talk: Terahertz and Gigahertz Electronics and Photonics III, part of the Photoncs West Symposium Optoelectronics 2004: Integrated Optoelectronics Devices, San Jose, USA (invited); 24.01.2004 - 29.01.2004.

7. J. Darmo, J. Kröll, G. Strasser, K. Unterrainer:
"*Linear spectroscopy and imgaging with compact Terahertz sources*";
Talk: Terahertz Workshop 2004 Technology and Application, Freiburg, Germany (invited); 17.02.2004.

8. V. Dubec, S. Bychikhin, M. Blaho, M. Heer, D. Pogany, E. Gornik, M. Denison, N. Jensen, M. Stecher, G. Groos:
"*Multiple-time-instant 2D thermal mapping during a single ESD event*";
Talk: European Symposium on Reliability of Electron Devices, Failure Physics and Analysis (ESREF), Zürich, Schweiz; 04.10.2004 - 08.10.2004.

9. J.N. Heyman, N Coates, A Reinhardt, G. Strasser:
"*Ultrafast THz measurements of Hot Carrier Diffusion and Drift in Semiconductors*";
Poster: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

10. M. Kast, W Boxleitner, G. Strasser, E. Gornik:
"*High-resolution ballistic electron spectroscopy in parallel magnetic fields*";
Poster: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

11. C. Kranz, A. Kueng, A. Lugstein, E. Bertagnolli, B. Mizaikoff:
"*AFM Tip Integrated Electrochemical Biosensors for Simultaneous Topographical and Activity Mapping of Soft Samples*";
Talk: Annual Linz Winter Workshop on Scanning Probe Microscopy, Linz, Austria; 31.01.2004 - 02.02.2004.

12. C. Kranz, A. Kueng, A. Lugstein, E. Bertagnolli, B. Mizaikoff:
"*AFM-Tip Integrated Electrochmical Sensors - Simulaneous Electrochemical and AFM Imaging in Dynamic Mode Operation*";
Talk: 205th Meeting of the Electrochemical Society, San Antonio, TX; 09.05.2004 - 13.05.2004.

13. A. Lugstein, B. Basnar, E. Bertagnolli:
"*Metallic nanodots realized by a subtractive self organization process*";
Talk: European Materials Research Society (EMRS), Strassbourg, France; 24.05.2004 - 28.05.2004.

14. A. Lugstein, B. Basnar, W. Brezna, M. Weil, S. Golka, E. Bertagnolli:
"*Advanced nanopattern formation by a subtractive self organization process with Focused Ion Beams*";
Poster: International Conference on Ion Beam Modification of Materials (IBMM), Monterey, California, USA; 05.09.2004 - 10.09.2004.

15. A. Lugstein, B. Basnar, M. Weil, J. Smoliner, E. Bertagnolli:
"*Advanced nanoscale material processing with focused ion beams*";
Talk: International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication (EIPBN), San Diego; 01.06.2004 - 04.06.2004.

16. A. Lugstein, M. Weil, E. Bertagnolli:
"*Advanced nanopattern formation by a subtractive self organization process with Focused Ion Beams*";
Poster: European FIB User Group Meeting, Dübendorf, Schweiz; 01.10.2004.

17. C. Pflügl:
"*Quantum Dot Intraband Emission*";
Talk: Workshop on THz Electronics and Quantum Heterostructures, Regensburg, Deutschland (invited); 05.02.2004.

18. C. Pflügl, M. Austerer, W. Schrenk, T. Roch, S. Anders, G. Strasser:
"*Surface emitting quantum cascade laser*";
Talk: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

19. C. Pflügl, M. Austerer, W. Schrenk, T. Roch, G. Strasser:
"*Bound-to-Continuum GaAs/AlGaAs Quantum Cascade Laser*";
Poster: 13th Int. Winterschool on New Developments in Solid State Physics, Mauterndorf, Österreich; 15.02.2004 - 20.02.2004.

20. C. Pflügl, W. Schrenk, M. Kast, T. Roch, K. Unterrainer, G. Strasser:
"*Utilizing quantum dots in unipolar intraband emitters*";
Poster: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

21. G. Pillwein, G. Brunthaler, G. Strasser:
"*Conductance Fluctuations in the Coulomb Blockade Regime in AlGaAs Quantum Dots*";
Poster: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

22. G. Pillwein, G. Brunthaler, G. Strasser:
"*Fabrication and Characterisation of Lateral Quantum Dots in GaAs/AlGaAs Heterostructures*";
Poster: 13th Int. Winterschool on New Developments in Solid State Physics, Mauterndorf, Österreich; 15.02.2004 - 20.02.2004.

23. G. Pillwein, G. Brunthaler, G. Strasser:
"*Leitwertfluktuation im Coulomb Blockade Regime von AlGaAs Quantenpunkten*";
Poster: 54. Jahrestagung der Österreichischen Physikalischen Gesellschaft, Linz, Austria; 28.09.2004 - 30.09.2004.

24. T. Roch, W. Schrenk, F. Schrey, K. Unterrainer, G. Strasser:
"*X-ray investigation of quantum well intermixing after postgrowth rapid thermal processing*";
Poster: 7th Biennial Conference on High Resolution X-Ray Diffraction and Imaging (XTOP), Prag, Czech Republic; 07.09.2004 - 10.09.2004.

25. F. Schrey, G. Fasching, T. Müller, G. Strasser, K. Unterrainer:
"*Ultrafast intersublevel spectroscopy of a single quantum dot*";

Poster: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

26. G. Strasser:
"*Design, growth and processing of GaAs-based Quantum Cascade Lasers*";
Talk: Int. Conf. on Solid State Crystals & 7th Polish Conf. on Crystal Growth, Zakopane, Poland (invited); 16.05.2004 - 20.05.2004.

27. G. Strasser:
"*High Power Single Mode Surface Emission of Quantum Cascade Lasers*";
Talk: Semiconductor Physics Institute, Vilnius, Germany (invited); 26.11.2004.

28. V Tamosiunas, S Anders, T. Müller, W. Schrenk, G. Strasser, K. Unterrainer:
"*THz Quantum Cascade Lasers: From quantum wells to quantum boxes*";
Talk: Fundamental Optical Prosesses in Semiconductors (FOPS), Estes Park, USA; 08.08.2004 - 13.08.2004.

29. V Tamosiunas, R. Zobl, G. Fasching, T. Müller, J. Darmo, J. Kröll, G. Strasser, K. Unterrainer, R. Colombelli, C. Gmachl, K. West, L. Pfeiffer, F. Capasso:
"*Field Control of THz Quantum Cascade Lasers*";
Talk: International Conference on Physics of Semiconductor (ICPS), Flagstaff, USA; 26.07.2004 - 30.07.2004.

30. H. D. Wanzenböck:
"*Electron beam systems - Nanotechnology and Applications in Semiconductor Technology*";
Talk: Leo GEMINI Meeting, Oberkochen, Germany (invited); 04.05.2004 - 05.05.2004.

31. K. Unterrainer:
"*Few cycle THz spectroscopy of semiconductor nanostructures*";
Talk: Seminar MSI Molecular Science Center Okazaki, Okazaki, Japan (invited); 27.02.2004.

32. K. Unterrainer:
"*Magnetic quantization in terahertz Quantum cascade lasers*";
Talk: Seminar University of Tokyo, Institute of Industrial Science, Tokyo, Japan (invited); 01.03.2004.

33. K. Unterrainer:
"*Materials - semiconductor and insulators*";
Talk: DOE-NSF-NIH, Washington, USA (invited); 12.02.2004 - 14.02.2004.

34. K. Unterrainer:
"*Quantum cascade structures*";
Talk: Colorado Meeting on Fundamental Optical Processes in Semiconductors (FOBS), Estes Park, COL, USA (invited); 08.08.2004 - 13.08.2004.

35. K. Unterrainer:
"*Quantum dots for infrared photonics*";
Talk: Pauli Colloquium of the Wolfgang Pauli Institute, TU Wien, Wien, Austria (invited); 12.09.2004.

36. K. Unterrainer:
"*Semiconductor nanostructures: THz spectroscopy - coherent control*";
Talk: SFB- Quanten-Interferenz-Kolloquium, Atominstitut Wien (invited); 10.12.2004.

37. K. Unterrainer:
"*Time resolved spectroscopy and control of semiconductor nanostructures*";
Talk: Applied Physics Colloquium, University Princeton, USA (invited); 29.11.2004.

38. R. Zobl, V Tamosiunas, G. Fasching, J. Ulrich, G. Strasser, K. Unterrainer: "*Terahertz Quantum Cascade Lasers Operating in Magnetic Fields*"; Talk: International Conference on High Magnetic Fields in Semiconductor Physics (SEMIMAG), Tallahassee, USA; 02.08.2004 - 06.08.2004.

## Doctor's Theses

1. Doris Rakoczy, "Elektronentransport durch Gebiete unterschiedlicher Elektronenmasse", TU Wien, May 2004

## Diploma Works

1. R. Pichler, "Untersuchung der Zündhomogenität von gg-nMOS ESD-Schutzstrukturen mittels optischer Interferometrie", TU Wien, June 2004
2. Philipp Schwaha, "*Quantum Cascade Ring Lasers*", TU Wien, March 2004
3. Karl Gruber, "Processing of Bragg Reflectors with Saturable Absorbers and LT-GaAs Emitter", TU Wien, April 2004
4. Maximilian Austerer, "*Surface Emitting Quantum Cascade Lasers*", TU Wien, May 2004
5. Matthias Schramböck, "Quantitative CV-Messungen mit dem Rasterkapazitäts–mikroskop", TU Wien, June 2004
6. Stefan Müller, "Elektronenstrahlinduzierte Abscheidung von Festkörperfilmen aus der Gasphase", TU Wien, October 2004
7. Thomas Zahel, "Investigation of the isotope effect in hydrogen-induced blistering of silicon using kinetic Monte Carlo simulation", TU Wien, December 2004

## Cooperations

1. JKU Linz, G. Bauer, W. Heiss, W. Jantsch, L. Palmetshofer, F. Schäffler
2. Universität Wien, H. Kauffmann, G. Kresse
3. TU Wien, H. Rauch, H. Hutter, P. Pongratz, G. Lendl
4. Universität für Bodenkultur Wien, U.Sleytr, D. Pum
5. Montanuniversität Leoben, F. Kuchar
6. Austrian Research Centers, H. Brückl
7. AMS-Unterbremstätten, H. Enichlmair, K. Tschernay, F. Unterleitner
8. Femtolasers, Wien, A. Stingl
9. High Q Laser, Hohenems, Dr. D. Kopf
10. IMS, Wien, E. Fantner, E. Platzgummer
11. AMIS, Oudenaarde, P. Moens, Belgien
12. Interuniversity Microelectronics Center (IMEC), Leuven, N. Mahadeva, Belgien
13. Siemens AG, E. Wolfgang, G. Sölkner, W. Maurer, A. Felder, Deutschland
14. Infineon München, M. Stecher, W. Stadler, Deutschland
15. ATMEL, Heilbronn, M. Graaf, Deutschland

16. TU-München, G. Abstreiter, P. Vogl, Deutschland
17. Universität Regensburg, W. Wegscheider, Deutschland
18. Friedrich-Schiller-Universität Jena, K. Gärtner, Deutschland
19. TU Braunschweig, D. Schneider, Deutschland
20. Technische Universität Berlin, D. Bimberg, Deutschland
21. Heinrich Hertz Institut, Berlin, H. Künzel, Deutschland
22. Paul Drude Institut, Berlin, H. Grahn, Deutschland
23. Institut für Kriststallzucht, Berlin, M. Albrecht, Deutschland
24. Universität Bremen, D. Hommel, Deutschland
25. Forschungszentrum Rossendorf, Dresden, M. Helm, Deutschland
26. Bosch, Reutlingen, W. Wilkening, Deutschland
27. XFAB, Erfurt, C. Foss, Deutschland
28. IZM Frauenhofer Institut, München, H. Grieser, Deutschland
29. Max Born Institut, Berlin, K. Reimann, M. Wörner, Deutschland
30. University Ulm, E. Kohn, Deutschland
31. University Darmstadt, D. Pavlidis, Deutschland
32. IZM Fraunhofer Institute, Munich, H. Gieser, H. Wolf, Deutschland
33. University of Armed Forces, Neubiberg, G. Groos, Deutschland
34. Research Center Jülich, Jülich, P. Kordos, Deutschland
35. WITEC, Ulm, O. Hollricher, Deutschland
36. MPI, Halle, U. Gösele, Deutschland
37. Imperial College, London, C. Phillips, England
38. Univ. Leeds, G. Davis, England
39. University of Sheffield, M. Skolnick, J. Cockburn, England
40. University of Surrey, B.N. Murdin, England
41. University Limoges, J.-P. Teyssier, Frankreich
42. University Lille, IEMN, De Jaeger, Frankreich
43. Centre National de la Recherche Scientific, Laboratoire de Microstructures et de Microelectronique, B. Etienne, Cedex, Frankreich
44. CEA, Grenoble, E. Monroy, Frankreich
45. Thales, Orsay , H. Page, D. Corbin, S. Delage, Frankreich
46. Universite Paris Sud, F. Julien, Frankreich
47. Universite Paris 7, C. Sirtori, Frankreich
48. FORTH, Crete, Konstantinidis, G. Georgakilas, Griechenland
49. Technische Universität Delft, P. Planken, Holland
50. Philips Neimegen, T. Smedes, Holland
51. Sub-Micron Center, Weizmann Institute, Rehovot, M. Heiblum, Israel
52. INFM-SNS Pisa, F. Beltram, A. Tredicucci, Italien

53. TASC Trient, L. Sorba, Italien
54. Universita Bari, G. Scamarcio, Italien
55. STMicroelectronics, A. Andreini, Italien
56. University Bologna, Bologna, G. Baccarani, S. Reggiani, Italien
57. Univ. Osaka, C. Hamaguchi, Japan
58. Univ. Nagoya, N. Sawaki, Japan
59. RIKEN, K. Ishibashi, Japan
60. Universite de Quebec, Quebec, B. Terreault, Kanada
61. TopGaN, Warschau, C. Skierbiszewski, S. Porowski, Polen
62. UniPress, Warschau, T. Suski, P. Perlin, Polen
63. Ioffe Physico-Technical Institute, St. Petersburg, Y. Ivanov, P. Rodin, Rußland
64. Herriot Watt University, Edinburgh, C. Pidgeon, Schottland
65. Univ. Glasgow, C. Ironside, Schottland
66. University Neuchatel, J. Faist, Schweiz
67. EPFL Lausanne, M. Ilegems, N Grandjean, Schweiz
68. ETH Zürich, W. Fichtner, Schweiz
69. Alpes Lasers, Neuchatel, A. Müller, Schweiz
70. EMPA, Thun, J. Michler, Schweiz
71. Slovak Academy of Sciences, Bratislava, Slowakei
72. Univ. of California, Lawrence Berkeley Laboratories, E. E. Haller , USA
73. Univ. of California, Los Angeles, S. Prussin, USA
74. Univ. of California, Santa Barbara, J. Allen, A. Gossard, M. Sherwin, USA
75. Columbia University, New York, H. Störmer, USA
76. Princeton University, C. Gmachl, S. Lyon, USA
77. Boston College, Boston, MA, K. Kempa, P. Bakshi, USA
78. EPI MBE Components, St. Paul, Minnesota, USA