

# Cleanroom Vienna

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In this report a summary of the main activities in the ZMNS TU Wien (*Zentrum für Mikro- und Nanostrukturen der Technischen Universität Wien*) during the years 2005 and 2006 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, 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*) and the photonics institute (*Photonik TU Wien*) during the last two years. 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 and Nanowires
- Transport in III-V Semiconductors
- Silicon Device Testing
- Focused Ion Beam and Electron 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 and advanced nanowire growth techniques), as well as a complete process line including structure definition (lithography), structure transfer (reactive ion etching, focused ion

beam etching and deposition, wet chemical etching 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.

In 2006, a new electron beam lithography system and an atomic layer deposition system had been installed, extending the possibilities in nanostructure fabrication.

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**

- A.M. Andrews *et al.*: Optimization of MBE Growth Parameters for GaAs-based THz Quantum Cascade Lasers (*page 33*)
- M. Austerer *et al.*: Vertical Second-Harmonic Emission from Quantum Cascade Lasers (*page 37*)
- M. Austerer *et al.*: Second-Harmonic Emission from Quantum Cascade Lasers (*page 41*)
- A. Benz *et al.*: Doping in Terahertz Quantum-Cascade Lasers (*page 45*)
- G. Fasching *et al.*: Mode Degeneracy of “Single-Mode” Whispering-Gallery Terahertz Quantum Cascade Lasers (*page 49*)
- T. Gebhard *et al.*: Polarization Dependence of Photocurrent in Quantum-Dot Infrared Photodetectors (*page 53*)
- L.K. Hoffmann *et al.*: Y-coupled Quantum Cascade Lasers (*page 59*)
- M. Martl *et al.*: THz Time-Domain Spectroscopy of Surface Plasmon Polaritons on Periodic Metal Arrays (*page 63*)
- W. Parz *et al.*: Time Domain Spectroscopy of Mid Infrared Quantum Cascade Lasers (*page 67*)
- S. Schartner *et al.*: Far Field Investigations on Quantum Cascade Lasers (*page 71*)
- W. Brezna *et al.*: Force and Bias Dependent Contrast in Atomic Force Microscopy Based Photocurrent Imaging on GaAs-AlAs Heterostructures (*page 75*)

### **Quantum Dots and Nanowires**

- A.M. Andrews *et al.*: MBE Growth of GaAs Whiskers on LPCVD Si Nanowire Trunks (*page 83*)
- T. Müller *et al.*: Ultrafast Spectral Hole Burning Spectroscopy of Exciton Spin Relaxation in Quantum Dots (*page 87*)

- T. Gebhard *et al.*: Polarization Dependence of Photocurrent in Quantum-Dot Infrared Photodetectors (*page 91*)
- A. Lugstein *et al.*: Growth of Branched Single Crystalline GaAs Whiskers on Si Nanowire Trunks (*page 97*)
- A. Lugstein *et al.*: Ga/Au Alloy Catalyst for Single Crystal Silicon-Nanowire Epitaxy (*page 101*)
- M. Schramboeck *et al.*: Self-Assembled InAs QDs Grown on AlGaAs Surfaces (*page 105*)
- F.F. Schrey *et al.*: Ultrafast Spectroscopy of QD Structures for Mid-Infrared Applications (*page 111*)

### **Transport in III-V Semiconductors**

- S. Golka *et al.*: Dislocation-Free GaN/AlGaN Double-Barrier Diodes Grown on Bulk GaN (*page 115*)
- J. Kuzmik *et al.*: InAlN/GaN HEMTs: A First Insight into Technological Optimization (*page 119*)
- J. Kuzmik *et al.*: Influence of Surface Trapping on Determination of Electron Saturation Velocity in AlGaN/GaN Heterostructures (*page 123*)
- S. Özcan *et al.*: Ballistic Electron Emission Microscopy/Spectroscopy on Au/Titanyl-phthalocyanine/GaAs Heterostructures (*page 127*)
- G. Pozzovivo *et al.*: Technology of InAlN/(In)GaN-Based HEMTs (*page 133*)

### **Silicon Device Testing**

- S. Abermann *et al.*: Comparative Study on the Impact of TiN and Mo Metal Gates on MOCVD-Grown HfO<sub>2</sub> and ZrO<sub>2</sub> High-k Dielectrics for CMOS Technology (*page 137*)

### **Focused Ion Beam and Electron Beam Developments**

- A. Lugstein *et al.*: Synthesis of Nanowires in Room Temperature Ambient with Focused Ion Beams (*page 141*)
- C. Schoendorfer *et al.*: Focused Ion Beam Induced Synthesis of a Porous Antimony Nanowires Network (*page 145*)
- C. Schoendorfer *et al.*: Focused Ion Beam Induced Nanodot, Nanocrystal and Nanofiber Growth (*page 149*)
- H.D. Wanzenboeck *et al.*: Perpendicular Iron Nanopillars by Electron Beam Induced Deposition (*page 153*)
- H. Wanzenboeck *et al.*: Pure Silicon Oxide by Electron Beam Induced Deposition for Nanooptical Applications (*page 159*)

### **Novel Characterization Techniques and Devices**

- S. Schartner *et al.*: Photonic Band Structure Mapping in Mid-Infrared Photodetectors (*page 163*)

## Project Information

### Project Manager

**Ao.Univ.Prof. Dr. Gottfried Strasser**

Institut für Festkörperelektronik und ZMNS  
 Floragasse 7  
 A-1040 Wien

### Project Group

Last Name	First Name	Status	Remarks
Abermann	Stephan	dissertation	
Andrews	A. Maxwell	postdoc	
Auer	Erwin	univ. ass.	
Austerer	Maximilian	dissertation	
Bae	Kim Heung	dissertation	
Benz	Alexander	student	
Bertagnolli	Emmerich	o. prof.	
Blaho	Matej	dissertation	
Bychikhin	Sergey	postdoc	
Brezna	Wolfgang	postdoc	
Coquelin	Michael	dissertation	
Dalibor	Kovac	dissertation	
Darmo	juraj	univ. ass.	
Dominizi	Karl	student	
Dubec	Viktor	dissertation	
Dzidal	Elvira	technician	
Fasching	Gernot	dissertation	
Fischer	Markus	dissertation	
Gebhard	Thomas	dissertation	
Golka	Sebastian	dissertation	
Gornik	Erich	o. prof.	
Heer	Michael	dissertation	
Hobler	Gerhard	ao. prof.	
Hochleitner	Gottfried	student	
Hoffmann	Leonard	dissertation	
Hyun	Youn-Joo	dissertation	
Klang	Pavel	postdoc	
Köck	Thomas	student	

Last Name	First Name	Status	Remarks
Kröll	Josef	dissertation	
Kröll	Peter	technician	
Kuzmik	Ian	postdoc	
Lugstein	Alois	ass. Prof.	
Mujagic	Elvis	student	
Müller	Thomas	univ. ass.	
Nobile	Michele	dissertation	
Otto	Gustav	dissertation	
Özcan	Soner	dissertation	
Pacher	Christoph	dissertation	
Parz	Wolfgang	dissertation	
Pogany	Dionyz	ao. prof.	
Pozzovivo	Gianmauro	dissertation	
Prinzinger	Johannes	technician	
Riegler	Erich	technician	
Roch	Tomas	postdoc	
Schartner	Stefan	dissertation	
Schinnerl	Markus	technician	
Schenold	Helmut	technician	
Schöndorfer	Christoph	dissertation	
Schramböck	Matthias	dissertation	
Schrenk	Werner	cleanroom director	
Schrey	Frederik	dissertation	
Smoliner	Jürgen	ao. prof.	
Steiger	Andreas	dissertation	
Steinmair	Matthias	dissertation	
Strasser	Gottfried	ao. prof.	
Svarc	Markus	student	
Tamosiunas	Vincas	postdoc	
Unterrainer	Karl	prof.	
Wanzenböck	Heinz	ass. Prof.	
Zahel	Thomas	student	
Zobl	Reinhard	postdoc	

## Publications in Reviewed Journals

1. S. Abermann, W. Brezna, J. Smoliner, E. Bertagnolli:  
*"Nanoscopic versus macroscopic C-V characterization of high-k - MOCVD ZrO<sub>2</sub> thin films"*;  
 Microelectronic Engineering, **83** (2006), S. 1055 - 1057.

2. S. Abermann, C. Jordan, M. Harasek, E. Bertagnolli:  
"Processing and simulation of few nm thick high-k dielectric films";  
Microelectronic Engineering, **83** (2006), S. 1571 - 1572.
3. M. Austerer, C. Pflügl, S. Golka, W. Schrenk, A. M. Andrews, T. Roch, G. Strasser:  
"Coherent 5.35  $\mu\text{m}$  surface emission from a GaAs-based distributed feedback quantum-cascade laser";  
Applied Physics Letters, **88** (2006), S. 1211041 - 1211043.
4. M. Austerer, S. Schartner, C. Pflügl, A. M. Andrews, T. Roch, W. Schrenk, G. Strasser:  
"Second-harmonic generation in GaAs-based quantum cascade lasers";  
Physica E, **35** (2006), S. 234 - 240.
5. E. Baumann, F. Giorgetta, D. Hofstetter, S. Golka, W. Schrenk, G. Strasser, L. Kirste, E. Feltin, J. Carlin, N. Grandjean:  
"Near infrared absorption and room temperature photovoltaic response in AlN/GaN superlattices grown by metal-organic vapour-phase epitaxy";  
Applied Physics Letters, **89** (2006), S. 0411061 - 0411063.
6. e. Bogner, K. Dominizi, P. Hagl, E. Bertagnolli, M. Wirth, F. Gabor, W. Brezna, H. D. Wanzenböck:  
"Bridging the gap - Biocompatibility of microelectronic materials";  
Acta Biomaterialia, **2** (2006), 2; S. 229 - 237.
7. W. Brezna, M. Fischer, H. D. Wanzenböck, E. Bertagnolli, J. Smoliner:  
"Electron beam deposited SiO<sub>2</sub> investigated by Scanning Capacitance Microscopy";  
Applied Physics Letters, **88** (2006), S. 1221161 - 1221163.
8. M. Coquelin, C. Pacher, M. Kast, G. Strasser, E. Gornik:  
"Wannier-Stark level anticrossing in biperiodic superlattices";  
Physica Status Solidi (b), **14** (2006), S. 3692 - 3695.
9. G. Fasching, A. Benz, R. Zobl, A.M. Andrews, T. Roch, W. Schrenk, G. Strasser, V. Tamosiunas, K. Unterrainer:  
"Microcavity THz quantum cascade laser";  
Physica E, **32** (2006), S. 316 - 319.
10. G. Fasching, F. Schrey, T. Roch, A.M. Andrews, W. Brezna, J. Smoliner, G. Strasser, K. Unterrainer:  
"Single InAs/GaAs quantum dots: photoncurrent and cross-sectional AFM analysis";  
Physica E, **32** (2006), S. 183 - 186.
11. M. Fischer, H. D. Wanzenböck, J. Gottsbachner, S. Müller, W. Brezna, M. Schramböck, E. Bertagnolli:  
"Direct-Writing with a Focused Electron Beam";  
Microelectronic Engineering, **83** (2006), S. 784 - 787.
12. S. Golka, C. Pflügl, W. Schrenk, G. Strasser, C. Skierbiszewski, M. Siekacz, I. Grzegory, S. Porowski:  
"Negative differential resistance in dislocation-free GaN/AlGaIn double-barrier diodes grown on bulk GaN";  
Applied Physics Letters, **88** (2006), S. 1721061 - 1721063.
13. M. Heer, V. Dubec, S. Bychikhin, D. Pogany, E. Gornik, M. Frank, A. Konrad, J. Schulz:  
"Analysis of triggering behaviour of high voltage CMOS LDMOS clamps and SCRs during ESD induced latch-up";  
Microelectronics Reliability, **46** (2006), S. 1591 - 1596.

14. G. Hobler, K. Bourdelle, T. Akatsu:  
"Random and channeling stopping power of H in Si below 100keV";  
Nuclear Instruments & Methods B, **242** (2006), S. 617 - 619.
15. D. Kovac, G. Hobler:  
"Investigation of the impact of defect models on Monte Carlo simulations of RBS/C spectra";  
Nuclear Instruments & Methods B, **249** (2006), S. 776 - 779.
16. J. Kuzmik, S. Bychikhin, D. Pogany, C. Gaquière, E. Morvan:  
"Current conduction and saturation mechanism in AlGaN/GaN ungated structures";  
Journal of Applied Physics, **99** (2006), S. 1237201 - 1237207.
17. J. Kuzmik, T. Kostopoulos, G. Konstantinidis, J. Carlin, A. Georgakilas, D. Pogany:  
"InAlN/GaN HEMTs: A first insight into technological optimization";  
IEEE Transactions on Electron Devices, **53** (2006), 3; S. 422 - 426.
18. A. Lugstein, B. Basnar, W. Brezna, M. Weil, S. Golka, E. Bertagnolli:  
"Advanced nanopattern formation by a subtrative self-organization process with focused ion beams";  
Nuclear Instruments & Methods B, **242** (2006), S. 93 - 95.
19. A. Lugstein, J. Bernardi, C. Tomastik, E. Bertagnolli:  
"Synthesis of nanowires in room temperature ambient: A focused ion beam approach";  
Applied Physics Letters, **88** (2006), S. 1631141 - 1631143.
20. P. Moens, S. Bychikhin, D. Pogany:  
"Ruggedness of integrated VDMOS transistors under TLP stress";  
IEEE Transactions on Device and Materials Reliability, **6** (2006), 3; S. 393 - 398.
21. O. Moutanabbir, B. Terreault, M. Chicoine, J. Simpson, T. Zahel, G. Hobler:  
"Hydrogen/Deuterium-defect complexes involved in the ion cutting of Si (0 0 1) at the sub-100 nm scale";  
Physica B, **376** (2006), S. 36 - 40.
22. T. Müller, G. Strasser, K. Unterrainer:  
"Ultrafast spectral hole burning spectroscopy of exciton spin flip processes in InAs/GaAs quantum dots";  
Applied Physics Letters, **88** (2006), 192105.
23. G. Otto, G. Hobler, L. Palmetshofer, K Mayerhofer, K Piplits, H. Hutter:  
"Dose-rate dependence of damage formation in Si by N implantation as determined from channeling profile measurements";  
Nuclear Instruments & Methods B, **242** (2006), S. 667 - 669.
24. G. Otto, G. Hobler, L. Palmetshofer, P. Pongratz:  
"Amorphous pocktes in Si: Comparison of coupled molecular dynamics and TEM image contrast simulations with experimental results";  
angenommen für Nuclear Instruments & Methods B.
25. G. Otto, G. Hobler, P. Pongratz, L. Palmetshofer:  
"s there an influence of ion-beam-induced interfacial amorphization on the a/c-interface depth in silicon at common implantation energies?";  
Nuclear Instruments & Methods B, **253** (2006), S. 227 - 231.
26. C. Pflügl, M. Austerer, S. Golka, W. Schrenk, A. M. Andrews, T. Roch, G. Strasser:  
"Second-harmonic generation in three-well and bound-to-continuum GaAs-based quantum-cascade lasers";  
Applied Physics B, **85** (2006), S. 231 - 234.

27. D. Rakoczy, G. Strasser, J. Smoliner:  
"Cross Sectional Ballistic Electron Emission Microscopy for Schottky Barrier Height Profiling on Heterostructures";  
Journal of Applied Physics, **45** (2006), 3B; S. 2204 - 2207.
28. S. Schartner, S. Golka, C. Pflügl, W. Schrenk, A. M. Andrews, T. Roch, G. Strasser:  
"Band structure mapping of photonic crystal intersubband detectors";  
Applied Physics Letters, **89** (2006), S. 1511071 - 1511073.
29. S. Schartner, S. Golka, C. Pflügl, W. Schrenk, G. Strasser:  
"Deeply etched waveguides structures for quantum cascade lasers";  
Microelectronic Engineering, **83** (2006), S. 1163 - 1166.
30. C. Schöndorfer, A. Lugstein, E. Bertagnolli:  
"Focused Ion Beam induced Nanodot and Nanofiber Growth";  
Microelectronic Engineering, **83** (2006), S. 1491 - 1494.
31. M. Schramböck, A. M. Andrews, T. Roch, W. Schrenk, A. Lugstein, G. Strasser:  
"Nano-patterning and growth of self-assembled quantum dots";  
Microelectronics Journal, **37** (2006), S. 1532 - 1543.
32. M. Schramböck, W. Schrenk, T. Roch, A. M. Andrews, M. Austerer, G. Strasser:  
"Self organized InAs quantum dots grown on patterned GaAs substrates";  
Microelectronic Engineering, **83** (2006), S. 1573 - 1576.
33. F. Schrey F., D. Nguyen, N. Regnault, R. Ferreira, G. Bastard, G. Strasser, K. Unterrainer:  
"Optical properties of IR quantum dot detectors with miniband tunnel extraction";  
angenommen für Journal of Applied Physics 2006 (2006).
34. H. D. Wanzenböck, C. Ostermaier, A. Gruen, B. Eichinger, M. Karner, E. Bertagnolli:  
"Dot-array implantation for patterned doping of semiconductors";  
Nuclear Instruments & Methods B, **242** (2006), S. 257 - 260.

### **Talks and Poster Presentations (with Proceedings):**

1. R. Heer, J. Smoliner, J. Bornemeier, H. Brückl:  
"Temperature Dependent Ballistic Electron Transport in Spin Valve Transistors";  
Vortrag: International Conference on Nonequilibrium Carrier Dynamics in Semiconductors (HCIS), Chicago, USA; 24.07.2005 - 29.07.2005; in:  
"Nonequilibrium Carrier Dynamics in Semiconductors/Proceedings of the 14 International Conference", (2006), S. 159 - 162.
2. A. M. Andrews, T. Roch, G. Fasching, W. Schrenk, R. Zobl, K. Unterrainer, G. Strasser:  
"Growth Optimization of GaAs-based Quantum Cascade Laser for Terahertz Emission";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf; 13.02.2006 - 17.02.2006; in: "Book of Abstracts", (2006), S. 148.
3. M. Austerer, S. Schartner, S. Golka, C. Pflügl, W. Schrenk, A. M. Andrews, T. Roch, G. Strasser, R. Green, L.R. Wilson, J.W. Cockburn, A.B. Krysa, J.S. Roberts:  
"Single mode quantum cascade lasers";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf; 13.02.2006 - 17.02.2006; in: "Book of Abstracts", (2006), S. 149 - 150.



4. G. Fasching, A. Benz, A.M. Andrews, K. Unterrainer, R. Zobl, T. Roch, W. Schrenk, G. Strasser, V Tamosiunas:  
"Microcavity THz quantum cascade laser";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria; 13.02.2006 - 17.02.2006; in: "Book of Abstract", (2006), S. 151.
5. T. Gebhard, F. Schrey F., G. Strasser, K. Unterrainer, M. Pires, S. Landi, P. Souza:  
"Intraband transitions in InAs/InGaAs/InP quantum dots for infrared photodetection";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria; 13.02.2006 - 17.02.2006; in: "Book of Abstract", (2006), S. 81 - 82.
6. J. Kröll, J. Darmo, K. Unterrainer, S. Dhillon, C. Sirtori:  
"70. Optical processes in terahertz quantum-cascade laser waveguides";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria; 13.02.2006 - 17.02.2006; in: "Book of Abstract", (2006), S. 152.
7. T. Müller, G. Strasser, K. Unterrainer:  
"Ultrafast spectral hole burning spectroscopy of exciton spin relaxation in InAs/GaAs quantum dots";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria; 13.02.2006 - 17.02.2006; in: "Book of Abstract", (2006), S. 89 - 90.
8. M. Schramböck, W. Schrenk, T. Roch, A. M. Andrews, M. Austerer, A. Lugstein, G. Strasser:  
"Nano-patterning and growth of self-assembled nano-structures";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf; 13.02.2006 - 17.02.2006; in: "Book of Abstracts", (2006), S. 139.
9. F.F. Schrey, E. Magerl, G. Fasching, G. Strasser, K. Unterrainer:  
"Ultrafast intersublevel spectroscopy of a single InAs Quantum Dot";  
Poster: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf, Austria; 13.02.2006 - 17.02.2006; in: "Book of Abstract", (2006), S. 91 - 92.
10. G. Strasser:  
"Nonlinear effects in quantum cascade lasers";  
Vortrag: 14th International Winterschool on New Developments in Solid State Physics, Mauterndorf (eingeladen); 13.02.2006 - 17.02.2006; in: "Book of Abstracts", (2006), S. 34.
11. M. Schramböck, A. M. Andrews, T. Roch, W. Schrenk, A. Lugstein, G. Strasser:  
"Nano-patterning and growth of self-assembled quantum dots";  
Poster: 6th International Workshop on Epitaxial Semiconductors on Patterned Substrates and Novel Index Surfaces, Nottingham, Great Britain; 03.04.2006 - 05.04.2006; in: "Book of Abstract", (2006), S. 56.
12. A. M. Andrews, G. Fasching, A. Benz, T. Roch, W. Schrenk, K. Unterrainer, G. Strasser:  
"Ga-As-based Quantum Cascade Laser for Dual Frequency Terahertz Emission";  
Vortrag: Materials Research Society Spring Meeting (MRS), San Francisco, USA; 17.04.2006 - 21.04.2006; in: "MRS Spring Meeting Abstracts", (2006), S. 231.
13. A. Benz, G. Fasching, K. Unterrainer, R. Zobl, A.M. Andrews, T. Roch, W. Schrenk, G. Strasser:

- "Quantum-Mechanical designed Terahertz Laser"*;  
Poster: Junior Scientist Conference 2006, Vienna, University of Technology, Wien;  
19.04.2006 - 21.04.2006; in: *"Proceedings"*, (2006), 3-902463-05-8; S. 91 - 92.
14. S. Schartner, S. Golka, M. Austerer, C. Pflügl, W. Schrenk, G. Strasser:  
*"Photonic Crystal Cavities for Quantum Cascade Lasers"*;  
Poster: Junior Scientist Conference 2006, Wien; 19.04.2006 - 21.04.2006; in:  
*"Proceedings of the Junior Scientist Conference 2006"*, (2006), S. 169 - 170.
15. M. Schramböck, A. M. Andrews, T. Roch, W. Schrenk, A. Lugstein, G. Strasser:  
*"Nano-patterning and growth of self-assembled nano-structures"*;  
Poster: Junior Scientist Conference 2006, Wien; 19.04.2006 - 21.04.2006; in:  
*"Proceedings of the Junior Scientist Conference 2006"*, (2006), S. 171 - 172.
16. J. Kröll, K. Unterrainer:  
*"Quantum cascade laser dynamics probed by broad-band Terahertz pulses"*;  
Poster: Junior Scientist Conference 2006, Vienna, University of Technology;  
19.04.2006 - 21.04.2006; in: *"Proceedings"*, (2006), ISBN 3-902463-05-8; S. 311 -  
312.
17. P. Schwaha, R. Heinzl, W. Brezna, J. Smoliner, H. Enichlmair, R. Minixhofer, T.  
Grasser:  
*"Leakage Current Analysis of a Real World Silicon-Silicon Dioxide Capacitance"*;  
Vortrag: International Caracas Conference on Devices, Circuits and Systems  
(ICCDSCS), Playa del Carmen; 26.04.2006 - 28.04.2006; in: *"Proceedings  
International Caribbean Conference on Devices, Circuits and Systems"*, (2006),  
ISBN: 1-4244-0042-2; S. 365 - 370.
18. J. Kuzmik, S. Bychikhin, R. Lossy, H. Würfl, M. di Forte Poisson, J. Teyssier, C.  
Gaquière, D. Pogany:  
*"Investigation of the cooling effect introduced by the airbridge structure in the  
multifinger AlGaIn/GaN HEMTs"*;  
Vortrag: Workshop on Compound Semiconductor Devices and Integrated Circuits  
(WOCSDICE), Fiskebäckskil, Schweden; 14.05.2006 - 17.05.2006; in: *"Abstract  
Book WOCSDICE"*, (2006), S. 181 - 183.
19. M. Austerer, C. Pflügl, S. Golka, S. Schartner, W. Schrenk, T. Roch, A. M.  
Andrews, G. Strasser:  
*"Surface Emission of Intracavity Frequency-Doubled Light from Quantum Cascade  
Lasers"*;  
Vortrag: CLEO/QELS, Long Beach, California, USA; 21.05.2006 - 26.05.2006; in:  
*"Conference Programm"*, (2006).
20. J. Kröll, J. Darmo, K. Unterrainer, S. Dhillon, C. Sirtori, X. Marcadet, M. Calligaro:  
*"Terahertz time-domain spectroscopy of a quantum cascade laser"*;  
Vortrag: CLEO/QELS, Long Beach California, USA; 21.05.2006 - 26.05.2006; in:  
*"Postdeadline papers"*, (2006), ISBN 1-55752-815-2; 2 S.
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Georgakilas, D. Pogany:  
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*"Dual-mode microdisk terahertz quantum-cascade lasers"*;  
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### **Talks and Poster Presentations (without Proceedings):**

1. A. M. Andrews, T. Roch, G. Fasching, W. Schrenk, R. Zobl, K. Unterrainer, G. Strasser:  
"*Growth Optimization of GaAs-based Quantum Cascade Laser for Terahertz*"

- Emission*";  
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  4. T. Gebhard, F. Schrey F., G. Strasser, K. Unterrainer, M. Pires, S. Landi, P. Souza: "*Intraband transitions in InAs/InGaAs/InP quantum dots for infrared photodetection*";  
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  7. M. Schramböck, W. Schrenk, T. Roch, A. M. Andrews, M. Austerer, A. Lugstein, G. Strasser: "*Nano-patterning and growth of self-assembled nano-structures*";  
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  8. F. Schrey, F. Schrey F., E. Magerl, G. Fasching, G. Strasser, K. Unterrainer: "*Ultrafast intersublevel spectroscopy of a single InAs Quantum Dot*";  
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  9. G. Strasser: "*Nonlinear effects in quantum cascade lasers*";  
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  17. S. Özcan, T. Roch, G. Strasser, R. Franke, T. Fritz:  
"*Ballistic Electron Emission Microscopy/Spectroscopy on Au/Titanylphthalocyanine/GaAs Heterostructures*";  
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"*Alignment and growth of III-V semiconductor nano-structures*";  
Vortrag: Infrared Optical Nanostructures workshop, Wien; 12.05.2006.
  19. J. Kuzmik, S. Bychikhin, R. Lossy, H. Würfl, M. di Forte Poisson, J. Teyssier, C. Gaquière, D. Pogany:  
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Supervisor: E. Bertagnolli, H. D. Wanzenböck; Institut für Festkörperelektronik, 2006; Diplomprüfung: 10.03.2006.
4. T. Prikoszovits:  
"Terahertz Characterization and Imaging of Semiconductors";  
Supervisor: K. Unterrainer, J Darmo; Institut für Photonik, 2006; Diplomprüfung: 27.04.2006.
5. T.B. Moldaschl:  
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Supervisor: K. Unterrainer, T. Müller; Institut für Photonik, 2006; Diplomprüfung: 23.11.2006.

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