Performance Report 2012/13

Institute for Electron Microscopy and Nanoanalysis
Graz University of Technology

Graz Centre for Electron Microscopy
ACR Austrian Cooperative Research

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Statement from the Rector of Graz University of Technology

I have great pleasure in presenting this report from the Institute for Electron Microscopy and Nanoanalysis of Graz University of Technology. As you will see from the following pages, successful operation of this facility has both a national as well as an international impact.

The installation of the first electron microscope in Styria more than 60 years ago followed a decision taken by the university board in 1949 and was a key element of the former Technische Hochschule Graz. From the very beginning, electron microscopy became an invaluable tool both for university research and industrial collaborations. In these early days, the electron microscopy group headed by Dr. Fritz Grasenick paved the way to the Institute for Electron Microscopy and Nanoanalysis (FELMI), which is now a member of the Faculty of Technical Mathematics and Technical Physics. Today, the Institute significantly contributes to several fields of expertise at Graz University of Technology, especially to “Advanced Materials Science” and is now also a member institute of the joint NAWI faculty of Graz University of Technology and the University of Graz.

Over the past decade, methods for developing new materials and examining their detailed nature have become more subtle, sensitive and precise. Nowadays, electron microscopes can identify the location of individual atoms in materials and focused ion beams can create structures with dimensions of less than 10 nanometers. These powerful capabilities are essential in the era of nanosciences and nanotechnology. However, these achievements come at a price: today’s sophisticated microscopes have become so expensive and complex that individual researchers cannot own or adequately operate or maintain them. It is therefore clear that such resources must be concentrated and managed in special institutions (mid-size multi-user facilities). In the case of the Institute this works very well via the close collaboration with the Graz Centre for Electron Microscopy thus creating the basis for cutting-edge instrumentation such as the Austrian Scanning Transmission Electron Microscope.

I hope that the Institute will continue to work in this cooperative way and I also wish great success for the years to come.

Univ.-Prof. Dipl.-Ing. Dr.techn. Dr. h.c. Harald Kainz

Directors‘ Report

Research using electrons makes essential and unique contributions to some major challenges facing our society. Accordingly, the key activities of the institute concentrate on academic issues and research with industrial partners. For example, the FELMI-ZFE conducted collaborative partnerships with both national and international companies through a wide range of contacts, programs and joint ventures.

The competence and experience is reflected in particular in the strengthening of the links to other Austrian research institutes and leading European microscopy laboratories via the ESTEEM2 network.

When the Austrian Scanning Transmission Electron Microscope (ASTEM) was introduced in summer 2011, it was a high-risk, high reward project. Through the hard work of everyone involved, exciting scientific findings have been obtained with the ASTEM, which is one of the best electron microscopes in the world. We operate it as a national resource in atomic resolution microscopy which is open for collaboration with Austrian scientists.

Furthermore, great steps towards the implementation of high precision instrumentation have been made: It was possible to extend the ASTEM with a Gatan Imaging Filter, a Lorentz-lens for studying magnetic materials and the important 60 kV alignment for studying biological materials and low dimensional solids. Additionally, the Focused-ion beam instrument was brought to a new level of performance, new specimen preparation techniques were introduced and the old infrared microscope could be exchanged with a high-end FTIR-infrared microspectrometer.

Finally, the enthusiasm and the dedication of the people at the Institute must be honoured, being fundamental to our success. The key element for future progress is based on their motivation to generate new ideas and to work hard.

Ferdinand Hofer

Gerald Kothleitner

Peter Pölt

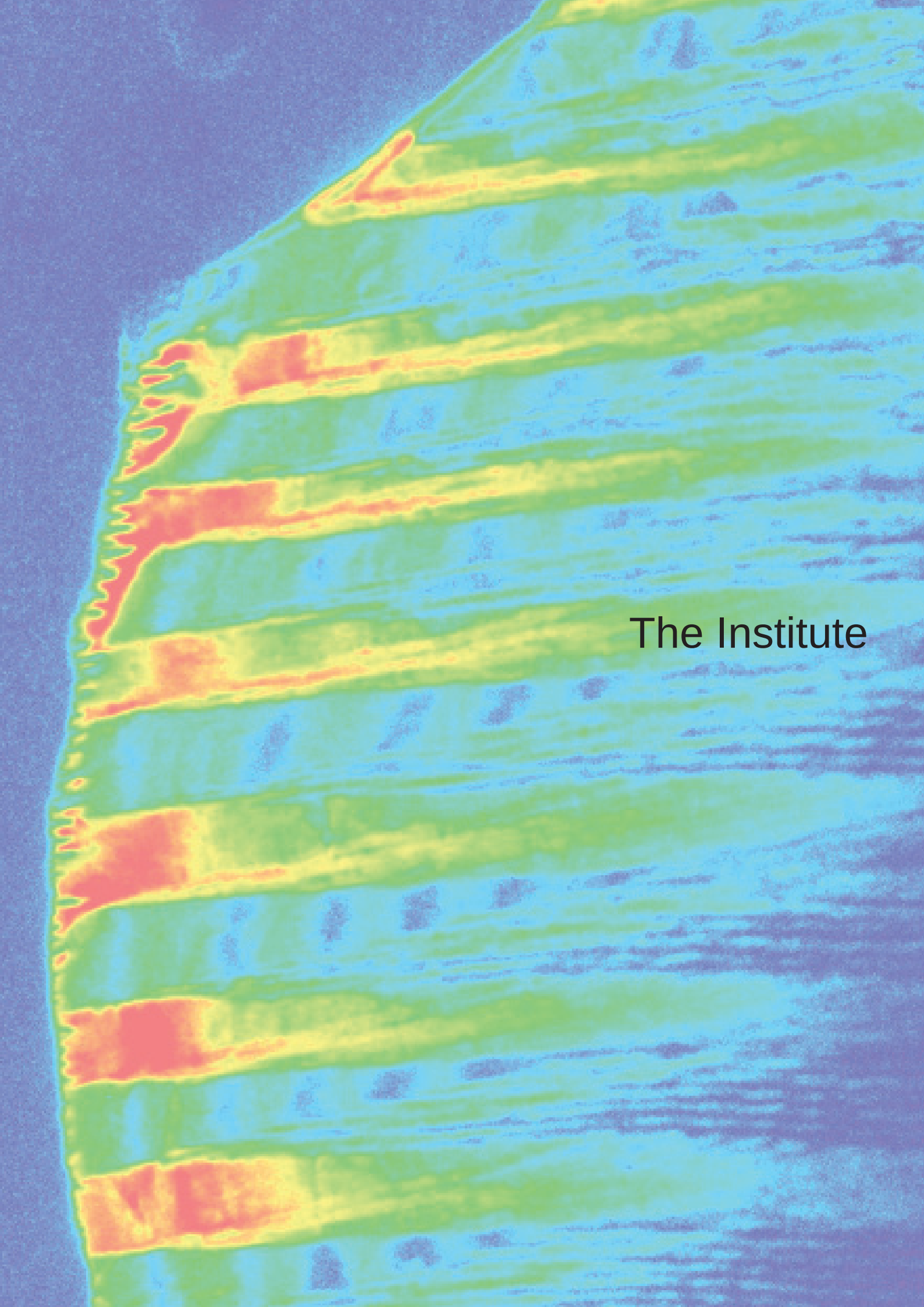
Statement from the Presidents of the Association

The FELMI-ZFE looks back at two years of strong growths marked by exciting scientific results and increasing collaboration with Austrian companies – in particular with small and medium enterprises.
Our international networks are also expanding. The successful cooperation with other leading electron microscopy laboratories in Europe within the ESTEEM2 project is big step forward for playing at the forefront of the international microscopy community.
A long-term commitment

We are very grateful to all who have contributed to the achievements and we thank the Rector of the TU Graz, Harald Kainz, the President of the Austrian Cooperative Research, Martin Leitl and the Dean of the Faculty of Technical Mathematics and Technical Physics, Wolfgang Ernst, for their strong support. It is also crucial that our funding agencies in particular the Austrian Research Promotion Agency (FFG), the Styrian Business Promotion Agency (SFG) and the Styrian Government jointly continue to develop the Institute which is a national resource with international impact.

Prof. Dipl.-Ing. Dr.-Ing.h.c. Helmut List
President of the Association

KR Dipl.-Ing. Ulrich Santner
Vice-President of the Association



The Institute

The Institute

The Institute at a Glance

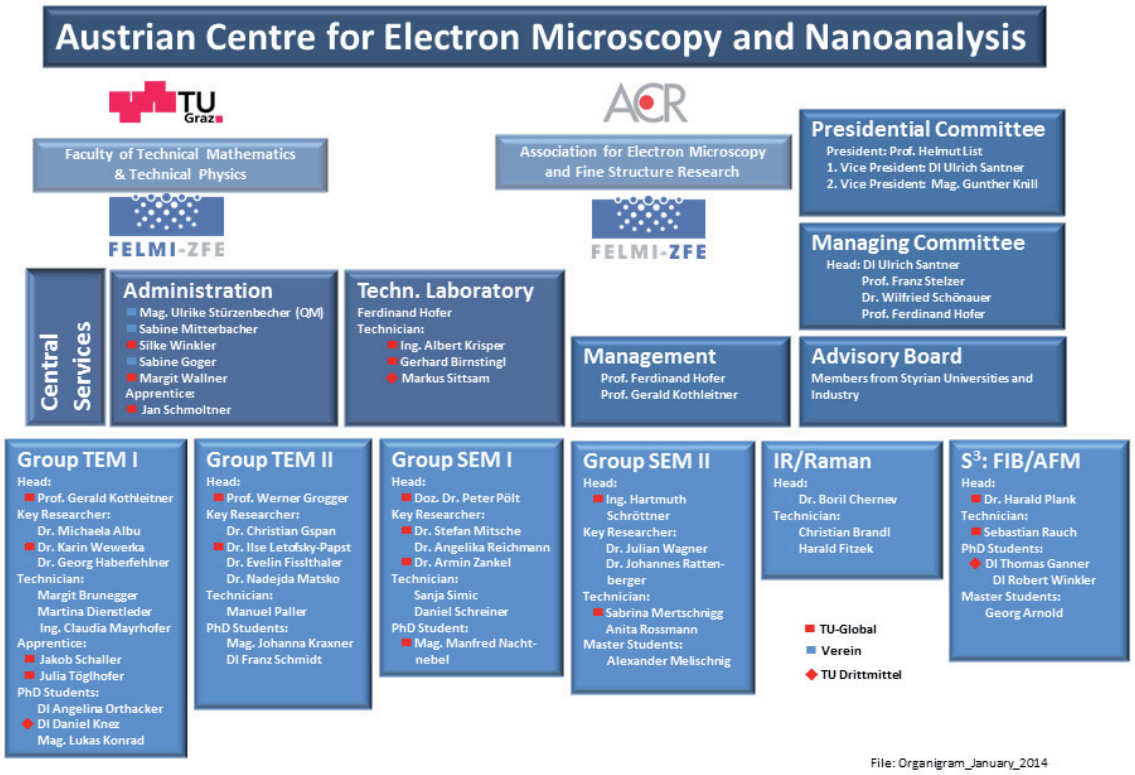
The Institute concentrates on research and teaching in the fields of physics, materials science, micro- and nanotechnology. Since the fifties of the last century, the institute has been built on two main columns:

- the **Institute for Electron Microscopy and Nanoanalysis** (FELMI) at the Faculty of Technical Mathematics
- the **Graz Centre for Electron Microscopy** (ZFE), a member of Austrian Cooperative Research (ACR).

Although the two organisations have their own legal status and budget, both institutes work in close alliance to ensure efficient use of personnel and instrumental resource. The institute is located in the city of Graz, on the campus of the Graz University of Technology. It is organized in research groups focused on specific aspects of microscopy or important material classes.

The Institute in the building Steyrergasse 17 is located on the 2nd and 3rd floor.

Our Organizational Structure



Organigram of FELMI-ZFE on 31 Dec 2011

Research Focus

A unique feature of the Institute is its broad field of activities ranging from fundamental to applied research and contractual projects with Austrian and European companies. Major areas of research include the micro- and nanoanalysis of materials, electronic devices and biomaterials.

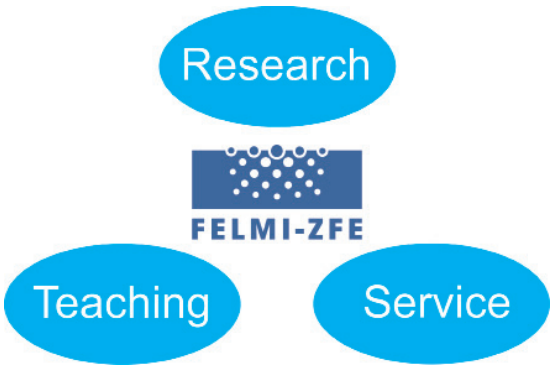
The Institute brings together

- well-accepted laboratory methods,
- cutting edge instrumentation, and
- advanced research skills.

The primary aim is to study fundamental scientific problems and to transfer the knowledge about advanced microscopy methods into practical collaborations with other university institutes and industry (with a clear focus on small and medium-sized enterprises). However, the spectacular developments of the Institute‘s research groups also rely on an increasing number of high level research projects supported by European and Austrian funding organisations.

During the past few years we have focused on the following research topics, which are described in detail in the research chapter of this report:

- In-situ electron microscopy and surface analysis
- Nanoanalysis of materials
- Soft-matter characterization
- 3D microscopy
- Nanoprototyping and preparation



Operation areas of the FELMI-ZFE

A Unique Position in Austria

The institute is one of the leading microscopy facilities in Europe and has a global profile worldwide. Its unique position is based on the leading-edge instrumentation ranging from advanced light and probe microscopes via specialized scanning electron microscopes to transmission electron microscopy at atomic resolution.

On this basis the Institute is endeavouring to develop new microscopy methods and to improve special preparation methods, especially for the materials and life sciences.

These techniques are used intensively to characterize all kinds of materials, providing efficient answers and solutions to scientific and industrial problems.

The Institute in Figures

The development of personnel is increasingly influenced by funded research projects and contractual research for industry.

The Institute‘s staff has been dedicated to special programmes in recent work to compensate for the decrease in industrial projects in 2009 and is very successful with this strategy.

The number of scientists has increased during this period, a factor which is helping to expand the expertise into new research areas, e.g. cryo-microscopy and atomic resolution microscopy.

Since we are also hosting more master students the space pressure we face remains very tight. The budget development also shows very high expenses for the ASTEM microscope and for the ongoing renovation of the Institute and the Steyrergasse 17 premises.

Quality Assurance

The institute works under an advanced quality management system according to the rules of EN ISO 900. The aim is to maintain the outstandingly quality of our work and analysis results and to continuously improve our organization & management structures. Following the successful audits performed by TÜV Austria, the institute was awarded the EN ISO 9001 certificate, which is valid until May 2015.


ZERTIFIKAT

TÜV AUSTRIA

für das Managementsystem nach
EN ISO 9001:2008

Forschungsverbund Zentrum für Elektronenmikroskopie Graz und
Institut für Elektronenmikroskopie und Feinstrukturforschung
Steyrergasse 17/III
A-8010 Graz

Forschung und Lehre auf dem Gebiet der Mikrostrukturforschung und Materialcharakterisierung mittels Elektronenmikroskopie und Micro- und Nanoanalytik; Entwicklung von Analysen- und Präparationsmethoden

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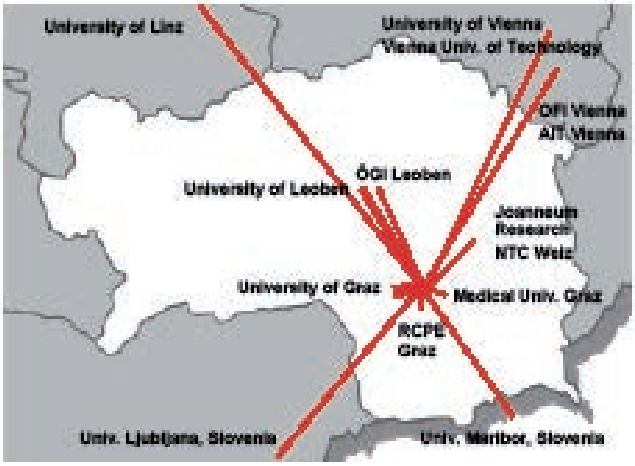
Collaborations

The Institute has collaborated with around 39 university institutes and more than 120 companies on average each year – mainly from Austria, but increasingly also from other European countries. It should be mentioned that two main directions have been followed during recent years:

Firstly, collaborations within the ACR group which are developing well, and secondly, the incorporation into important European research networks such as the STREP project “CopPeR”, the ENIAC initiative or the forthcoming ESTEEM2 project.

Our activities in technology transfer are also manifested in the 300 visitors from other research groups and companies each year. During the report period 133 master and PhD students from other institutions benefited from the scientific and technical support of the Institute.

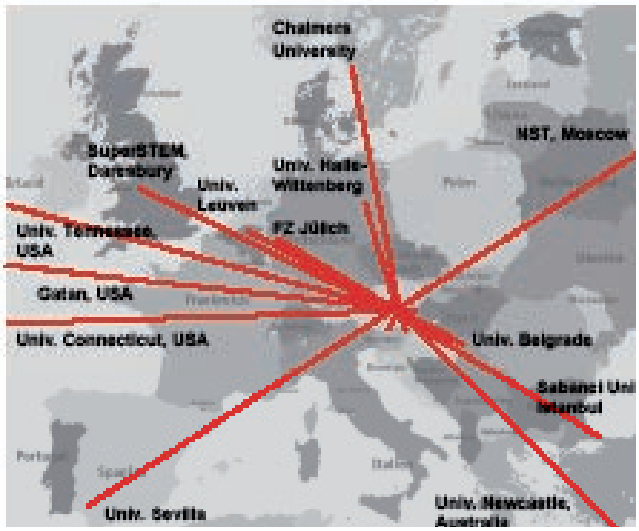


Scientific collaborations with local universities and research institutes

Research Expert for Austrian SMEs

For around sixty years the Institute has supported Austrian companies in the innovation process. We have made a considerable contribution to the competitiveness of the Austrian economy through our numerous projects and short-term activities.

The strengths of the Institute are its research and development competence with close links between the academic world and business, strong and flexible research groups in close contact with SMEs and expert knowledge of the national and international funding landscape.



Scientific network of the institute with ongoing international collaborations

Research

Analytical Electron Microscopy

Counting atoms and resolving the TEM projection issue

In the past couple of years, the AEM group at the FELMI has undertaken big efforts to extend and fully harness the experimental capabilities of the ASTEM microscope. These include the possibility to count atomic species with picometer resolution and to perform electron tomography on materials science specimens.

Analytics in the ASTEM

Spherical-aberration (CS) correction of electron probes as used in the Austrian scanning transmission electron microscope (ASTEM) has enabled numerous applications, showing atomic resolution analysis from interesting materials science samples. This progress in STEM imaging for a long time remained unaccompanied by equivalent improvements in the equipment needed to augment such measurements with analytical EELS (electron energy loss spectroscopy) and EDXS (energy dispersive x-ray spectroscopy) data. In order to combine both techniques and harness their respective potentials for light- and heavy-element quantitative atomic resolution analysis, we have teamed up with the key analytical suppliers (Gatan / Bruker / FEI) and have set up a powerful and unique hardware and software configuration (GIF Quantum, Bruker / FEI Super-X detector, CS-probe corrected Titan, operated under 64bit DigitalMicrograph and driven by DigiScan) enabling unprecedented analytical investigations at the atomic scale.

Atomic resolution quantification

Putting quantitative figures on atomic resolution maps, revealing elemental compositions, requires detailed theoretical simulations, ensuring the observed analytical intensities are not disconnected from the projected atomic positions. For this we have ongoing collaborations with the theory group in Melbourne / Australia around Prof. Les Allen, who is able to calculate multiple dynamic electron scattering processes in solid state materials. The product of this team-work is the first atomic resolution EDX and EELS quantification published in Physical Review Letters 2014 [1].

New analysis concept

Even on a lower scale no overlapping framework existed that links EELS and EDX analytical signals such that absolute volumetric concentrations could be derived without any assumptions made apriori about the bulk. A new mathematical framework was therefore developed that reduced the need for estimates on most of the parameters needed for quantification. With a smart preparation approach on the samples, the relevant quantities like concentrations, partial ionization cross-sections, densities and thicknesses can now be determined explicitly [2].

Electron Tomography

Nanospatial factors often hold the key to a deeper understanding of the properties of matter at the nanoscale level. At the FELMI, tomographic investigations can be carried out in the TEM, enabling the investigation of materials in all three dimensions. One research focus of the group is the development and implementation of new alignment, segmentation, reconstruction and analysis routines for tomograms, with the goal to access some of the relevant parameters like shape, size, distribution and elemental composition amongst others.

Recently magnetite nanoparticles embedded within the pores of a mesoporous silicon template have been characterized using electron tomography. It was possible to calculate the demagnetizing factors and the direction of the shape anisotropy easy axis for every particle. Together with Monte Carlo simulations, zero field cooling/ field cooling and magnetic hysteresis curves could be derived. This work was published in Nanoscale 2013 [3].

Gruppenbild

Senior Scientist
Prof. Dipl.-Ing. Dr. Gerald Kothleitner
PostDoc
Dr. Mihaela Albu
Dr. Karin Wewerka
Dr. Georg Haberfehlner
PHD Students
DI Angelina Orthacker
DI Daniel Knez
Mag. Lukas Konrad
Technical Assistant
Margit Brunegger
Martina Dienstleder
Ing. Claudia Mayrhofer
Apprentice
Jakob Schaller
Julia Tögelhofer

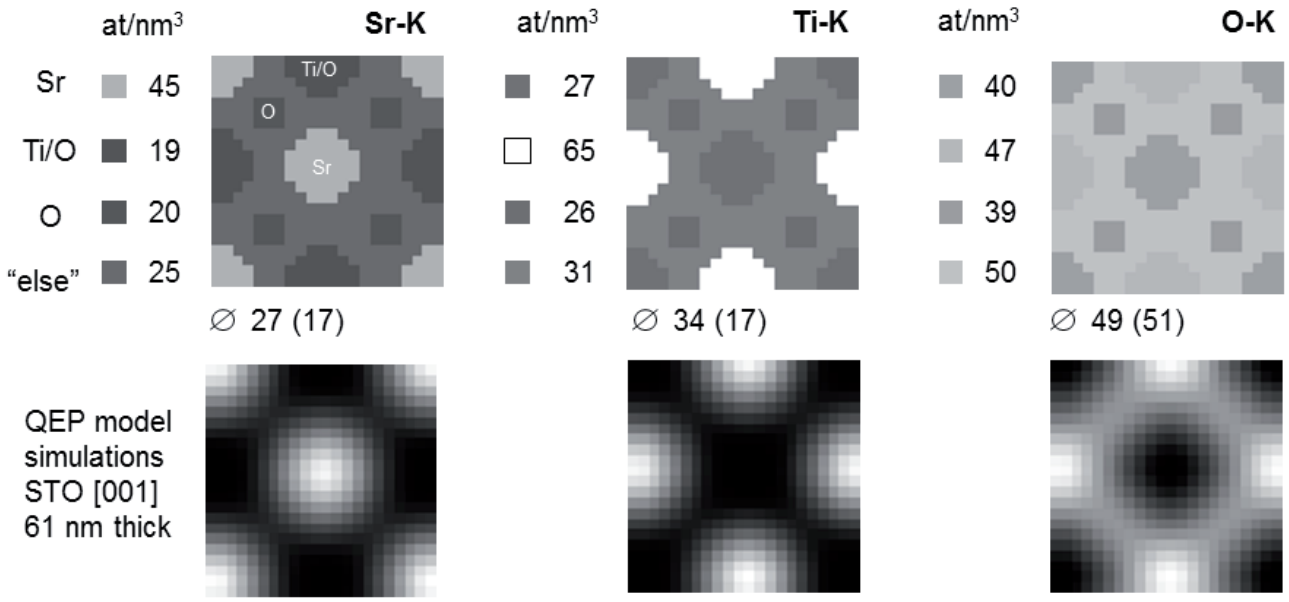


Fig 1
Absolute volumetric concentrations from X-ray data (upper row) together with QEP (Quantum Excitation of Phonons) simulations (below)from a 61 nm thick Strontiumtitanate crystal, imaged along [001] zone axis.

Fig. 2 tomography ??

References:

[1] G. Kothleitner, M. J. Neish, N. R. Lugg, S. D. Findlay, W. Grogger, F. Hofer and L. J. Allen, Physical Review Letters 2014, 112, 085501
[2] G. Kothleitner, W. Grogger, M. Dienstleder and F. Hofer, Microscopy and Microanalysis 2014, 20, 678
[3] T. Uusimäki, G. Margaris, K. Trohidou, P. Granitzer, K. Rumpf, M. Sezen and G. Kothleitner, Nanoscale 2013, 5, 11944

Workgroup S3
Scanning-Electrons, -Ions and –Probes

From Functional Nanofabrication toward Bioapplications

Focused Electron Beam Induced Processing (FEBID)

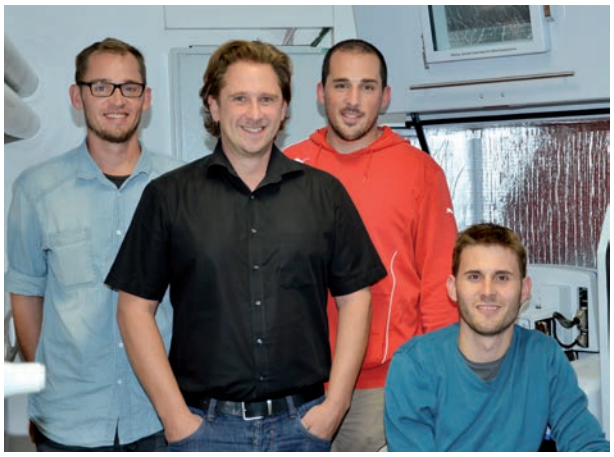
FEBID is a maskless, direct-write method for the additive fabrication of functional nanostructures with spatial nanometer resolution also allowing real-3D nano-architectures barely possible via other techniques (Fig.1a). The technique is based on the local decomposition and immobilization of functional precursor molecules by a scanning electron beam. The scientific main focus of FELMIs workgroup S3 is the fundamental understanding of the deposition process in dependency on the preparation parameters and patterning strategies. The gained knowledge is then used to tune the chemistry and internal structure on the atomic level while specifically controlling the deposit shapes with respect to highest spatial resolution on the lower nanoscale. This approach led to the development of a solution for the long lasting problem of chemical impurities in FEBID structures. They typically exhibit a metal-matrix composition of metallic nanoparticles (~ 2 – 5 nm) which are homogeneously embedded in a carbon matrix of up to 90 at.%. As this high degree of impurities can lead to reduced or even masked functionalities, we have demonstrated the first approach to purify these structures without pore / crack formation or lateral deposit shrinkage. Although successful in this direction, strong emphasis is put on the development of new sensor concepts based on the original metal-matrix structure. In 2013 the workgroup S3 demonstrated the first FEBID based gas sensor which uses the carbon matrix as intrinsic transducer to detect polar molecules on its surface. Currently, these concepts are further expanded towards selective detection of biological analytes in liquids. By that the scientific activities in the field of FEBID span the bow from fundamentals towards applications (Fig.1b-c) [1,2].

Enzymatic Cellulose Degradation

Based on a strong collaboration with the Institute for Biotechnology (TU Graz) the work group S3 is focused on the fundamental understanding of enzymatic cellulose degradation as key element for the production of 2nd generation biofuels. This is mainly done by atomic force microscopy (AFM) in liquid environments for direct observation of enzymatic dynamics down to the molecular scale (Fig.1d). As the reliability of such investigations strongly depends on the cellulose substrates, increasing efforts have been placed on the development of appropriate specimens. This led to so-called mixed amorphous–crystalline-cellulose-substrates (MACS), enabling specific control about their internal structure while exhibiting nano-flat surfaces for high-resolution AFM investigations. These MACS are currently used to gain deeper insight in fundamental processes during enzymatic and synergistic hydrolysis on multiphasic cellulose systems as present in nature [3,4].

Focused Ion Beam Processing

Focused ion beam (FIB) processing has become an integrative part in science and technology with particular attention on the site-specific preparation of ultra-thin lamellas for transmission electron microscopy investigations. However, in combination with low melting materials such as polymers or biological specimens, FIB procedures mostly led to chemical and morphological degradation which led to the status of “practically incompatible”. FELMIs workgroup S3 focused on the origins of these degradation and could demonstrate that the patterning strategy itself leads to additional heating effects beyond the acceptable limit for low melting materials. Based on a combined approach between experiments and simulations we could introduce an alternative patterning approach which minimizes these technically induced heating effects. This opened the door for FIB processing of low melting materials which often had been considered as impossible in the past (Fig. 1e) [5,6]. .



Group leader: Dr. Harald Plank

PostDoc: NONE

PHD Students:

- **DI Thomas Ganner (AFM)**
- **DI Roland Schmied (FIB)**

Technical Assistant:

- **Sebastian Rauch (FIB)**

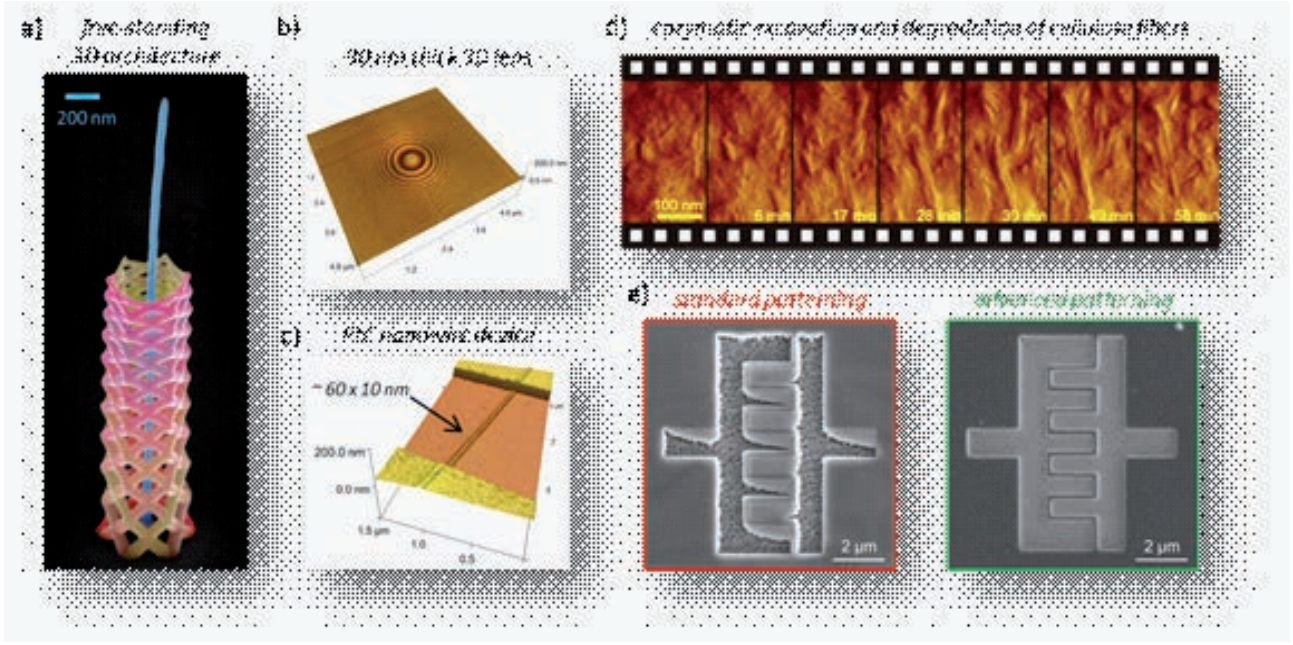


Fig 1: (a) – (c): examples of FEBIDs direct-write capabilities by means of free-standing 3D nanoarchitecture (a); sine-modulated Gabor lens for passive focusing applications (b); and nano-granular PtC nanowire for active (sensing) applications. (d) shows a time resolved AFM sequence of a cellulose sample exposed to enzymes which excavate and degrade individual cellulose fibers. (e) gives a direct comparison of FIB processed polymer surfaces using standard conditions (left) and advanced patterning (right) for identical process times and beam conditions.

References:

[1] H. Plank, D. A. Smith, T. Haber, P. D. Rack, F. Hofer ACS Nano (2012) 6 (1) 286
[2] F. Kolb, K. Schmoltner, M. Huth, A. Hohenau, J. Krenn, A. Klug, E.J.W. List, H. Plank Nanotechnology (2013) 24, 305501
[3] T. Ganner, P. Bubner, M. Eibinger, C. Mayrhofer, H. Plank, B. Nidetzky Journal of Biological Chemistry (2012) 287, 43215
[4] P. Bubner, H. Plank, B. Nidetzky Biotechnology and Bioengineering (2013) 110, 6, 1529
[5] R. Schmied, B. Chernev, H. Plank RSC Advances (2012), 2, 6932
[6] A. Orthacker, R. Schmied, B. Chernev, J.E. Fröch, J. Hobisch, G. Trimmel, H. Plank PCCP (2013) 16, 1658

Research Grants

Peer-reviewed research grants acquired or active in 2012 and 2013

FELMI projects

ESTEEM2
Leader: Ferdinand Hofer
Coordinator: CEMES-CRNS, Toulouse
EC-FP/ Infrastructures, Brussels, 10/2012-9/2016

FWF Plank und Hofer
Peter Pölt

Mapping Surface Plasmons of Designed Metal Nanostructures with an Electron Beam
Leader: Ferdinand Hofer
Coordinator: Karl-Franzens-University of Graz
Austrian Science Fund (FWF), Vienna, 10/2010-7/2014

Integrated Organic Sensor and Optoelectronic Technologies (ISOTEC)
Leader: Werner Grogger
Coordinator: Nanotec Center Weiz
FFG, Vienna, 1/2005-4/2012

Nanoprobe – Analytics on Nanosized Objects
Leader: Gerald Kothleitner
Coordinator: Johannes-Kepler-University of Linz
FFG, Vienna 3/2009-2/2012

CD Laboratory for Nanocomposite Solar Cells
Leader: Ferdinand Hofer
Coordinator: Institute for Chemistry and Technology of Materials, TU Graz
Christian Doppler Research Society, Vienna,

ZFE projects

Austrian Scanning Transmission Electron Microscope (ASTEM)
Leader: Ferdinand Hofer, Gerald Kothleitner, Werner Grogger
Austrian Research Promotion Agency (FFG), Vienna, 10/2009-9/2014

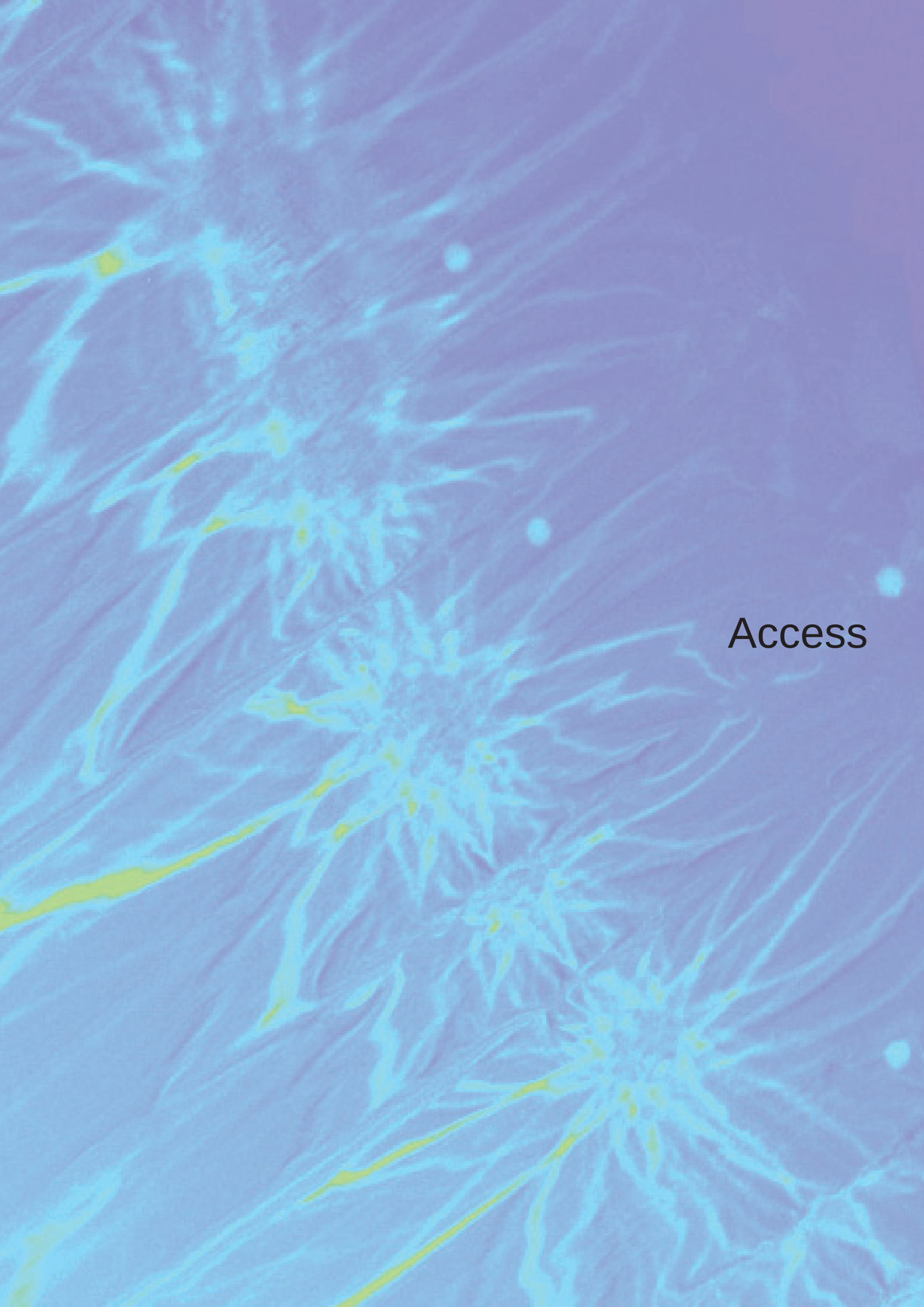
Electronic Circuits for Hot-embossed Organic Devices (NILecho)
Leader: Werner Grogger
Coordinator: Joanneum Research, Graz
Austrian Research Promotion Agency (FFG), Vienna, 4/2008-3/2014

ESIP 2
Leader, Ferdinand Hofer, Werner Grogger
Coordinator: Infineon, Regensburg
ENIAC & Austrian Research Promotion Agency (FFG), Vienna
5/2010-6/2013

Soft Matter Processing via Focused Ion Beams
Leader: Harald Plank
Austrian Research Promotion Agency (FFG), Vienna, 1/2010-3/2013

Microscopical Analysis of Composites for Automotive Applications
Leader: Hartmuth Schröttner
Coordinator: Austrian Foundry Research Institute (ÖGI), Leoben
Federal Ministry of Economy, Family and Youth (BMWFJ), Vienna, 7/2009-6/2012

COIN OPTIMATSTRUCT


Access

Access

Services to Industry and Research Institutes

Our collaborative facility brings together specialized resources, making it easier for researchers to access microscopy and microanalysis. Our expert staff support and conduct partners through planning, training, data acquisition and analysis to maximize high quality-results.

- Grant-aided partnerships

This includes Austrian research platforms, which are ideal for industry partners to access the full range of technical and academic expertise that exists within the FELMI-ZFE. Here we provide long-term alliances to solve important research questions for industry and research institutes.

- Contract Research

These activities occur where an industrial partner funds the costs of research, including instrument fees, consumables and salaries for research staff or student scholarships

- Testing services

Testing and consultancy services such as failure analysis, materials testing, identification of contaminants and quality assurance are available at commercial rates.

- Training courses

Participation in FELMI-ZFE training and specialist courses builds competency for institutions that have microscopy capability in-house (see LLL courses of the TU Graz, page „http://portal.tugraz.at/portal/page/portal/TU_Graz/Studium_Lehre/Life_Long_Learning“).

International Impact

As a leading European facility the institute is a resource of expertise that is in high demand. Since it is clear, that international collaboration often underlies the development of new ideas, the institute is focused on achieving results on two fronts: It enhances the participation in European research programs (FP7) such as ESTEEM2 in Infrastructures or S3 in Eurostars. On another front, the institute engages in world-wide collaborations on special research tasks like shown in the graph below.

ESTEEM2 is an integrated infrastructure of electron microscopy facilities providing access for the academic and industrial research community in the physical sciences to some of the most powerful characterization techniques available at the nanoscale. The European network benefits from European Union support until September 2016.

ESTEEM2 offers free access to the most powerful TEM installations in Europe through a simple application procedure based on merit and scientific priorities for HR(S) TEM and related techniques. In the transnational access activities of ESTEEM2 the FELMI-ZFE concentrates on nanoanalytical characterization techniques such as EELS and EDX and studies of surface plasmons of nanostructures.

Academic Education

LLL Courses

LIFE LONG LEARNING

Problem Solving with Scanning Electron Microscopy and X-ray Microanalysis

(S. Mitsche, P. Pölt, A. Reichmann, H. Schröttner)

The course benefits scientists, engineers and technicians by helping them to solve their analytical problems. It is a concentrated three day hands-on laboratory workshop taking participants step-by-step through the use of advanced scanning electron microscopy. The course will familiarise them with the latest equipment and will cover the fundamental principles and methods critical to obtaining meaningful images, spectra and elemental maps.

The methods are applicable to fields ranging from materials research (steels, ceramics, semiconductors, polymers, etc.) to biological research. An important aspect of the course is the practical use of the microscope. Several advanced microscopes are available and the participants are invited to bring their own samples and are given the opportunity to analyse them themselves with the help of the advisor.

GIF-School in Cooperation with Gatan, USA

(T. Haber, G. Kothleitner, W. Grogger)

The EELS & EFTEM course is a concentrated three day hands-on laboratory workshop that takes participants step-by-step through the use of an integrated FEI energy-filtering / EELS system (CM20 - GIF, TF20 GIF). Participants are introduced to the important fundamental principles and methods in EELS and EFTEM acquisition and analysis by qualified staff members.

Participants are familiarized with the latest EELS & EFTEM equipment and will teach the fundamental principles and methods critical to obtaining meaningful EELS spectra and energy-filtered images or elemental maps. The techniques are applicable to fields ranging from biological to materials research. The participants benefit from tightly coupled lectures and discussions with some of the top experts in the field and will gain hands-on experience in various techniques.

Presentations and Lab Tours

Presentations and tours of the Institute including lectures and demonstrations have also been organised for groups of physics and chemistry teachers and for students from TU Graz, schools and local universities. Around 250 pupils, teachers and students from other institutions visited the Institute during the period 2009-2011.

- **Tours 2012**

4 Dec. 2009 for the Rector of Tomsk Polytechnic University, Russia (N. Matsko)

3 Dec. 2009 for participants of the URANIA course “Electron Microscopy“ (W. Grogger)

29 Oct. 2009 for students of the Chemie-Ingenieurschule in Graz (G. Kothleitner)

1 Oct. 2009 for Tokyo University of Agriculture and Technology, Japan (P. Pölt)

27 Feb. 2009 for students of the Chemie-Ingenieurschule in Graz

- **Tours 2013**

13 Jan. 2010 for VDI Austria (A. Zankel)

25 Feb. 2010 for pupils from the „Kirchengasse Gymnasium“ in Graz

5 Mar. 2010 for Institute of Molecular Biotechnology (N. Matsko)

28 Mar. 2010 for visitors from Infineon (G. Kothleitner, H. Plank)

26 Apr. 2010 for Austrian Academy of Sciences (W. Grogger, N. Matsko, W. Haas)

30 Jun. 2010 for employees of the Harbin Institute of Technology, China (M. Albu)

19 Aug. 2010 for participants of the ICPS-Comfernce in Graz (S. Fladischer)

18 Aug. 2010 for visitors from the Keio University in Japan and for Orbita Film GmbH (A. Zankel)

10 Oct. 2010 for Chalmers University of Technology, Sweden (M. Albu)

3 Nov. 2010 for AUDI AG (H. Schröttner, J. Wagner)

9 Nov. 2010 for physics students and TU Graz employees

23 Nov. 2010 for National Academy of Science of Ukraine (F. Hofer)

9 Nov. 2010 for the Chemie-Ingenieurschule in Graz (G. Kothleitner)

6 Dec. 2010 for a delegation from the “Industriellenvereinigung“ in Graz

- **Tours 2011**

31 Mar. 2011 for visitors from the Swiss Federal Institute of Technology in Lausanne (P. Pölt, A. Reichmann)

1 Apr. 2011 for students of the Chemie Ingenieurschule in Graz (K. Wewerka, M. Brunegger)

4 Feb. 2011 for “Fachhochschule Kärnten“ (P. Pölt, P. Reichmann)

14 Jun. 2011 for visitors from India and the IWS institute (Ing. Schröttner)

8 Aug. 2011 for visitors from “Philipps Universität Marburg“ (H. Reingruber, A. Zankel)

12 Dec. 2011 for participants of the URANIA course “Electron microscopy“ (W. Grogger, C. Mayrhofer)

Speakers at the Institute

Speakers 2012

10 Feb. 2012, Klaus PASTL

AKH Linz, Austria, „Entwicklung und Einsatz von Knochenschrauben aus humaner Corticalis“

24 Feb. 2012, Harald THOMMESEN

Woher? XXX, „Bestimmung der Korngrößenverteilung und Domänenstruktur von NTC-Keramiken“

11 May 2012, Marc WILLINGER

Fritz-Haber-Institut (MPG), Berlin, Germany, „Observation of dynamic processes on the surface of metallic systems by environmental SEM“

1 Jun. 2012, Ulrich HOHENESTER

Institute of Physics, University of Graz, Austria, “The promise of plasmonics”

22 Jun. 2012, Christian MITTERER

University of Leoben, Austria, “Multifunctional hard coatings”

25 Jun. 2012, Philip D. RACK

The University of Tennessee, Knoxville, USA, „Focused electron beam induced processing: experiments, simulations, and applications“

13 Jul. 2012, Ramona KÖPPL

Woher ? XXX, „Morphologische Untersuchung von Papier- und cellulosischen Faserproben mittels Rasterelektronenmikroskopie“

16 Oct. 2012, Stanislav GORB

University of Kiel, Germany, „Biologically-Inspired reversible Adhesives: Where Are We Now?“

23 Nov. 2012, Christian RANACHER

Woher ? XXX, „Evaluierung von leitfähigen Inkjet Tintensystemen und Sintermethoden für Anwendungen im Bereich der gedruckten Elektronik“

Speakers 2013

8 Jan. 2013, Knut URBAN

Peter Gruenberg Institute, Research Centre Jülich, Germany, „Pikometer Elektronenmikroskopie - Auf der Spur der Atome an den Grenzen der Optik“

19 Mar. 2013, Eva OLSSON

Chalmers University of Technology, Gothenburg, Sweden, „Correlating transport properties to local nanostructure using in situ microscopy“

19 Apr. 2013, René de KLOE

EDAX, wo?, „High resolution EBSD mapping: data collection and orientation accuracy considerations“

23 Apr. 2013, Peter SCHATTSCHNEIDER

Vienna University of Technology, Vienna, Austria, “Electrons with topological charge”

14 Jun. 2013, Heinz WANZENBÖCK

Vienna University of Technology, Vienna, Austria, „FEBID of Fe based precursors: toward direct write CNT templating“

Master & Doctoral Theses at the Institute

Finished PhD theses

REINGRUBER Herbert (2012), New microscopic methods for the characterization of microfiltration membranes.
FLADISCHER Stefanie (2013), Application of new EDXS quantification schemes in TEM to organic semiconducting devices.
HAAS Wernfried (2013), Morphology control of high-performance polymer solar cells.

PhD theses in progress

GANNER Thomas, XXX
KNEZ Daniel, High resolution STEM of nanoparticles and nanoalloys.
KONRAD Lukas, XXX
KRAXNER Johanna, XXX
MEINGAST Arno, STEM investigations of GaN-based semiconductors.
NACHTNEBEL Manfred, XXX
ORTHACKER Angelina, XXX
SCHMIDT Franz, Mapping surface plasmons of designed nanostructures with an electron beam.
SCHMIED Roland, Focused ion beam processing of soft matter.
WINKLER Robert, XXX
UUSIMÄKI, Toni, Nanotomography in the transmission electron microscope

Finished master theses

GANNER Thomas (2012), Enzymatic cellulose degradation via atomic force microscopy in liquid environments.
ASCHL Timothy (2012),Tunable artificial cellulose substrates for in situ AFM investigation of enzymatic degradation.
KNITEL Serafin (2013), Defect analysis of abrasive wear of cutting inserts.
KNEZ Daniel (2013), Preparation and electron microscopy of graphene.
ORTHACKER Angelina (2013), Focused ion beam processing of polymers: the influence of material properties.
KOLB Florian (2013), Development of a humidity sensor based on focused electron beam induced PtC deposition.
ROSKER Stephanie (2013), Fabrication of multiphase artificial cellulose substrates for AFM based real time investigations of enzymatic degradation.
WINKLER Robert (2013), Implications of precursor dynamics on nanostructures during focused electron beam induced deposition.

Master theses in progress

ARNOLD Georg, XXX
GEIER Barbara, Rapid and highly compact purification at room temperature for focused electron beam induced Pt-C deposits.
FITZEK Harald, Optimizing the environmental scanning electron microscope for chamber pressures up to 2700 Pa.
MELISCHNIG Alexander, Thin films for high resolution electron microscopy.
PLATZER Julia, XXX
STERMITZ Martin, Free standing quasi-1D resonators for sensing applications.

Master and Doctoral Students from other Institutes

- **Graz University of Technology**

Faculty of Technical Mathematics and Technical Physics

Institute of Solid State Physics
- Tatjana DJURIC, PhD thesis
- Piet REUTER, PhD thesis
- Lisbeth KAPPEL, PhD thesis
- Wolfgang FISCHER, PhD thesis
- Nora MAYRHOFER, Master thesis
- Christian GRUBER, Master thesis
- Wolfgang FISCHER, PhD thesis
- Markus POSTL, Master thesis
- Andreas HIRZER, Master thesis
- Barbara LENDL, Master thesis
- Alfred NEUHOLD, PhD thesis
- Marco MARCHL, PhD thesis
- Kerstin SCHMOLTNER, PhD thesis
- Alexander BLÜMEL, PhD thesis
- Roman TRATTNIG, PhD thesis
- Christoph AUNER, PhD thesis

Institute of Experimental Physics
- Andreas SANBACH, Master thesis
- Alexander VOLK, PhD thesis

Institute of Materials Physics
- Andreas KAUTSCH, Master thesis
- Mario ARAR, Master thesis
- Thomas TRAUSZNIG, PhD thesis
- Bernd OBERDORFER, PhD thesis
- Eva-Maria STEYSKAL, PhD thesis

Faculty of Chemistry, Engineering and Biotechnology

Institute for Chemistry a. Technology of Materials
- Bernadette ALLNOCH, Master Thesis
- Cornelia BAYER, PhD thesis
- Ute DASCHIEL, PhD thesis
- Michael EDER, PhD thesis
- Achim FISCHEREDER, PhD thesis
- Christopher FRADLER, PhD thesis
- Verena KALTENHAUSER, PhD thesis
- Kathleen KIRSTEIN, PhD thesis
- Harald KREN, PhD thesis
- Eugen MAIER, PhD thesis
- Angelika PATETER, Master thesis
- Marta PAWLAK, PhD thesis
- Andreas PEIN, PhD thesis
- Alejandro SANTIS, Master thesis
- Alexander SCHENK, Master thesis
- Elisabeth STRUNZ, Master thesis
- Elisabeth ZIEGLER, PhD thesis

Institute of Analytical Chemistry and Food Chemistry
- Günter MISTLBERGER, PhD thesis
- Elisabeth SCHEUCHER, Master thesis
- Stefan KOREN, Master thesis

Institute of Inorganic Chemistry
- Kathrin SCHITTELKOPF, PhD thesis
- Dominik GENSER, PhD thesis
- Johanna FLOCK, Master thesis
- Judith BINDER, Master thesis
- Stefan PADLESAK, Master thesis

Institute of Environmental Biotechnology
- Stefan Weiß, PhD thesis
- Konstantin SCHNEIDER, PhD thesis

Institute of Paper, Pulp and Fibre Technology
- Johannes KRITZINGER, PhD thesis
- Harald SCHÄFFER, PhD thesis

Institute of Chemical Engineering and Environmental Technology
- Munazza Mohsin, PhD thesis
- Markus PERTHALER, PhD thesis
- Gerd RABENSTEIN, PhD thesis
- Astrid STADLOBER, Master thesis
- Nikolaus SCHWAIGER, PhD thesis
- Eva WALLNÖFER, PhD thesis

Institute of Process and Particle Engineering
- Eva-Maria LITTRINGER, PhD thesis
- Sabrina SCHNEPFLEITNER, PhD thesis
- Jakob REDLINGER-POHN, Master thesis
- Georg LICHTENEGGER, Master thesis
- Sarah ZELLNITZ, Master thesis
- Markus MAIER, Master thesis
- Daniela STROHMEIER, Master thesis

Faculty of Mechanical Engineering and Economic Sciences

Institute of Materials Science and Welding
- Francisca MENDEZ-MARTIN, PhD thesis
- Thomas WEINBERGER, PhD thesis
- Saeid SABERI, PhD thesis
- Asmir KUDUZOVIC, PhD thesis
- Friedrich KRUMPHALS, PhD thesis

Alexander TIMOSHENKOV, PhD thesis
Mizanur Rachman, PhD thesis
Christian SCHLACHER, PhD thesis
Rene RADIS, PhD thesis
Suleiman SCHWERWAN, Master thesis
F. WIRNSBERBER, Master thesis
Bernhard THOMAS, Master thesis
Christian PFEIFFER, Master thesis
Johannes WINKELHOFER, Master thesis
Bernhard BERGER, Master thesis

Institute of Tools and Forming
Robert VOLLMER, Master thesis

Institute of Thermal Engineering
Bernhard GATTERNIG, PhD thesis
Michael WOHLMUTHER, Master thesis
Thomas KIENBERGER, PhD thesis

Faculty of Informatics

Institute of Computer Vision and Graphics
Peter KONTSCHIEDER, Master thesis

Faculty for Electrical and Information Engineering

Institute of High Voltage Engineering and System Management
Denis IMANOVIC, PhD thesis
Jürgen FABIAN, PhD thesis
Thomas Berg, PhD thesis

Institute of Genomics and Bioinformatics
Michael KARBIENER, PhD thesis

Faculty of Civil Engineering

Institute of Hydraulic Engineering and Water Resources Management
Wolfgang DOBLER, PhD thesis

Institute of Applied Geosciences
Andrea NIEDERMAYR, PhD thesis

Bioenergy 2020+
Stefan MARTINI, PhD thesis

- **University of Graz**

Institute of Pharmaceutical Sciences
Sabrina WEBER, PhD thesis
Christina PETSCHACHER, PhD thesis

Institute of Zoology
Tobias PFINGSTL, PhD thesis
Anna TRUCK, Master thesis

Institute of Chemistry
Doris BREITWIESER, PhD thesis
Bernhard GUTMANN, PhD thesis
Martin DULLE, PhD thesis

Institute of Physics
Nadeem KASHIF, PhD thesis
Andreas TRÜGLER, PhD thesis
Judith DOHR, Master thesis

Joanneum Research

Andreas HIRZER, PhD thesis
Thomas ROTHLÄNDER, PhD thesis
Johanna KRAXNER, Master Thesis
Andreas PETRITS, Master Thesis
Julien MAGNIEN, Master Thesis
Philipp HÜTTER, Master Thesis

- **Medical University of Graz**

Division of Preventive and Operative Dentistry
Daniela PRAUSE, PhD thesis

Institute of Cell Biology, Histology a. Embryology
Stefanie KRASSNIG, Master thesis

Institute of Pathophysiology and Immunology
Victor AGUIRIANO-MOSER, Master thesis

- **University of Leoben**

Department of General, Analytical and Physical Chemistry
Robert SONNLEITNER, PhD thesis
Manuela PROHASKA, PhD thesis
Johannes ZAUNER, PhD thesis
Clemens VICHYTIL, PhD thesis

Chair of Chemistry of Polymeric Materials
Nina MUHR, PhD thesis
Mathias EDLER, PhD thesis

Chair of Materials Science a. Testing of Polymers
Michael SEEMANN, Master thesis

Chair of Functional Materials a. Materials Systems
Christian TRITREMMEL, PhD thesis
Viktoria EDLYMAYR, PhD thesis
Markus POHLER, PhD thesis
Marlene MÜHLBACHER, PhD thesis
Thomas WEIRATHER, PhD thesis

- **Vienna University of Technology**

Institute of Materials Science and Technology
Klaus CICHA, PhD thesis
Aleksandr OVSIANIKOV, PhD thesis

- **University of Vienna**

Department of Pharmaceutical Technology and Biopharmaceutics
Viktoria KLANG, PhD thesis
Julia SCHWARZ, PhD thesis

- **Johannes-Kepler University of Linz**

Institute of Semiconductor a. Solid State Physics
Tanweer Ashraf, PhD thesis
Christian Gusenbauer, Master thesis

- **University of Connecticut, USA**

School of Engineering
Jonathan WINTERSTEIN, PhD thesis

- **University of Marburg, Germany**

Institute of Chemistry
Tibor MÜLLER, PhD thesis

- **Munich University of Technology, Germany**

Department for Materials and Manufacture
Merle HURRLE, PhD thesis

- **University of Erlangen, Germany**

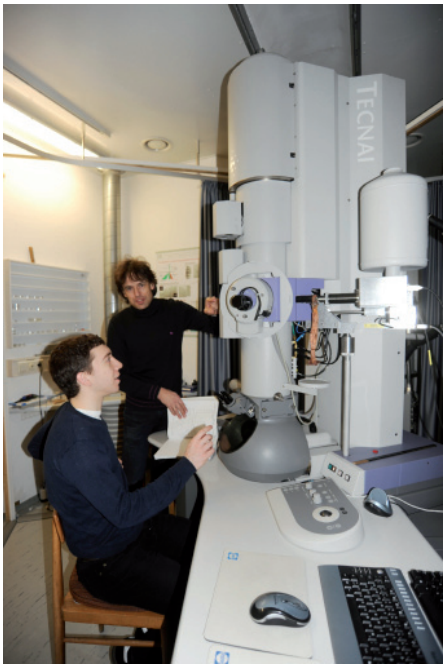
Department for Materials Science a. Engineering
Andreas SCHÖNBERGER, PhD thesis

- **Chalmers University of Technology, Sweden**

Department of Applied Physics
Jenny ANGSERYD, PhD thesis

- **Tel Aviv University, Israel**

School of Chemistry
Assaf BEN MOSHE, Master thesis



Johnathan Winterstein (Fulbright-Award) with Werner Grogger at the microscope.

Dr. Christian Gspan after his PhD rigorosum, May 2011.

Outreach

The Institute in the News

▪ News 2012

DIE PRESSE/WISSEN, 15 Jan. 2012, „Sicher verbunden“
TU GRAZ PEOPLE, 21 Jan. 2012, „Spezialkurs für Nanoanalytik an der TU Graz“
ACR NEWSLETTER, 12 Feb. 2012, „ACR Pilotprojekt: Gemeinsame Forschungsinfrastruktur“
TU GRAZ PEOPLE, 15 Mar. 2012, „Very Good News“
WIENER ZEITUNG, 7 Apr. 2012, “Deutliche Signale”
WOMAN, 8 Jun. 2012, „Silke Winkler: Gewinnerin Secretary Success 2012“
FACTORY, 1 Jul. 2012, “ACR-Pilotprojekt Forschungsinfrastruktur”
TOP OF AUTOMOTIVE 2012, 10 Oct. 2012, „Weniger Material, weniger Energie“
KLEINE ZEITUNG, 14 Oct. 2012, „Erklär mir das Elektronenmikroskop“
TU GRAZ NEWS & STORIES, 16 Oct. 2012, “Der Unsichtbarkeit auf der Spur: Physiker untersuchen Elektronenwolken”
DIEPRESSE.COM, 20 Oct. 2012, „Eine Schraube, die sich nach getaner Arbeit auflöst“
DIE PRESSE am Sonntag, 21 Oct. 2012, „Eine Schraube, die sich nach getaner Arbeit auflöst“
KURIER, 24 Oct. 2012, „Verbesserung der Lebensqualität“
DERSTANDARD, 27 Oct. 2012, „Mit der dunklen, atmenden Mode der Unsichtbarkeit auf der Spur“
MEDICAL TRIBUNE, 31 Oct. 2012, „Kooperationspreise vergeben – Desinfektion und Schrauben“
SALZBURGER WIRTSCHAFT, 2 Nov. 2012, „Innovative Medizintechnik“
DIE PRESSE/WISSEN, 25 Nov. 2012, „Größe, Form, Chemie: Partikel auf einen Blick“
NEW BUSINESS, Dec. 2012, „Werkstoffprüfung bis in die Atome“
UNI.ON, 11 Dec. 2012, „Kleine Teile, große Forschung“

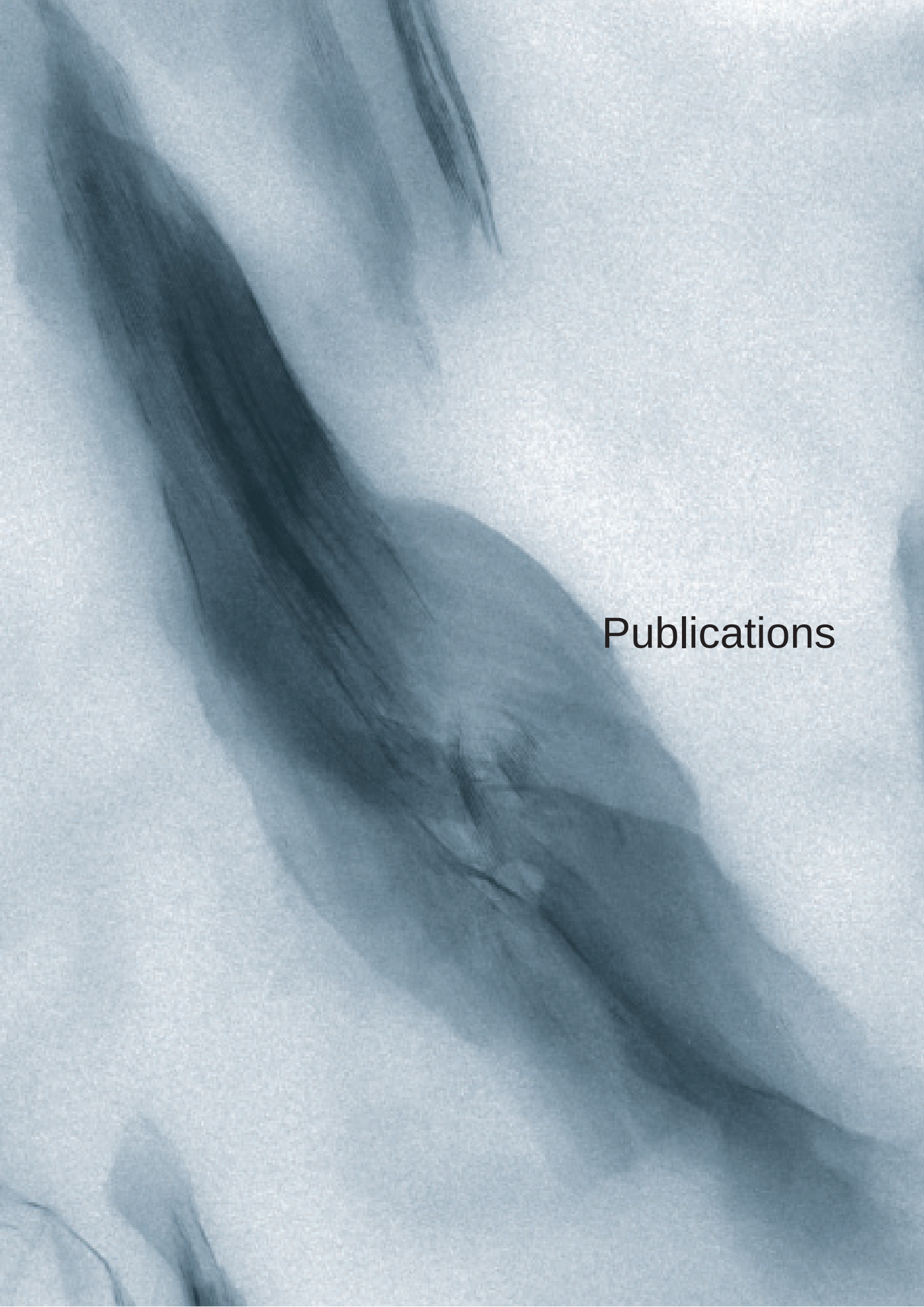
▪ News 2013

TU GRAZ PEOPLE, Mar. 2013, „e-mail from Granada“
ACR-NEWSLETTER, Mar. 2013, “Weltpremiere in Graz: Atomare Auflösung mit 1000 Spektren pro Sekunde”
DER STANDARD, 24 Aug. 2013, „Neuartiger Nano-Sensor für Luftanalysen der Zukunft“
FORUM SCIENCE, Sep. 2013, „Investitionen in die Innovationskraft“
FACTORY, Sep. 2013, „Durchbruch in der Sensorik“
KRONENZEITUNG, 10 Nov. 2013, „Das Super-Mikroskop“,
KLEINE ZEITUNG, 13 Nov. 2013, „Die Kleine macht Schule“
JAHRESBERICHT TUGraz 2013, „Forschungsthemen“


Erklär mir das
Elektronenmikroskop
Seit einem Jahr steht in Graz eines der besten Mikroskope der Welt. Wie es funktioniert und wofür es eingesetzt wird – G7 hat ganz genau hingeschaut.
REDAKTION: SABRINA LUTTENBERGER, GRAFIK: WABSCHEG/PELIZZARI
EXAKTESTES ELEKTRONENMIKROSKOP
Das ASTEM (Austrian Scanning Transmission Electron Microscope) war bei seiner Installation im Jahr 2011 das beste – also genaueste – Elektronenmikroskop weltweit.
ASTEM ALLGEMEIN
Ziel jeder Mikroskopie ist es, Objektdetails in hoher Vergrößerung und mit hohem Auflösungsvermögen sichtbar zu machen – bis zu 1.000.000-fach vergrößert. Das ASTEM in Graz arbeitet hiefür im sogenannten Rastertransmissionsbetrieb mit X-FEG-Kathode. Das Gerät ist 3,7 Meter hoch und wiegt mehr als drei Tonnen.


Werkstoffprüfung bis in die Atome
Die Anschaffung gemeinsamer Forschungsinfrastruktur für das ACR-Netzwerk ist ein Pilotprojekt des Wirtschaftsministeriums. 2012 wurde mit insgesamt 500.000 EUR der Kauf von drei Großgeräten, die vor allem in Forschung & Entwicklung eingesetzt werden, unterstützt. Die koordinierte und bedarfsorientierte Anschaffung von gemeinsamer Forschungsinfrastruktur, die in Österreich schwer zugänglich ist, erlaubt es den ACR-Instituten, zeit- und kosteneffizient auf die F&E Anfragen ihrer Kunden (77 Prozent davon KMU) zu reagieren.
Prof. F. Hofer und Team vor dem ASTEM-Mikroskop
Kooperationspreise vergeben
Desinfektion und Schrauben
Funktionelle Nanostrukturen mittels fokussierter Elektronenstrahle
Functional Nanostructures via Focused Electron Beams
Harald Plank


Das Super-Mikroskop
Wirtschaft profitiert
„Billardspiel“
Proben (kleines Bild) werden in diesem 300.000-Volt-Gerät ... bis auf ihre atomaren Bausteine „ausgeleuchtet“.

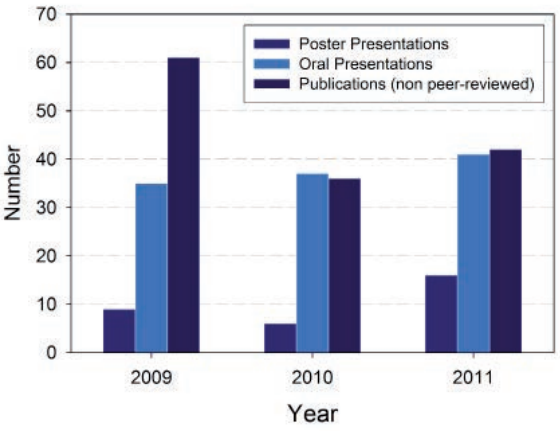


Publications

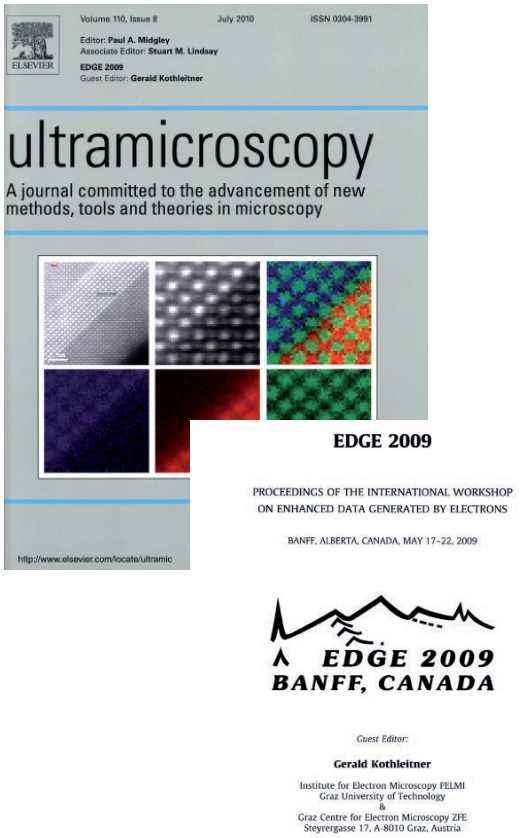
Publications

Although the institute is not only a pure research institute, but also devoted to teaching activities and service research, the number of peer reviewed publications has arrived at a high level and the number of citations is steadily rising.

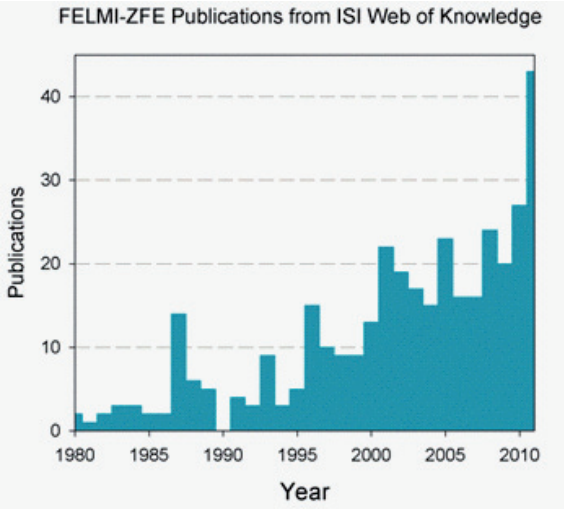
These are good figures, which have to be increased especially with publications in high ranking journals, such as ACS Nano, Chem.Commun. Angewandte Chemie, Ultramicroscopy, Advanced Materials, Soft Matter etc..

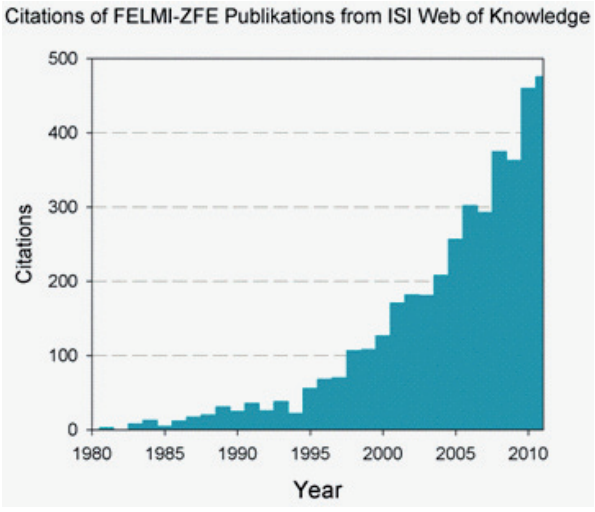


Development of poster presentations and oral presentations (conferences, workshops, etc.) of FELMI-ZFE staff and of non peer-reviewed publications of the institute.



Gerald Kothleitner is the guest editor for the proceedings of EDGE 2009.





Development of of peer-reviewed publications of the FELMI-ZFE and citations of these publications taken from the ISI Web of Knowledge.

Publications

Peer Reviewed Publications 2012

Albu, M.; Mayr, P.; Hofer, F.; Kothleitner, G.: "Comprehensive analysis of precipitates in rich chromium steels by means of electron energy loss spectrometry spectrum imaging" - in: *Metallurgical analysis = Yejin-fenxi* (2012) 12, 8 - 14

Arar, M.; Pein, A.; Haas, W.; Hofer, F.; Norrman, K.; Krebs, F. C.; Rath, T.; Trimmel, G.: "Comprehensive Investigation of Silver Nanoparticle/Aluminum Electrodes for Copper Indium Sulfide/Polymer Hybrid Solar Cells" - in: *The Journal of Physical Chemistry* C 116 (2012) 36, 19191 - 19196

Bubner, P.; Dohr, J.; Plank, H.; Mayrhofer, C.; Nidetzky, B.: "Cellulases dig deep: in situ observation of the mesoscopic structural dynamics of enzymatic cellulose degradation" - in: *The journal of biological chemistry* 287 (2012) 4, S. 2759 - 2765

Chernev, B. S.; Eder, G.C.: "Side Effects in the Application of Polyamide 6 Barrier Materials for Fuel Tanks" - in: *Journal of Applied Polymer Science* 127 (2012) 1 , 230 - 236

Eder, G.C.; Spoljaric-Lukacic, L.; Chernev, B. S.: "Visualisation and characterisation of ageing induced changes of polymeric surfaces by spectroscopic imaging methods" - in: *Analytical and Bioanalytical Chemistry 403* (2012) 3, 683 - 695

Djuric, T.; Ules, T.; Gusenleitner, S.; Kayunkid, N.; Plank, H.; Hlawacek, G.; Teichert, C.; Brinkmann, M.; Ramsey, M.; Resel, R.: "Substrate selected polymorphism of epitaxially aligned tetraphenyl-porphyrin thin films" - in: *Physical Chemistry Chemical Physics* 14 (2012) 1, 262 - 272

Fischereder, A.; Martinez-Ricci, M. L.; Wolosiuk, A.; Haas, W.; Hofer, F.; Trimmel, G.; Soler-Illia, G. J. A. A.: "Mesoporous ZnS Thin Films Prepared by a Nanocasting Route" - in: *Chemistry of Materials* 24 (2012) 10, 1837 - 1845

Fladischer, S.; Neuhold, A.; Kraker, E.; Haber, T.; Lamprecht, B.; Salzmann, I.; Resel, R.; Grogger, W.: "Diffusion of Ag into Organic Semiconducting Materials: A Combined Analytical Study Using Transmission Electron Microscopy and X- ray Reflectivity" - in: *ACS Applied Materials & Interfaces* 4 (2012) 10 , 5608 - 5612

Ganner, T.; Bubner, P.; Eibinger, M.; Mayrhofer, C.; Plank, H.; Nidetzky, B.: "Dissecting and Reconstructing Synergism - IN SITU VISUALIZATION OF COOPERATIVITY AMONG CELLULASES" - in: *Journal of Biological Chemistry* 287 (2012) 52, 43215 - 43222

Rumpf, K.; Granitzer, P.; Morales, P. M.; Poelt, P.; Reissner, M.: "Variable blocking temperature of a porous silicon/ Fe3O4 composite due to different interactions of the magnetic nanoparticles" - in: *Nanoscale Research Letters 7* (2012), 445-1 - 445-4

Granitzer, P.; Rumpf, K.; Ohta, T.; Koshida, N.; Reissner, M.; Poelt, P.: "Enhanced magnetic anisotropy of Ni nanowire arrays fabricated on nano-structured silicon templates" - in: *Applied Physics Letters* 101 (2012) , 033110-1 - 033110-4

Granitzer, P.; Rumpf, K.; Ohta, T.; Koshida, N.; Poelt, P.; Reissner, M.: "Porous silicon/Ni composites of high coercivity due to magnetic field-assisted etching" - in: *Nanoscale Research Letters 7* (2012), 384-1 - 384-4

Rumpf, K.; Granitzer, P.; Hilscher, G.; Albu, M.; Poelt, P.: "Magnetically interacting low dimensional Ni-nanostructures within porous silicon" - in: *Microelectronic Engineering* 90 (2012) , 83 - 87

Efimov, A. E.; Gnaegi, H.; Schaller, R.; Grogger, W.; Hofer, F.; Matsko, N. B.: "Analysis of native structures of soft materials by cryo scanning probe tomography" - in: *Soft Matter* 8 (2012) , 9756 - 9760

Gruber-Woelfler, H.; Radaschitz, P. F.; Feenstra, P.W.; Haas, W.; Khinast, J.G.: "Synthesis, catalytic activity, and leaching studies of a heterogeneous Pd-catalyst including an immobilized bis(oxazoline) ligand" - in: *Journal of Catalysis* 286 (2012) , 30 - 40

Steinhauer, S.; Brunet, E.; Maier, T.; Mutinati, G.C.; Köck, A.; Freudenberg, O.; Gspan, C.; Grogger, W.; Neuhold, A.; Resel, R.: "Gas sensing properties of novel CuO nanowire devices" - in: *Sensors and Actuators* B 187 (2013) 50 - 57

Brunet, E.; Maier, T.; Mutinati, G.C.; Steinhauer, S.; Köck, A.; Gspan, C.; Grogger, W.: "Comparison of the gas sensing performance of SnO2 thin film and SnO2 nanowire sensors" - in: *Sensors and Actuators* B 165 (2012) , 110 - 118

Höllen, D.; Klammer, D.; Letofsky-Papst, I.; Dietzel, M.: "Hydrothermal Alteration of Diatomite for Removal of Aqueous Cu2+, Pb2+ and Zn2+" - in: *Journal of Materials Science and Engineering B 2* (2012) 10, 523 - 533

Kock, C.; Gahleitner, M.; Schausberger, A.; Ingolic, E.: "Polypropylene/Polyethylene Blends as Models for High-Impact Propylene-Ethylene Copolymers, Part 1: Interaction Between Rheology and Morphology" - in: *Journal of Applied Polymer Science 128* (2012) 3 , 1484 - 1496

Kremser, G.; Rath, T.; Kunert, B.; Edler, M.; Fritz-Popovski, G.; Resel, R.; Letofsky-Papst, I.; Grogger, W.; Trimmel, G.: "Structural characterisation of alkyl amine-capped zinc sulphide nanoparticles" - in: *Journal of Colloid and Interface Science* 369 (2012) , 154 - 159

Lipovsek, S.; Letofsky-Papst, I.; Hofer, F.; Leitinger, G.; Devetak, D.: "The evidence on the degradation processes in the midgut epithelial cells of the larval antlion Euroleon nostras (Geoffroy in Fourcroy, 1785) (Myrmeleontidae, Neuroptera)" - in: *Micron* 43 (2012) , 651 - 665

Okan, B. S.; Kocabas, Z. Ö.; Ergün, A. N.; Baysal, M.; Letofsky-Papst, I.; Yürüm, Y.: “Effect of Reaction Temperature and Catalyst Type on the Formation of Boron Nitride Nanotubes by Chemical Vapor Deposition and Measurement of Their Hydrogen Storage Capacity” - in: *Industrial & Engineering Chemistry Research* 51 (2012) 35, 11341 - 11347

Littringer, E. M.; Mescher, A.; Eckhard, S.; Schröttner, H.; Langes, C.; Fries, M.; Griesser, U.; Walzel, P.; Urbanetz, N. A.: “Spray Drying

of Mannitol as a Drug Carrier – The Impact of Process Parameters on the Product Properties" - in: *Drying Technology* 30 (2012) 1, 114 - 124

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FELMI-ZFE
Stand Jänner 2013

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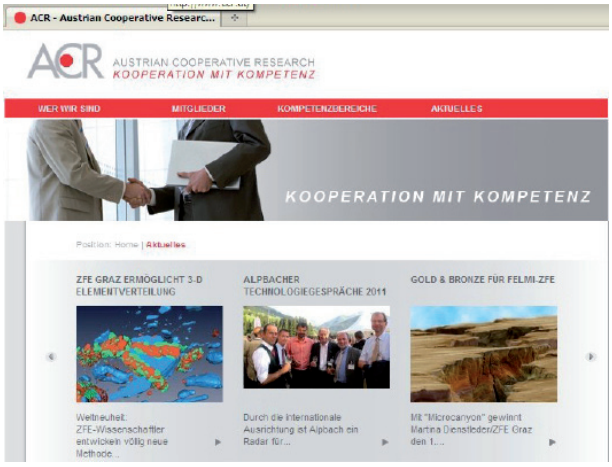

Location & Directions

FELMI-ZFE Calendar 2012

Based on an internal image competition, the best micrographs are chosen once a year and published in the Institute's biannual calendar. The calendar for 2010 highlights micrographs from the world of crystals.