MATERIALS CENTER LEOBEN
FORSCHUNG GMBH

ANNUAL REPORT 2013

COMET K2 Center MPPE

Integrated Research in Materials, Processing and Product Engineering

Competence Centers for Excellent Technologies

The strategic objectives of COMET are to develop new expertise by initiating and supporting long-term research co-operation between science and industry and to promote the exploitation of the results obtained from these collaborations. The programme aims to advance and pool existing strengths, to integrate international research expertise and to establish and secure the technological leadership of companies in order to strengthen Austria's position as a research location in the long term.

We are grateful for funding from the Austrian Federal Government (especially the Federal Ministry for Transport, Innovation and Technology and the Federal Ministry of Science, Research and Economy) represented by the Austrian Research Promotion Agency (FFG), the Regional Government of Styria represented by the Styrian Business Promotion Agency (SFG) and the Regional Government of Tyrol represented by the Business Promotion Agency Tyrol (Standortagentur Tirol).

Our Expertise – Our Objectives

MCL focuses on the following research areas, partly in cooperation with partners:

The Materials Center Leoben (MCL) is an internationally active research institution specialising in materials, production and processing engineering and innovative material applications.

MCL focuses on the following research areas, partly in cooperation with partners:

- **Metallic materials, in particular steels – development, processing, design and innovative applications**
- **Tooling, tool materials as well as tool loading and service life**
- **Material composites – materials and component reliability (in particular for the electronics industry) and ceramic materials**
- **Materials analysis on all length scales**
- **Materials mechanics and simulation – processing, design and reliability, material models**

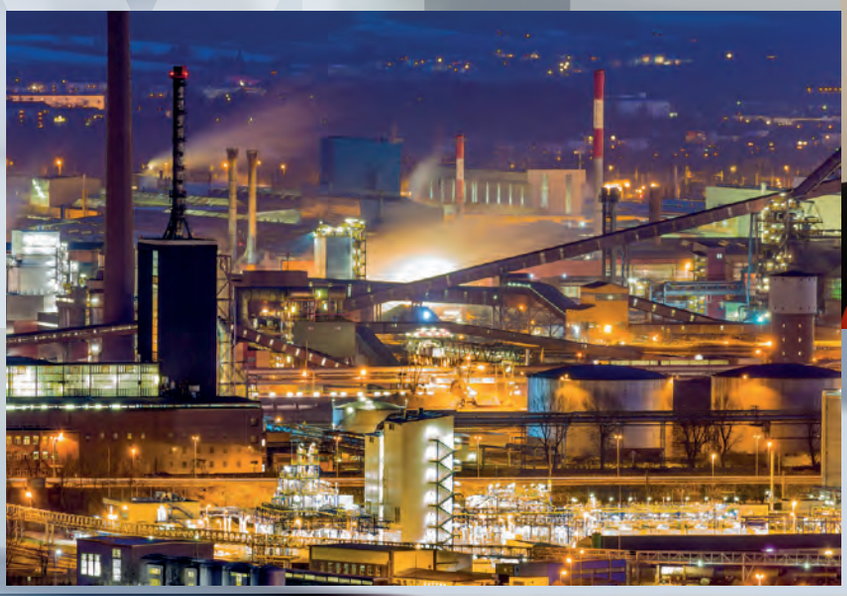
MCL carries out cooperative research and development projects with partners from industry and science and offers a comprehensive range of services.

MCL also acts as the operating company and research partner of the COMET K2 Competence Center "MPPE – Integrated Research in Materials, Processing and Product Engineering", which provides a sound basis for solving complex research and development tasks.

MCL is Austria's leading cooperative materials research centre for industry and science, offering state-of-the-art research and development services.

MCL is aimed at providing industry with sector-specific and scientifically sound knowledge in the field of materials research in order to strengthen the competitiveness of European and especially Austrian companies in this promising sector.

A professional team of around 150 highly trained experts is working on fundamental and innovative developments along the entire value chain of materials research by carrying out research and development projects in cooperation with a total of some 100 industrial and scientific partners.



Company partners

COMET K2 Centre MPPE

Research projects

Scientific partners

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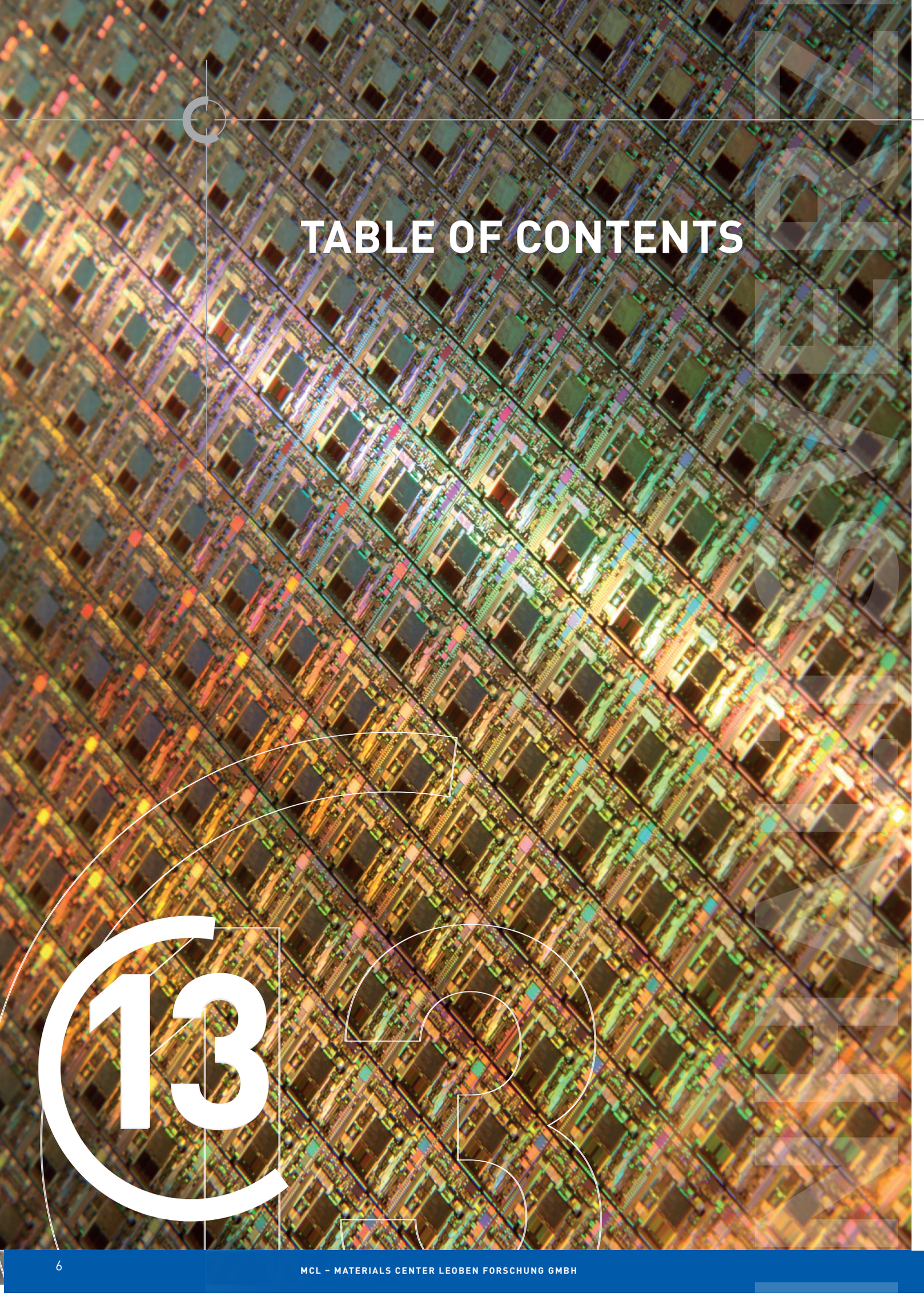

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Management Report

THE COMPANY

Univ.-Prof. Dr. Reinhold Ebner
Geschäftsführer

A successful start to the second funding period for the COMET K2 Centre for Integrated Research in Materials, Processing und Product Engineering (MPPE) (2013 to 2017)

2013 was the first year of the second funding period (Phase II) for the COMET K2 Centre for Integrated Research in Materials, Processing und Product Engineering (MPPE). The funding contract with the Austrian Research Promotion Agency (FFG) was signed in January 2013, the contract with the Styrian Business Promotion Agency (SFG, on behalf of the Styrian Regional Government) in April 2013 and the contract with Standortagentur Tirol (on behalf of the Tyrolean Regional Government) in May 2013.

The agreement required for the implementation of the COMET research programme was finalised in May 2013 following intensive negotiations with the company and scientific partners, thus completing the organisational foundations for the second funding period.

Preparatory work for the new projects began in mid-2012, directly after the announcement of the approval of COMET Phase II, so that the projects could be started simultaneously with the establishment of the relevant organisational and legal structures.

During the second funding period (2013 to 2017), MCL and its company and scientific partners will have access to a COMET project volume of EUR 59.5 million.

Business development 2013

Since some new projects of COMET Phase II started earlier, it was possible not only to avoid a slump in projects during the transition phase but also to generate the largest annual COMET volume to date with approx. EUR 13.9 million (COMET volume 2012: approx. EUR 13.8 million) due to the overlapping of completed projects from Phase I and new projects from Phase II.

In 2013, the COMET activities at MCL accounted for by far the largest portion at just over 87%. The COMET project volume will fall over the next few years, given the approved annual average of EUR 11.9 million for COMET Phase II.

The Non-K area, i.e. activities outside the COMET programme, was also expanded in 2013 and achieved a total volume of just over EUR 2 million for the first time (2012: approx. EUR 1.5 million). It is particularly gratifying to see that this increase includes both the number of contracts from companies and funded projects outside of COMET. In 2013, contracts from companies reached a volume of approx. EUR 1.6 million (2012: approx. EUR 1.1 million) and funded Non-K projects approx. EUR 0.5 million (2012: approx. EUR 0.4 million). While not yet reflected in the 2013 results, a significant expansion of the funded Non-K projects was initiated through both national projects (e.g. under the 'Intelligent Production' programme) and internationally funded projects (e.g. as part of FP7 and ENIAC projects).

Total investments of approx. EUR 1.1 million were made in the 2013 financial year. The focus of investment was on further expanding the microelectronics sector as well as driving forward the expansion of the mechanical testing lab.

Development of the 'Materials for Microelectronics' area

In March 2012, the MCL Supervisory Board decided on the establishment of a new research area, 'Materials for Microelectronics', which laid the foundation for the future strategic orientation of MCL. By the end of 2012, the first investments were made and the new facilities at the Kerpelystraße premises began operation.

On 13 March 2013, the official opening of the new office and laboratory premises was celebrated. Numerous invited guests were in attendance including Regional Minister Dr. Christian Buchmann, CEO Heinz Moitzi (AT&S AG) and Rector Univ. Prof. Dr. Wilfried Eichlseder (Montanuniversitaet Leoben).

The area 'Materials for Microelectronics' has developed as planned. Special highlights include the launch of the first large-scale FP7 project coordinated by MCL in September 2013 as well as the start of several projects under the FFG 'Intelligent Production' programme. Successful proposals were also submitted to the FFG 'Production of the Future' programme and the EU ENIAC programme.

MCL also started to develop methods involving the new research infrastructure. Overall, development of the 'Materials for Microelectronics' area progresses according to plan.

Outlook for 2014

The COMET volume will slightly fall to approx. EUR 13.3 million due to the completion of projects from COMET Phase I.

A 50% increase to approx. EUR 2.9 million is planned for the Non-K area. Here we anticipate a consistent volume of non-funded projects which should again reach approx. EUR 1.5 million. Growth in the Non-K area should be achieved through a substantial increase in funded Non-K research. A volume of approx. EUR 1.4 million is planned in funded Non-K research projects, corresponding to an increase of approx. 200% on 2013. This significant growth is due to the successful project proposals submitted to national and international programmes in 2013.

Investments totalling approx. EUR 1.5 million are planned for 2014. The focus of investment will be in the fields of microelectronics and materials engineering. MCL will also participate in the VSC-3, a high performance computer system at the Vienna University of Technology. This participation is designed to secure the computing requirements of the MCL simulation group in the field of 'Atomistic Modelling' over the next few years.

2014 should set the course for the MCL strategy for the next COMET Phase. The first step is to prepare an MCL business plan defining the key topics. These issues will subsequently be integrated into the research programme for COMET Phase II and will be coordinated with the activities of the company and scientific partners.

In 2014, a special focus will be placed on stronger involvement in international programmes. This includes intensified participation in EU projects and increased involvement in programmes of different Joint Undertakings (JUs) or Joint Technology Initiatives (JTIs) such as ECSEL, Shift2Rail or Clean Sky 2.

Shareholder Statement

THE COMPANY

Magn. Univ.-Prof. Dr. Wilfried Eichlseder
(Chairman of the General Meeting)

Start of COMET Phase II

The 2013 financial year was the first year of COMET Phase II. The approved project volume was increased from € 53 million in COMET Phase I to € 59.5 million in the new funding period. This enables MCL to implement more projects with company and scientific partners to generate material-based innovations. Given the intensive planning phase for this funding period, MCL succeeded in significantly exceeding the € 11.9 million annual average of COMET Phase II in the first year. In the non-COMET area, the volume of nationally and internationally funded projects as well as turnover from non-funded research contracts and services increased substantially in 2013. MCL has shown excellent development in all of its business areas. At the end of 2013, a total of 135 employees were working for MCL. Additional staff were recruited in 2013, or committed for 2014, especially in the new 'Materials for Microelectronics' research area. In November 2013, additional premises were rented at Rosegger-strasse 15 in Leoben offering space for 15 employees from the 'Atomistic Modelling' area.

The key requirement for MCL in COMET Phase II is to increase its international focus and set up an international scientific board. In 2013, MCL was involved in two internationally funded projects and coordinates one of these projects. The members of the International Scientific Advisory Board (ISAB) were appointed in the second half of 2013. The first board meeting will be held in Leoben in February 2014.

Report from the General Meeting

The Management Board and the Supervisory Board reported to two General Meetings held in 2013. Dr. Richard Schanner left his position as MCL Commercial Managing Director with effect from 30 April 2013. The selection process for his successor is now in its final stages.

The annual accounts for 2013 were unanimously approved and the Management Board and the Supervisory Board were formally discharged for 2013. The shareholders would like to thank the members of both boards for their excellent work.

The owners are very pleased about MCL's positive business development and scientific achievements. Its continued trend for growth is also reflected in the budget allocated for 2014.

Shareholder structure of Materials Center Leoben Forschung GmbH:

47.5 %	Montanuniversitaet Leoben
17.5 %	Joanneum Research Forschungsgesellschaft mbH
15.0 %	Municipality of Leoben
12.5 %	Austrian Academy of Sciences
5.0 %	Vienna University of Technology
2.5 %	Graz University of Technology

From the Supervisory Board

Implementation of objectives 2013

The transition from COMET Phase I to COMET Phase II has been seamless. This is the result of excellent planning and preparation for the new funding period in collaboration with the company and scientific partners. In 2013, due to the start of a large number of projects, the COMET project volume exceeded plans at approx. € 14 million, thus significantly exceeding the COMET phase II annual average of € 11.9 million.

MCL's aim was to increase involvement in EU projects and tap into various national funding channels in order to diversify the financing of MCL across various funding sources. In 2013, MCL was involved in two EU projects and coordinates the 'MSP – Multi Sensor Platform for Smart Building Management' project, which was launched on 1 September. The project volume in the nationally funded sector could also be significantly increased due to new projects in the FFG funding programme 'Intelligent Production'. Turnover in non-funded research contracts and services has continued to grow over the last few years thanks to continuous infrastructure expansion.

Strategic further development and challenges

In addition to the successful implementation of the COMET programme, MCL will also continue to work intensively on the development of the non-COMET area. MCL sees particular potential in the 'Horizon 2020' EU programme, which launched its first call in December 2013 as well as in the national FFG funding programme on 'Production of the Future'. Ongoing growth is also expected in the field of non-funded research and services. The development of the latest MCL research area 'Materials for Microelectronics' will go ahead as planned. These strategic developments will only work if MCL succeeds in further expanding its partner network with companies and universities/research institutions.

Another focal point of MCL in the next few years will be the registration and exploitation of patents. Research carried out by MCL has resulted in numerous improvements and innovations among its company partners. The future focus will be on using this expertise not only at the research partners but also examining its potential application in other companies and industries.

The position of Commercial Managing Director is currently vacant following the departure of Dr. Schanner as Managing Director in April of this year. The selection process will be completed shortly.

Dr. **Martha Mühlburger**
Chair
delegated by Montanuniversitaet Leoben

Dr. **Bruno Hribernik**
Deputy Chair
appointed by the General Meeting

Dr. **Knut Consemüller**
appointed by the General Meeting

Univ.-Prof. Dr. **Gerhard Dehm**
delegated by the Austrian Academy of Sciences

Mag. **Katharina Kocher-Lichem**
appointed by the General Meeting

Univ.-Prof. Dr. **Wolfgang Pribyl**
delegated by JOANNEUM RESEARCH Forschungsgesellschaft mbH

SChef a.D. Senator h.c.
Dr. **Norbert Rozsenich**
delegated by Montanuniversitaet Leoben

Univ.-Prof. Dr. **Christof Sommitsch**
delegated by Graz University of Technology

Dr. **Christian Wolf**
delegated by Vienna University of Technology

From the COMET K2 Programme Committee

Representatives of company partners:


Dr. **Christoph Auer**
EPCOS OHG - A Group Company of TDK-EPC Corporation


DI **Josef Hagler**
voestalpine Stahl GmbH


Dr. **Christian Hinteregger**
MAGNA Powertrain AG


Dr. **Gerhard Jesner**
Böhler Edelstahl GmbH & Co KG


Dr. **Raimund Ratzi**
Miba AG


Dr. **Martin Schrems**
ams AG


Dr. **Axel Sormann**
voestalpine Metal Engineering GmbH & Co KG

Tasks of the Programme Committee

The Programme Committee reviews, assesses and approves new research projects for inclusion in the research programme of the COMET K2 Centre MPPE. The proposed projects are assessed in terms of their coherence with the objectives of the MPPE research programme for the second funding period, their contribution to achieving the goals of the MPPE research programme and their compliance with the requirements specified for the second funding period, i.e. scientific and/or technological excellence, level of innovation and practical applicability of the results.

New members in the Programme Committee

There have been several changes in the membership of the Programme Committee due both to career changes and a shift in subject focus, with a greater emphasis on electronics, microelectronics and functional properties during the second COMET funding period.

The following members have left the Programme Committee:

- Univ.-Prof. Dr. Helmut Antrekowitsch (Montanuniversität Leoben)
- Univ.-Prof. Dr. Franz Dieter Fischer (Montanuniversität Leoben)
- Univ.-Prof. Dr. Andreas Ludwig (Montanuniversität Leoben)
- Dr. Christian Majcenovic (RHI AG)
- Univ.-Prof. Dr. Werner Sitte (Montanuniversität Leoben)

The MCL management would like to thank the members who have left the Programme Committee for their past work, and wishes them all the best in the future.

The new members of the Programme Committee are:

- DDr. Martin Schrems (ams AG)
- Univ.-Prof. Dr. Christian Mitterer (Montanuniversitaet Leoben)
- Assoz. Prof. Dr. Norbert Enzinger (Graz University of Technology)
- Univ.-Prof. Dr. Johannes Schenk (Montanuniversitaet Leoben)
- Dr. Barbara Stadlober (JOANNEUM RESEARCH Forschungsgesellschaft mbH)

The MCL management also thanks the new members for agreeing to join the Programme Committee, and looks forward to working with them.

New projects approved by the Programme Committee

In its three meetings held in 2013, the Programme Committee approved a total of 12 new projects with a total volume of around EUR 11 million for inclusion in the COMET Programme. The increasing size of the proposed research projects shows that its unique structure enables the Competence Centre to tackle larger projects in order to develop solutions to highly complex problems in industry and to achieve innovations.

The Programme Committee imposed requirements for some of the projects, which were taken into account by the relevant project managers in drawing up the final project plans.

The projects continued from COMET Phase I and the projects approved in 2013 together already account for around 66% of the total project volume for COMET Phase II.

Representatives of scientific partners:

Assoz. Prof. Dr. **Norbert Enzinger**
Graz University of Technology

Univ.-Prof. Dr. **Florian Grün**
Montanuniversitaet Leoben

Univ.-Prof. Dr. **Otmar Kolednik**
Austrian Academy of Sciences

Univ.-Prof.
Dr. **Ernst Kozeschnik**
Vienna University of Technology

Univ.-Prof.
Dr. **Christian Mitterer**
Montanuniversitaet Leoben

Univ.-Prof. Dr. **Johannes Schenk**
Montanuniversitaet Leoben

Mag. Dr. **Barbara Stadlober**
JOANNEUM RESEARCH
Forschungsgesellschaft mbH

RESEARCH PROGRAMME COMET K2 MPPE

Innovation through integrated materials, process and product engineering

Review of the first year of COMET Phase II

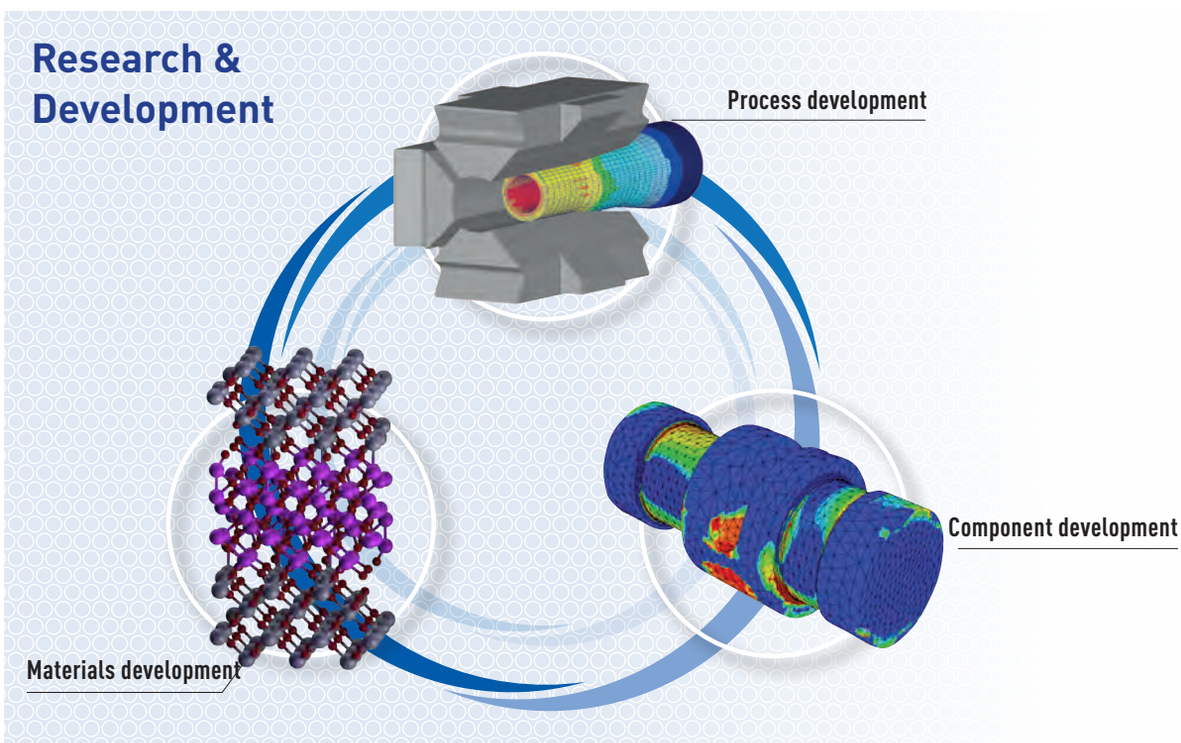
Highlights:

- **High-performance pressure casting for low-weight car components**
- **More power in lighting technology**
- **Does residual stress have a sell-by date?**
- **Atomistic modelling, or the art of understanding how atoms work**

Innovation through integrated materials, process and product engineering

The COMET K2 Centre for "Integrated Research in Materials, Processing and Product Engineering (MPPE)" provides a platform for MCL to carry out innovative materials research projects together with partners from industry and science.

Integrated materials, process and product engineering offers an enormous potential for innovation, cost reduction and resource efficiency, a potential that has scarcely been exploited to date due to the complex interactions involved.



This is where MPPE comes in: seamless simulations of complex sequential manufacturing processes enable a detailed understanding and numerical description of the processes involved across the entire value chain, from materials synthesis to the end of the component lifecycle.

The most significant advantages include shorter process times, lower production costs, higher quality, lower consumption of energy and material resources, improved design concepts and enhanced reliability. MPPE uses its detailed understanding of the entire value chain to develop innovations involving new materials, new processes and new high-strength structural parts as well as components with new functional properties.

This approach is used to exploit and extend the load limits of materials and components and reduce both unit costs and time to market, resulting in innovative high-strength products.

RESEARCH PROGRAMME
COMET K2 MPPE

Innovation through integrated materials, process and product engineering

The research projects, especially the strategic projects, provide the industrial partners with fundamental expertise and simulation methods required for the development of new processes and products.

The COMET Programme gives the partners access to the latest scientific findings as well as state-of-the-art simulation and experimental methods and the opportunity to implement innovative funded research projects together with scientific research institutions and other industrial partners. The project teams usually cover the entire value chain; but there are also cases where competing companies join forces to work on application-oriented fundamentals.

The long-term strategic projects provide the fundamentals for future developments. They are designed to ensure a sustainable research and development basis for the years to come.

The COMET research activities carried out in long-term projects in 2013 accounted for around 87% of the MCL volume. Some 10% of turnover came from direct research and development contracts or service activities and around 3% of the project volume came from research projects funded under other national and international research programmes.

Review of the first year of COMET Phase II:

Project volume and financing of COMET Phase II:

Phase II of the COMET Programme runs from 1 January 2013 to 31 December 2017. A total volume of € 59.5 million in funding has been granted to MCL for this period.

MCL and the scientific partners account for about € 48.5 million of the project volume. The company partners will provide in-kind contributions of at least € 11 million, thus making an essential contribution to the success of the projects and also to the implementation of the project results in the companies. The amount of € 11 million only includes the contributions to be claimed; the actual contributions will be significantly higher.

The project volume of € 59.5 million for COMET Phase II will be divided as follows: public funding: € 29.75 million, in-kind contributions by the scientific partners: approx. € 3 million, contributions by the company partners: € 26.8 million, of which € 15.8 million in cash and around € 11 million in kind.

The Austrian Research Promotion Agency (FFG), the Styrian Business Promotion Agency (SFG) and the Business Promotion Agency Tyrol will provide 50% of the total funding volume, another 5% will be contributed by the scientific partners in the form of in-kind contributions.

Period	**2013 to 2017**
Planned COMET project volume (€ million):	**59.5**
of which MCL and scientific partners	48.5
of which company partners	11,0
COMET financing (€ million):	**59.5**
Federal funding	19.8
Provincial funding	9.9
In-kind contributions by scientific partners	3.0
Cash contributions by company partners	15.8
In-kind contributions by company partners	11.0

Project volume in 2013:

The COMET project volume in 2013 was € 13.9 million, clearly exceeding the average annual value of € 11.9 million planned for COMET Phase II. This was due to the launch of many new projects resulting from the planning phase for the second funding period and the completion of projects from the first funding period

Projects and project development:

All COMET projects are cooperative research and development projects carried out in close cooperation between MCL and its scientific and company partners. The projects typically run for three to five years with budgets ranging between € 500,000 and € 2,500,000. Both the volume and the complexity of the projects have increased substantially over the past few years.

A total of 7 projects from COMET Phase I were completed in 2013. Another 36 projects from the first funding period were still ongoing at the end of 2013 and 13 new projects were started.

Projects 2013	
completed in 2013	7
ongoing at the end of 2013	49

Publications and patents:

A total of 78 publications were published in 2013, of which 51 appeared in scientific journals (43 of them refereed) and 27 in conference proceedings (20 of them refereed). Publications additionally included 111 other contributions (conference papers, posters etc.).

Two patents were filed in 2013, one by MCL and one by a company partner. The number of patents is expected to increase substantially over the next few years, as the competence centre reaches a higher level of maturity.

Publications 2013	**78**
of which in refereed journals	43
of which in refereed conference proceedings	20
of which not refereed	15
Patents 2013	**2**

Degree theses:

A total of 10 doctoral theses and 7 diploma/master's theses were completed in 2013. Another 63 academic theses (55 doctoral theses and 8 diploma/master's theses) were ongoing at the end of 2013).

Doctoral theses:	**65**
completed in 2013	10
ongoing at the end of 2013	55
Diploma/Master's theses	**15**
completed in 2013	7
ongoing at the end of 2013	8

Research areas:
The COMET K2 Center for Integrated Research in Materials, Processing and Product Engineering focuses on the core areas of the value chain and covers the following fields:

1. Development and characterisation of materials
2. Materials synthesis
3. Design and testing of parts and functional components
4. Materials processing into parts and functional components
5. Behaviour of materials in service

The scientific objectives of the individual research areas were revised and updated for COMET Phase II (2013 to 2017). Multidisciplinary projects are carried out in the following seven research areas to be able to investigate both the scientific and technological aspects of the entire value chain for materials and components, from manufacture through to behaviour in service:

- Area 1: Virtual Integration of Materials, Process and Product Engineering
- Area 2: Multi-Scale Materials Design
- Area 3: Advanced Manufacturing Processes
- Area 4: Damage – Mechanisms, Evolution and Modelling
- Area 5: Tooling
- Area 6: Smart Concepts for Structural Components
- Area 7: Design and Reliability of Functional Components

The research activities will be illustrated by some examples.

- High-performance pressure casting for low-weight car components
- More power in lighting technology
- Does residual stress have a sell-by date?
- Atomistic modelling, or the art of understanding how atoms work

RESEARCH PROGRAMME
COMET K2 MPPE

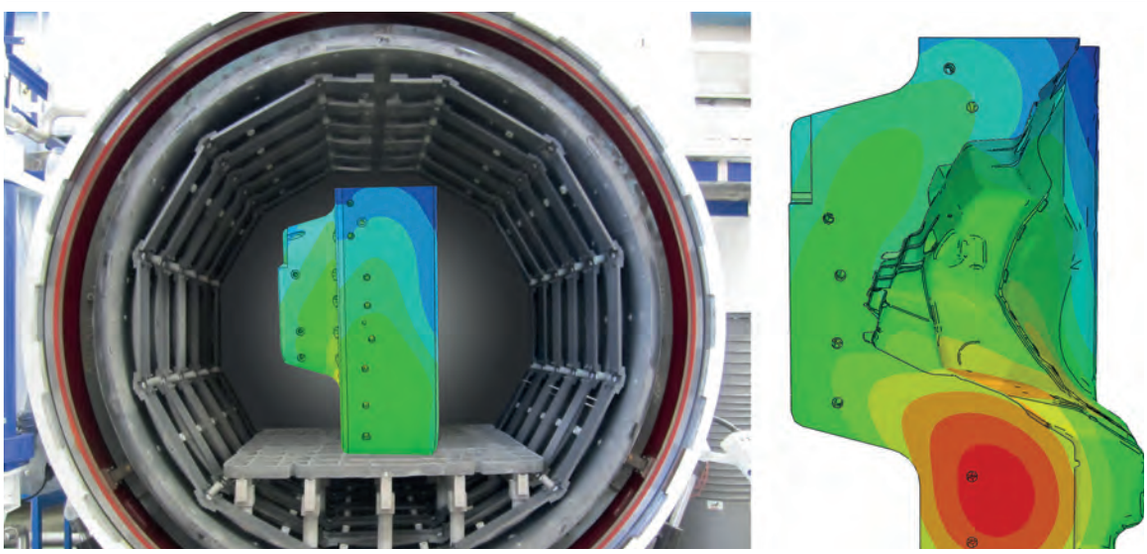
Highlights

High-performance pressure casting for low-weight car components

Light components for enhanced driving enjoyment

Accelerating a car to 100 km/h in just a few seconds and achieving a top speed of over 300 km/h requires not only a high-performance engine but also substantial reductions in vehicle weight. Lightweight components based on aluminium and magnesium alloys are increasingly replacing components previously made from steel, such as oil sumps, gearboxes and even entire vehicle doors. Their manufacture involves heating the light metal and injecting the molten metal into die-casting moulds under high pressure. The resulting casting requires only minimal mechanical finishing. One of the worldwide market leaders in automotive die-cast parts production is Georg Fischer GmbH in Altenmarkt (Styria), a production site of GF Automotive.

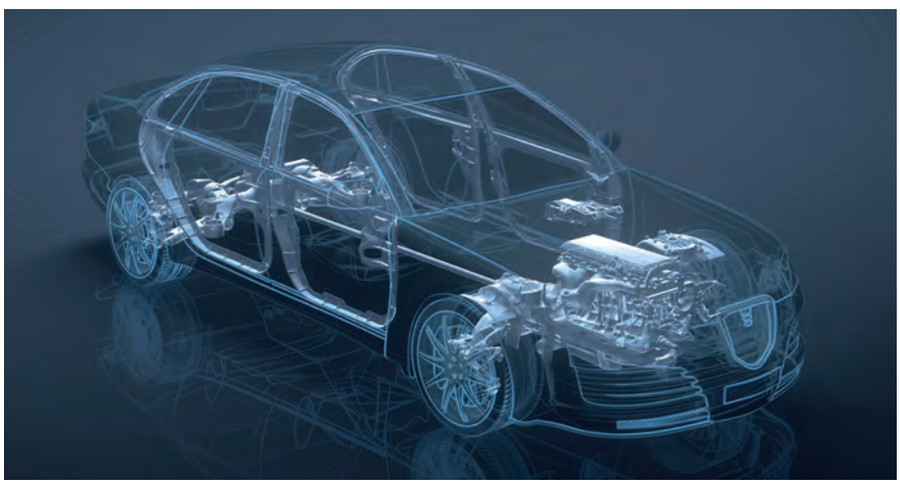
The mould plays an essential part in the success of die-casting. It represents a high cost factor because of its short lifespan and also has a major influence on the quality of the castings.



Temperature profile in a die-casting mould during the hardening process in the vacuum furnace (TAGS.r.l., Via Marconi 9, Dolzago, Italy)

Strike while the iron's hot

To ensure that the moulds have a long lifespan despite exposure to repeated high temperature loads at one minute intervals, they first undergo "training" in the form of heat treatment which makes the hot-work steel as hard and as tough as possible. Similar to a blacksmith who first shapes his piece of red-hot metal with a hammer and then quenches or hardens it in an oil or water bath, the die-cast moulds are first heated to around 1000°C in a vacuum furnace and then quenched with a stream of nitrogen. This gentler method of quenching with gas rather than oil minimises the stresses that arise from quenching, so that even moulds weighing up to 6 tonnes do not break. The hardened moulds are repeatedly heated to 550°C to give the steel exactly the right toughness for the production of up to 100,000 castings. This change in its mechanical



Vehicle parts produced using die-cast technology (Source: GF Automotive)

properties is attributable to microstructural processes in the atomic and nanometer ranges, which are deliberately modified by the addition of alloying elements like chromium, molybdenum and vanadium.

The purpose of the heat treatment is to make the die-cast moulds fit for industrial use. Paradoxically, however, the heat treatment itself represents the greatest thermal and mechanical stress, and this is where the Materials Center Leoben comes in. MCL describes the entire heat treatment process at micro and macro levels through experimental materials characterisation under real conditions using experimental heat treatments and through state-of-the-art simulation methods. This makes it possible to numerically calculate the stresses occurring during heat treatment and to predict the spatial and temporal development of adverse stress conditions as well as hardness development. The numeric calculation of these microstructural processes enables the development of tailored heat treatment processes and the design of optimised moulds. This makes it possible to actively prevent mould breakage during hardening and to improve the lifespan of the moulds and the quality of the castings, thus improving the overall efficiency of the production process.

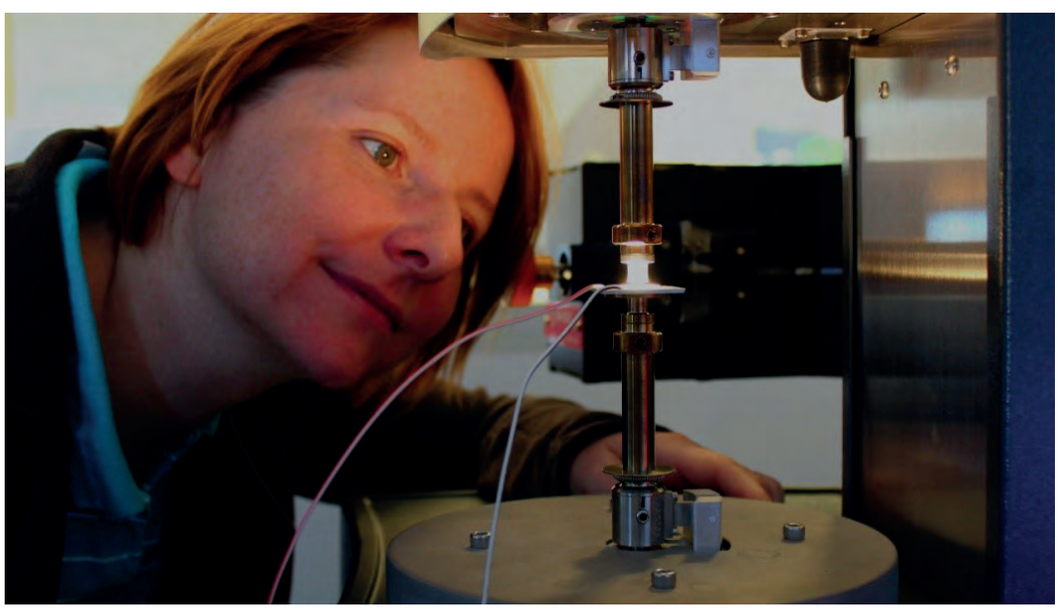
Impact

The knowledge gained from this project greatly reduces the risk of cracking and breakage of the moulds during heat treatment. In addition, the tailor-made microstructure and improved mechanical characteristics significantly increase the service life of these moulds. Given the ever-faster production cycles and constant price pressures in the automotive sector, the expertise developed at the Materials Center Leoben for Georg Fischer GmbH is an important tool for maintaining a competitive edge internationally and for securing local jobs in Altenmarkt.

More power in lighting technology

LEDs – everybody wants them

Light-emitting diodes, so-called 'LEDs', are the lighting technology of the present – and the future. LEDs can now be found as part of virtually every lighting concept: whether in medical engineering, the automotive sector or furniture lighting and panel lights. The trend now is for ever greater luminosity, longer lifespan and use in extreme environments. LEDs must meet ever higher technological requirements, which may lead to losses in terms of colour stability, efficiency and service life. When it comes to product life in particular, it is essential to know how the various materials interact when subjected to extreme operating temperatures and temperature fluctuations during switching processes. Mechanical tensions due to interactions between the various materials and resulting damage must be kept to an absolute minimum.



Together with Tridonic Jennersdorf GmbH, MCL explores the thermo-mechanical issues of white light LED modules. A white LED module consists of an LED chip, a transparent plastic capsule and 50 µm contact wires which are about as thin as a human hair. The component heats up during operation. This warming due to the different physical and mechanical properties of the materials does not occur evenly, however, resulting in thermo-mechanical interactions between the materials used, e.g. between the wire and the capsule. The resultant thermo-mechanical 'stress zones' can lead to breaking of the contact wires and thus total failure of the LED module.

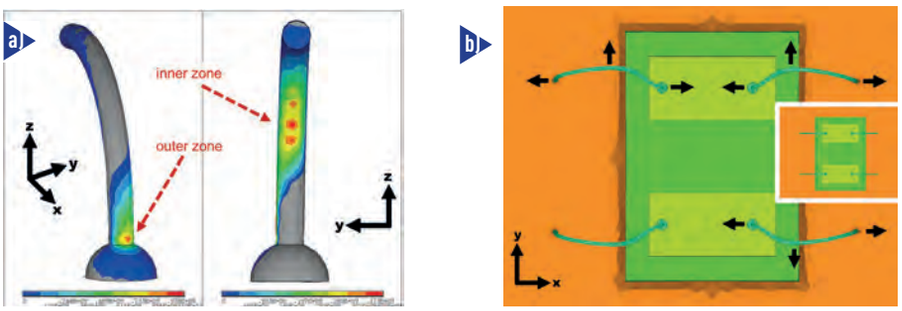
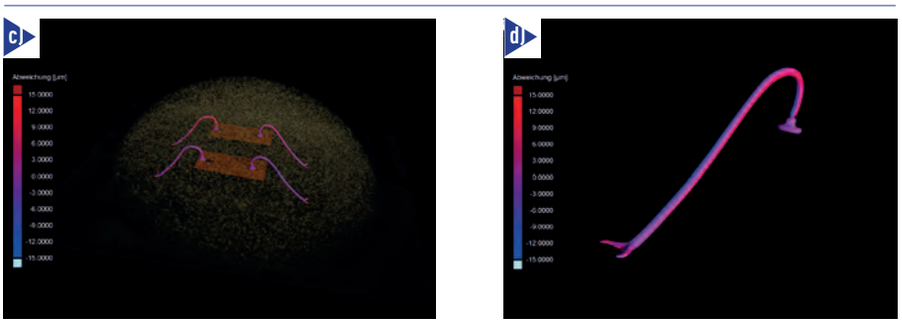


Fig. a) reveals critical stress zones in the wire contact transition points; Fig. b) shows the deformation of the wires caused by thermo-mechanical interaction with the surrounding environment

Greater Output through a new design and new materials

The aim of the project is to apply experimental methods and computer-aided thermo-mechanical simulation to investigate these critical stress zones in order to prevent potential component failure and thus increase product life. Verifying the reliability of the calculation models presents a particular challenge. The use of high resolution computer tomography (CT) provides a three-dimensional insight into the LED module. The combination of thermomechanical simulation and high resolution computer tomography opens up new possibilities for developing more robust LED modules in the future. This paves the way for targeted materials development and optimised thermomechanical component design. Further research in this field will be undertaken in a recently launched project under the FFG 'Production of the Future' programme in collaboration with the Graz University of Technology and Tridonic Jennersdorf GmbH.



CT images of an LED module; image c) shows a photograph of a white light LED module, image d) shows an enlarged section of the wire. The colours indicate the deformation of the wire with increas-ing temperature

Impact

According to a current market analysis, annual growth rates for LEDs are estimated at 5% until 2016 and subsequently 3% until 2020. The cutting-edge methods developed at MCL provide a detailed understanding of thermomechanical interactions in white LEDs and can therefore be used to identify potential weaknesses within the module. The results of this research help to considerably increase LED lifespan through the improved selection of materials in terms of their thermal and mechanical properties.

Does residual stress have a sell-by date?

Rolling prolongs lifespan

Mechanical surface hardening processes are firmly established in many sectors of engineering. For example, crankshafts for car engines are "deep rolled" in one of the final production processes in order to significantly prolong their lifespan. Deep rolling provides a simple method of slowing down or even preventing crack growth on defects. During the process, a powerful work roller is applied to the rotating crankshaft, producing an extremely smooth surface with high fatigue strength. This enhanced fatigue strength can be attributed in part to the smooth surface but is mainly due to the residual compressive stress caused by the plastic deformation of the material layers close to the surface. Deep rolling therefore represents a simple and cost-effective process for improving the damage tolerance of components by inducing residual compressive stress.

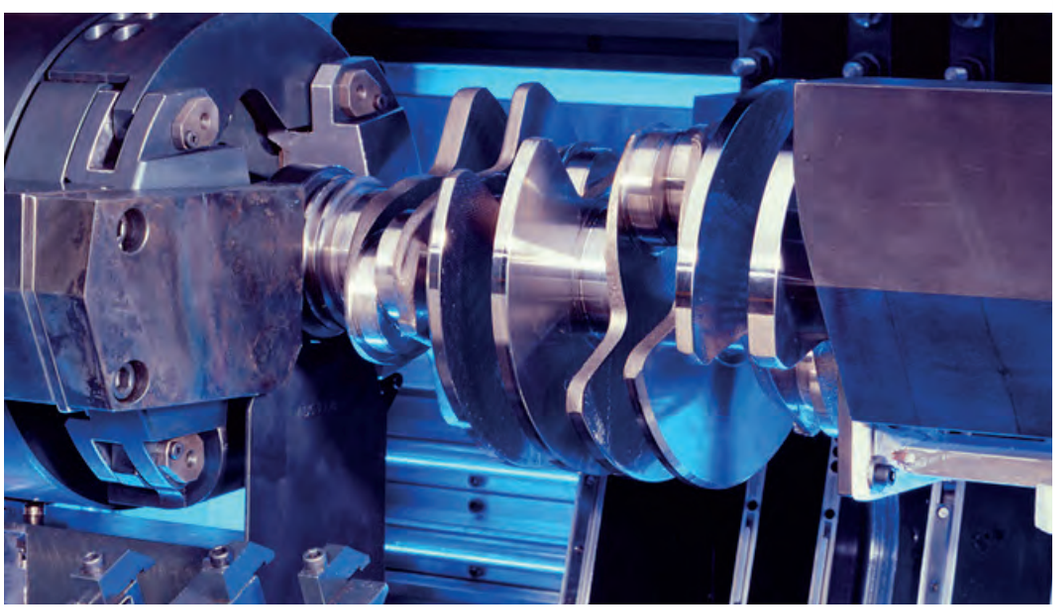
Deep rolling a wheelset axle (Source: Hegenscheidt)

Deep rolled crankshafts

How stable are these residual stresses in service, though? The Materials Center Leoben, Hegenscheidt-MFD GmbH and Siemens AG Österreich set out to find an answer to this question. Particular importance was attached to selecting a simple approach which was suitable for both initial rough estimates and for the comparison of different deep rolling tools. To achieve this, wheelset axles were deep rolled with different tools, followed by an evaluation of the residual stress curves. Laboratory samples with smaller dimensions were also deep rolled and subjected to a long-term test at various load levels and different load cycles. The remaining residual stresses were then measured. The experiments showed that the residual stresses and the associated fa-

tigue strength were reduced only at very high loads which far exceeded normal service loads. In order to make practical use of this knowledge, the project team developed a rule of thumb based on calculations and backed up by test results. This mathematical model makes it possible to predict the stability of the residual stresses induced by deep rolling during fatigue loading.

So there is no need to worry about deep rolled crankshafts in cars because the residual stresses applied keep their promises.



Crankshaft production (Source: Hegenscheidt)

Impact

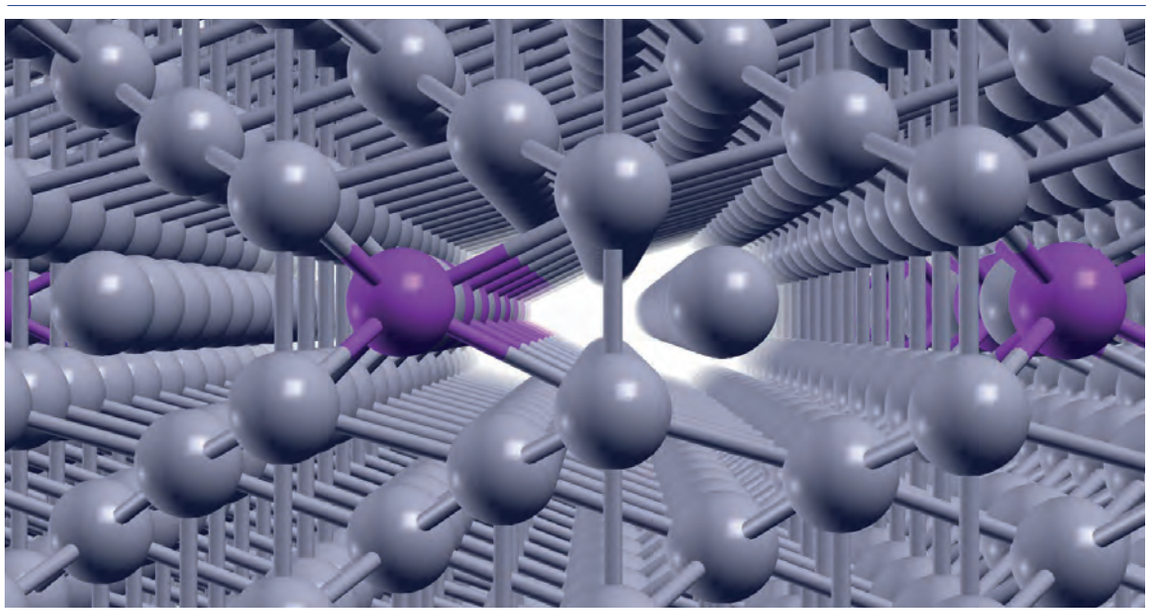
One significant outcome of this collaborative project has been the creation of an easy-to-use model for production companies. This model makes it possible to make a quick and reliable estimate of whether and to what extent the residual stresses in the material will change in service and what effect this will have on component fatigue strength. This will also facilitate the provision of appropriate safety verification.

Atomistic modelling, or the art of understanding how atoms work

Matter – the basis of everything and what holds it together

What makes a diamond hard? Why does copper conduct electricity but ceramic doesn't? How can steel be both hard and yet formable?

The answer to all these questions lies in the building blocks of matter – atoms. At the atomic level it is the power of attraction between the positively-charged atomic nucleus and its negatively-charged electrons which binds matter together and determines how materials react to external influences. But what is astounding is that, ultimately, it is purely the interplay between this 'plus' and 'minus' which is responsible for creating every different form of material and its properties, such as strength, magnetism or density.



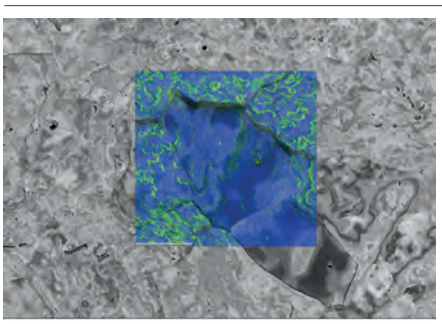
Model image of a grain boundary in tungsten (grey atoms) alloyed with rhenium (violet atoms)

Designing new materials with a computer – the idea is already 90 years old

Ninety years ago Erwin Schrödinger formulated a method for calculating the interplay of these particles using the equation which bears his name. In principle, this equation can be used to calculate the properties of all materials, but actually solving the equations proved so complicated that calculating even the simplest of materials was impossible. Walter Kohn formulated a more efficient theory for which he was awarded the Nobel Prize 15 years ago. This theory has helped to advance the calculations further and this, paired with rapid advances in computing power over recent decades, has made working through the equations easier. As a result, it is now possible to predict material properties on the basis of their atomic structure.

Modern industry relies on reliable calculations and a combination of theory and practice. At the Materials Center Leoben a team of 9 young scientists is investigating how so-called atomistic modelling can be used to improve material properties. This requires a fundamental understanding of matter as well as practical experience with the materials. With the aid of state-of-the-art computer programs, co-developed at Leoben, the properties of new materials are calculated in advance. This enables predictions to be made about the basic properties a new material will possess before it is created, for example, how strongly it will expand under increasing temperatures, its optical features, and whether it will exhibit good plastic flow properties.

A wide range of atomistic modelling applications are currently in use at MCL. One research project investigates how foreign atoms attach themselves to the grain boundaries in a variety of metals, and the impact this has on metal strength. Another project explores how diffusion barriers in semiconductor devices work at the atomic level and how they can be optimised. Yet another is concerned with calculating the influence of alloying elements, temperature and magnetism on defects in the atomic lattice. The results will provide the basis for the future design of new steels with exceptional formability.



A grain boundary seen under a scanning electron microscope: an alloy of molybdenum, titanium and zirconium displaying orientation defects in the crystal lattice caused by dislocation.

Impact

The long-term goal of atomistic modelling is to 'design' new materials directly on the computer. The aim is to make them particularly hard, corrosion-resistant or exceptionally light – or ideally able to fulfil several criteria at once. This saves expensive and time-consuming development processes involving the creation and testing of many thousands of samples.

In order to achieve the goal of computer-supported predictions of materials and material properties, atomistic modelling methods need to be further advanced, and more closely linked to modelling methods based on other length and time scales.

MCL is currently working on calculations for metal alloys, on the structure and properties of crystal defects (e.g. lattice vacancies, displacements, grain boundaries) and their impact on physical phe-nomena such as diffusion, and increasingly on functional properties (e.g. electrical and optical properties).

INTELLECTUAL CAPITAL REPORT

13

Intellectual Capital Report

I. Scope, Goals and Strategies

Knowledge and expertise are the key factors for the sustainable success of research institutions. The Intellectual Capital Report is designed to provide an overview of MCL's intellectual capital and research outcome. The key indicators in this context are scientific publications, human resources and international networks. Other important factors are output and impact, which are reflected in the number of completed projects or patent applications.
In addition to increasing its scientific excellence, MCL strives to gain better visibility at the international level over the coming years. Various measures have been and will be implemented to achieve this goal:

- COMET projects involving new international scientific and company partners have been defined and started.
- After successfully taking part in calls for proposals for international funding programmes, projects have been started with new international partners.
- Greater cooperation with international scientific partners, such as KTH in Stockholm, is being driven forward in order to strengthen the partner network.
- The International Scientific Advisory Board was established to enable renowned international scientists to critically assess future MCL strategy.
- More MCL employees are taking up positions on international committees.
- The drive to employ more international staff is being continued.
- MCL employees are being given the support needed to allow them to take part in international conferences and undertake research abroad.
- Greater attention is being paid to how MCL publications are perceived externally.

II. Intellectual Capital

A. Human capital

Development

Staff levels at MCL fell from 150 in 2012 to 135 as at 31 December 2013 due to an increasing number of staff registering with the universities and research institutions where they are based and the conclusion of several projects at the end of the first COMET funding period. However, in terms of full-time equivalents, this is only a drop of around 3 FTE.

By the end of 2013, MCL employed 24 international staff members from 13 different countries. This represents 18% of the workforce. Our international employees bring significant benefits to MCL, and their collective experience adds greatly to MCL's range of competencies.

Some further 500 employees of our company and scientific partners are working on projects in the COMET Programme. With a total of around 660 staff, the COMET Programme offers enormous potential for taking on highly complex scientific challenges.

Personnel MCL/MPPE 2013
as of: 31/12/2013

	Employees		
	male	**female**	**total**
Research	**96**	**17**	**113**
Management	1	0	1
Key scientist	13	0	13
Senior scientist	12	5	17
Junior scientist	70	12	82
Administration	**0**	**9**	**9**
Technicians / Skilled staff	**10**	**3**	**13**
Total MCL	**106**	**29**	**135**

Personnel at COMET Partners 2013

Company partners	321	34	355
Scientific partners	142	26	168
Total	**463**	**60**	**523**

MCL generally seeks to offer its employees an attractive working environment, including tailored continuing education and training measures and a high level of flexibility to ensure a sound work-life balance.

Gender Mainstreaming

Around 22% of MCL employees are female. As of 31 December 2013, female scientists including those on maternity leave accounted for 18% of the scientific workforce. The proportion of women working in the microelectronics division was significantly higher and reached almost 50%, taking into account technicians and students.

MCL is making every effort to continue to increase the number of female employees over the long term, for example by organising a range of activities such as school visits designed to encourage girls to consider careers in science and engineering.

The increasing number of female employees, and the generally low average age of all staff members, is leading to increasing demand for flexible working hours in order to accommodate child care, both amongst male and female staff. MCL offers flexible working for all employees with caregiving responsibilities. The concept of flexible working will continue to be developed to ensure MCL remains an attractive employer for male and female staff with young families.

Qualification measures and personnel development

The MCL qualification programme is designed to achieve the maximum possible overlap between the interests of the COMET Center and the professional skills and thematic interests of its staff. The qualification programme includes general measures to improve scientific and technical skills, as well as qualifications relevant to individual employees.

Young scientists are involved in research projects at an early stage in their training, and can undertake research as part of their bachelor's, master's and doctoral qualifications. MCL staff members are also given the opportunity to undertake research with national and international research partners, and to take part in national and international conferences. In addition to subject-related training, measures are available for MCL employees to improve other skills including scientific writing, communication and negotiation, project management and team leadership. Staff are also regularly trained in occupational safety and health.

MCL also helps employees organise their professional environment so that they can complete postdoctoral qualifications.

B. Relational capital

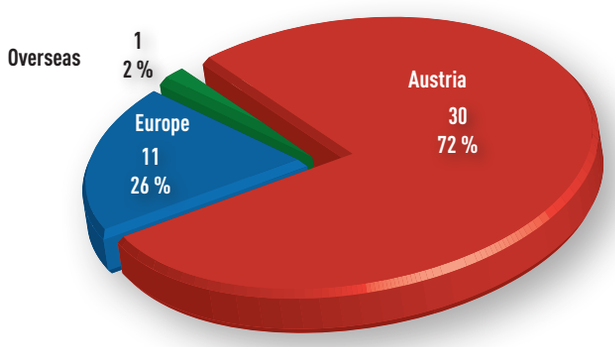
COMET – Scientific Partners

A large number of scientific partners have joined the COMET research programme over the past few years to work jointly on the solution of complex research problems. A total of 42 scientific partners from 22 research institutions and universities were involved in the first year of the COMET phase II:

- Aalto University, Department of Materials Science and Engineering
- Academy of Science of the Czech Republic , Institute of Physics of Materials
- Austrian Foundry Research Institute (Österreichisches Gießerei-Institut)
- Bay Zoltan Foundation for Applied Research
- Erich Schmid Institute for Materials Science, Austrian Academy of Science
- Ecole Nationale Supérieure de Céramique Industrielle (ENSCI), Groupe d'Étude des Matériaux Hétérogènes (GEMH), Limoges
- Graz University of Technology with Institute of Materials Science and Welding
- JOANNEUM RESEARCH Forschungsgesellschaft m.b.H
- Karl Franzens Universität Graz with Institute of Physics
- Forschungszentrum Karlsruhe GmbH, Eggenstein Leopoldshafen (KIT)
- LKR Leichtmetallkompetenzzentrum Ranshofen GmbH
- Max-Plank-Institut für Eisenforschung GmbH
- Max-Plank-Institut für Kolloid- und Grenzflächenforschung
- Montanuniversität Leoben with
  – Chair of Nonferrous Metallurgy
  – Chair of Thermal Processing
  – Institute of Mechanics
  – Institute of Physics
  – Chair of Subsurface Engineering
  – Institute for Structural and Functional Ceramics
  – Institute of Material Science and Testing of Plastics
  – Chair of Mechanical Engineering
  – Chair of General and Analytical Chemistry
  – Chair of Functional Materials and Materials Systems
  – Chair of Ceramics
  – Chair of Casting Research
  – Chair of Physical Metallurgy and Metallic Materials
  – Chair of Materials Physics
  – Chair of Metallurgy
  – Chair of Simulation and Modelling of Metallurgical Processes
  – Chair of Physical Chemistry
  – Chair of Metal Forming
  – Chair of Applied Mathematics
- Royal Institute of Technology, Department of Materials Science of Engineering
- Slovak Academy of Science, Institute of Physics, Bratislava

- Vienna University of Technology with
  – Institute of Chemical Technologies and Analytics, Faculty of Technical Chemistry
  – Institute for Mechanics of Materials and Structures
  – Institute of Materials Science and Technology, Faculty of Mechanical and Industrial Engineering
- Universität Wien
  Researchgroup Physics of Nanostructured Materials, Faculty of Physics
- Universite d' Orleans, Laboratoire PRISME
- University of Maribor, Faculty of Mechanical Engineering
- University of Wollongong
- VIF - Das Virtuelle Fahrzeug Forschungsgesellschaft mbH

42 COMET Scientific Partners



Number and origin of scientific partners

COMET – Company Partners

The majority of the company partners from the COMET phase I also participates in the second funding period. In 2013 another 2 industrial enterprises joined the COMET Programm. A total of 68 national and international companies were involved in the first year of the COMET phase II:

Agie Charmilles SA
Almatis GmbH
AMAG Casting GmbH
AMAG Rolling GmbH
AMSC Austria GmbH
Andritz AG
Andritz Hydro GmbH
AT&S AG
Böhler Edelstahl GmbH & Co KG
Böhler Schmiedetechnik GmbH & Co KG
Böhler Schweißtechnik Austria GmbH
Böhler Schweißtechnik Deutschland GmbH
BOLIDEN Commercial AB
Bruker AXS Analytical X-Ray Systems GmbH
Buderus Edelstahl GmbH
Calderys France SA
Ceratizit Austria Gesellschaft mbH
Ceratizit Deutschland GmbH
Ceratizit Luxembourg S.a.r.l.
Continental Automotive GmbH
Eisenwerk Sulzau-Werfen R. & E. Weinberger AG
Epcos OHG
Europipe GmbH
Faively Transport Witten GmbH
Federation for International Refractory Research and Education
Fritz Schiess AG
Georg Fischer Automotive AG
Hegenscheidt MFD GmbH & Co KG
Infineum International Limited
Kerneos SA
Komptech Umwelttechnik GmbH
Konrad Forsttechnik GmbH
Krenhof Aktiengesellschaft
MIBA Gleitlager GmbH
MIBA Sinter Austria GmbH
MTU Aero Engines GmbH
ÖBB Infrastruktur AG
OMV Exploration & Production GmbH
Panasonic Industrial Devices Materials Europe GmbH
Pewag Austria GmbH
Plansee SE
Platit AG
Pyrotek High-Temperature Industrial Products Inc.
RAG - Rohöl-Aufsuchungs AG
RHI AG
Rio Tinto Alcan
Robert Bosch GmbH
Sandvik Mining and Construction GmbH
Schoeller-Bleckmann Edelstahlrohr GmbH

Siemens Aktiengesellschaft Österreich

Siemens VAI Metals Technologies GmbH & Co

SKF Österreich AG

Stahl Judenburg GmbH

Sucotec AG

TAG s.r.l.

Tata Steel Ijmuiden B.V.

Thales Corporate Services

ThyssenKrupp Presta AG

TIWAG Tiroler Wasserkraft AG

Vallourec Group

voestalpine Edelstahl GmbH (former: Böhler Uddeholm AG)

voestalpine Grobblech GmbH

voestalpine Schienen GmbH

voestalpine Stahl Donawitz GmbH & Co KG

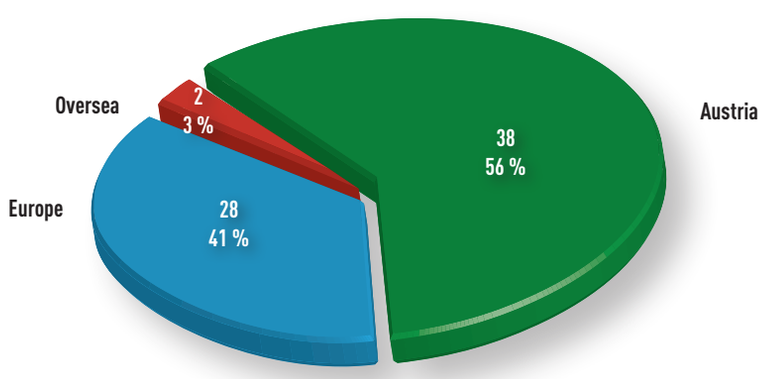
voestalpine Stahl GmbH

voestalpine Tubulars GmbH & Co KG

voestalpine VAE GmbH

W. Blösch AG

COMET – Company Partners



Number of company partners by origin

Non-COMET-partners

Nationally funded programmes

In addition to ongoing projects, MCL launched new nationally funded projects in 2013 under the "Intelligent Production" programme (ACINTECH, HighTempCFK and Tube Target), and the FWF project "Bridging length scales in piezoceramics for commercial actuators" under the Translational Research Programme, in which MCL is involved as coordinator or project partner. This has enabled MCL to win new company partners and scientific partners in this sector. For example, the FWF project gives MCL staff the opportunity to work together with research groups from the University of Florida and University College Dublin for the first time. A wide variety of national funding programmes are available for different target groups, so that MCL's company partners include small, medium and large enterprises in this area.

Programmes with international funding

2013 saw the start of the project "MSP - Multi Sensor Platform for Smart Building Management", coordinated by MCL as part of the EU "Collaborative Projects / Large-scale integrating projects (IP)" funding scheme. The overall volume for this 3-year project is € 18.1 million. The consortium consists of 17 partners from industry, universities and research institutions, from 6 European countries. They include AMS AG, EV Group, Siemens AG, Samsung R&D Institute UK, Fraunhofer, the University of Cambridge and the University of Oxford.

More information about this project is available on the project website: www.multisensorplatform.eu.

In 2013 MCL also launched the 2-year project "EasyForm - Laser assisted metal spinning for an efficient and flexible processing of nickel and titanium alloys" in which MCL works together with 5 project partners from industry and non-university research institutions.

Other projects with new partners submitted in 2013 have been approved and will begin in 2014.

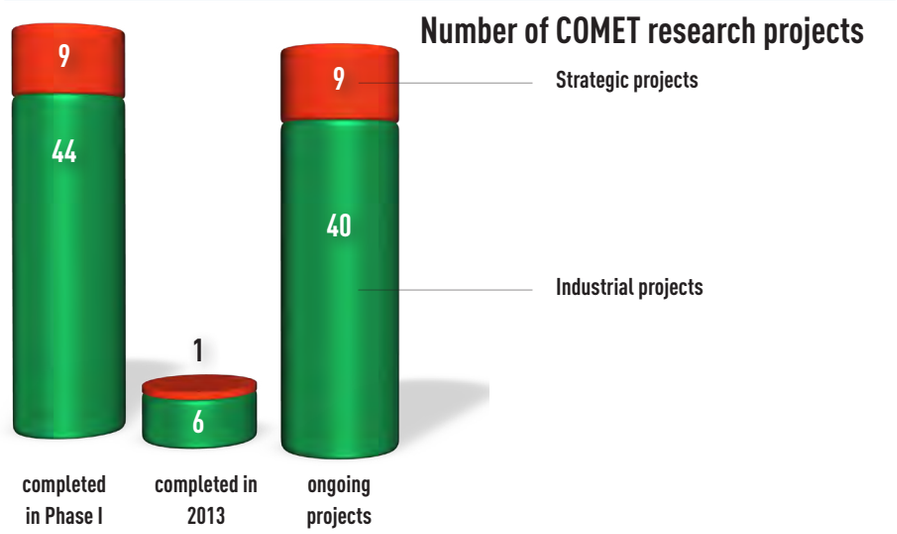
Unfunded non-COMET projects

There have been almost no changes to the list of our regular customers in the unfunded project sector, as well as for laboratory, computational and consultancy services. MCL again succeeded in winning many new customers during 2013. As in previous years, these new customers are largely involved in smaller contracts. While the list of regular customers is dominated by large enterprises, the smaller contracts come from many smaller and medium-sized businesses. All in all, MCL has a broad customer base of over 100 company partners in the unfunded sector.

III. Core Processes

A. Research and development

The transition between the first and second COMET funding periods was well prepared, with the result that MCL was able to start 13 new projects in 2013, increasing the COMET volume further and creating a stable basis for the coming years. In the past financial year MCL concluded 7 COMET projects from the first funding period. A total of 36 projects from the first funding period, and the new projects, had not been finalised by the end of 2013.



In the non-COMET area, MCL worked on a total of 8 nationally funded and 2 internationally funded projects in 2013. MCL was also extremely successful in national and international project applications:

- During 2012 MCL took part in an increasing number of calls for proposals for national funding programmes. Three applications (ACINTECH, HighTempCFK and TubeTarget) were submitted to the "Intelligent Production" programme, all of which were accepted.

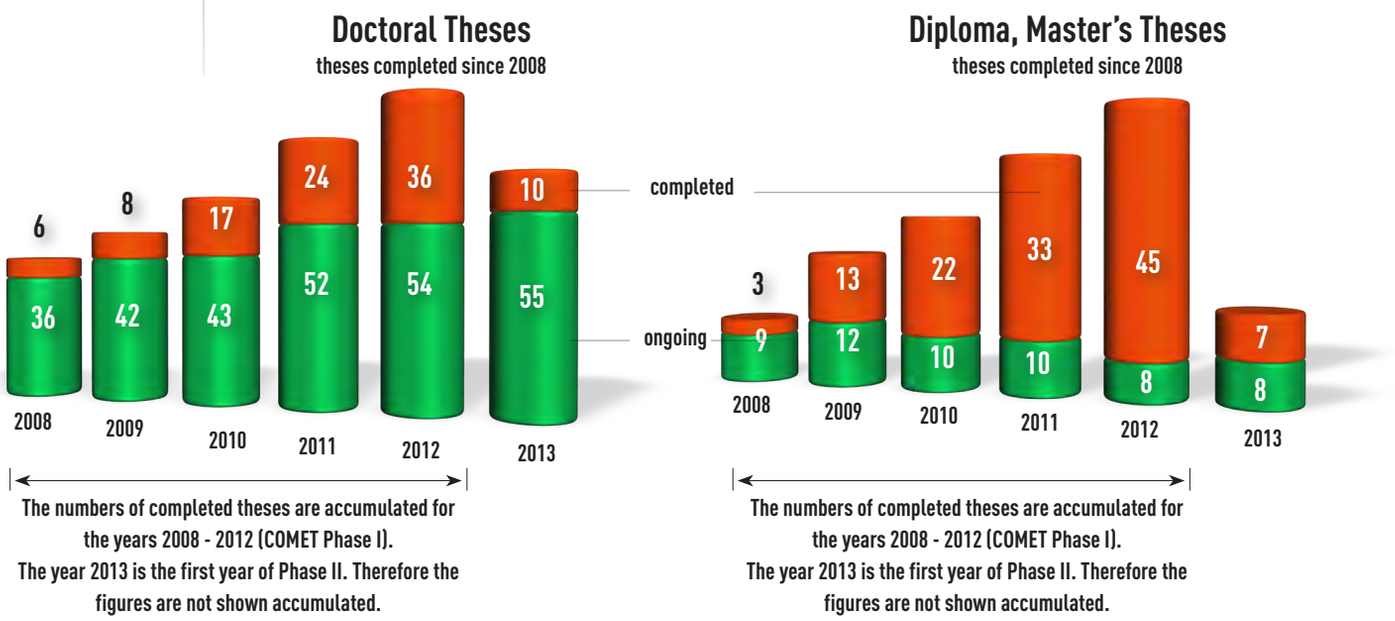
- The FWF project "Bridging length scales in piezoceramics for commercial actuators" under the Translational Research Programme was also approved.

- The two applications submitted in 2013 to the "Production of the Future" programme have also been approved and will start in 2014.

- The two applications submitted in 2013 as part of the ENIAC programme were positively evaluated by the EU, and also approved by the national funding bodies at the end of 2013. The projects are scheduled to start in the 1st half of 2014.

B. Degree theses

The degree theses (bachelor's, master's and doctoral theses) completed or in progress at MCL are making an invaluable contribution to the training of young scientists, ensuring that both business and science enjoy access to a pool of highly qualified personnel with practical know-how.



Doctoral theses:

During 2013, a total of 10 doctoral theses were completed as part of MCL projects. Another 15 were started, 10 of which at the Center itself. 55 doctoral theses were in progress by the end of 2013. In comparison, 6 doctoral theses were concluded during the first year of the first funding period, and 36 over the entire first COMET funding period.

Diploma/Master's theses:

To date 7 diploma/master's theses have been completed during the first year of the second funding period. A further 8 theses were in progress by the end of 2013. In 2008, 3 diploma/master's theses had been completed and 9 were ongoing.

IV. Output

A. Awards

DI Clemens Krautgasser won 3rd place in the Johann Puch Innovation Award

The Johann Puch Innovation Awards 2013 for diploma theses were presented by Magna Steyr on 17 September 2013. In the 14th year of existence of the competition the automotive supplier selected three prize-winners who made the most outstanding contributions to the topic of vehicle electrics and electronics.

The prize is awarded annually for outstanding diploma theses in memory of the great Austrian automotive pioneer Johann Puch. This year, DI Clemens Krautgasser secured third place with his diploma thesis on strength determination of LTCC ceramics under different environmental conditions. The diploma thesis was written as part of the COMET K2 project "Life time of functional multilayer ceramic systems".

The diploma thesis focused on exploring the influences of different environmental conditions, such as water, air, oil or inert gas on crack behaviour.

DI Clemens Krautgasser

Dr. Michael Fischlschweiger received the Josef Krainer Sponsorship Award

Dipl.-Ing. Dr. mont. Michael Fischlschweiger was among the winners of the Josef Krainer Awards 2013, which were presented on 15 March 2013 in the Great Hall of the Old University in Graz. He received the Josef Krainer Sponsorship Award from Styrian Deputy Governor Hermann Schützenhöfer in recognition of his outstanding academic achievements.

In his doctoral thesis, the polymer engineer Michael Fischlschweiger explored modelling strategies for structural phase transformation in shape memory alloys and steels. He "investigates the behaviour of high-performance materials under complex and extreme conditions", said the jury in its citation. "A special focus is placed on shape memory alloys. These materials are being applied, for example, in damping systems in aerospace engineering or the production of stents for treating severe circulatory problems in certain heart diseases and vascular occlusion in the leg vessels."

The research was carried out as part of the project A1.5 "Martensite – Fundamentals and Constitutive Equations" at the COMET K2 Center for Integrated Research in Materials, Processing and Product Engineering (MPPE). Dr. Fischlschweiger was employed at MCL during his doctoral thesis from 1 November 2008 to 31 July 2012.

The thesis was supervised by the Centre des Materiaux research unit of MINES ParisTech as part of a training agreement and the Institute of Mechanics (Univ.-Prof. Dr. Thomas Antretter) of Montanuniversitaet Leoben.

Josef Krainer Sponsorship Awards were presented to a total of nine young scientists. The awards were presented by Deputy Governor Hermann Schützenhöfer together with the Chairman of the Josef Krainer Memorial Association em.Univ.-Prof. DDr. Gerald Schöpfer and Heinz Krainer (son of Josef Krainer sen.).

Heinz Krainer, LH-Stv. Hermann Schützenhofer, Dr. Michael Fischlschweiger, Obmann em. Univ.-Prof. DDr. Gerald Schöpfer

o.Univ.-Prof. Dr. Robert Danzer received the JECS Trust Award

o.Univ.-Prof. Dr. Robert Danzer, Chair of the Institute of Structural and Functional Ceramics at Montanuniversitaet Leoben, received the JECS Trust Award for his scientific publications.

The prize is awarded by the Journal of the European Ceramic Society (JECS), which has developed into one of the most important scientific journals in the field of ceramic materials over the past ten years. It even has a higher impact factor than the Journal of the American Ceramic Society, which means that the articles published there are cited more often in other journals.

The Journal of the European Ceramic Society established the JECS Trust, which provides financial support to researchers in the form of scholarships and awards. The JECS Trust Award is presented every two years to the scientist who is judged to have had the highest impact during the preceding two years and has thus substantially contributed to the Journal's high quality and reputation. Prof. Danzer is only the second researcher to receive the award.

Many of his publications are based on projects carried out as part of the COMET K2 Center for Integrated Research in Materials, Processing and Product Engineering (MPPE). The Materials Center Leoben, which acts as the operating company of the COMET K2 Center, is delighted about the award and congratulates Prof. Danzer on receiving this prestigious accolade.

A list of Prof. Danzer's publications in the field of ceramic materials and components can be found at http://www.isfk.at.

o.Univ.-Prof. Mag. et Dr.rer.nat. Robert Danzer

Dr. Herbert Krampl won 1st prize from the Association of the Austrian Vehicle Industry for his doctoral thesis

On 21 June 2013 the Association of the Austrian Vehicle Industry for the 29th time presented awards to diploma and doctoral theses of high relevance to the automotive industry. A total of 13 awards with a total of 36,000 euros in prize money were presented to graduates from Vienna and Graz Universities of Technology, Montanuniversitaet Leoben and the University of Linz.

DI Dr. Herbert Krampl won 1st prize for his doctoral thesis entitled "Numerical and experimental investigation of lubricated contacts of inhomogeneous materials". The thesis was written as part of the COMET K2 project A6.8 "Advanced models and simulation methods for the assessment of mechanical engineering components subjected to fatigue and lubricated contact loading".

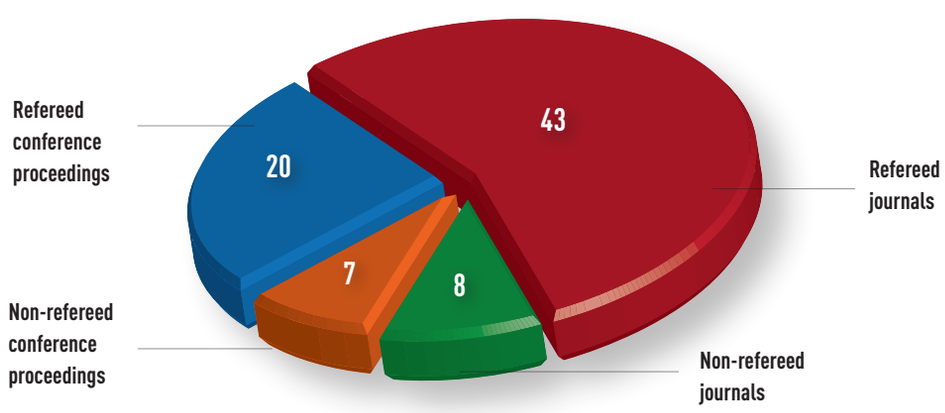
In his thesis Herbert Krampl developed a detailed numerical model of the physical processes involved in the lubrication gap of tribological contacts. He designed a two-disk test rig for traction measurements in lubricated contact and a wide range of calculation models for contact systems relevant in mechanical engineering over a period of two and a half years. Originally designed as a strategic project, the numerical approach to tribology established in the project has developed into a field of its own, which has already attracted great interest from leading industrial and research partners.

Dr. Herbert Krampl, o.Univ.Prof. DI Dr. Sabine Seidler, Magn. Univ.Prof. Dr. Wilfried Eichlseder

B. Publications and presentations

The majority of scientific papers appeared in refereed journals. The Center's results were also presented at numerous national and international conferences and workshops in the form of lectures and posters. In addition to attending key European research events, the scientists gave presentations at conferences in the USA, China, India and Israel.

Publications



During 2013 the Center was presented

- in 51 papers in specialist journals (of which 43 were refereed papers) and
- at 89 international conferences, workshops and specialist events with
  - 27 publications in conference proceedings (of which 20 were refereed publications)
  - 102 presentations

Over the past years greater attention has been paid to the external perception of MCL publications. Therefore in 2012 a database was set up to record and access citations of publications relating to MCL projects. The database is used to calculate and track the number of cited publications, the total number of citations, and the h-index of MCL team employees. The database showed a very positive development in these indicators already in the first year.

C. Degrees

The following doctoral and diploma theses were completed in 2013.

Doctoral theses:

Czettl Christoph
Design of CVD Coatings for Cutting Tools

Gholizadeh Hojjat
The influence of alloying and temperature on the stacking-fault energy of iron-based alloys

Golesorkhtabar Rostam
Ab initio Calculation of Elastic Properties - General Implementation and Specific Application to the shape-memory Material NiTi

Kainzinger Paul
Schwingfestigkeit von ferritischem Gusseisen mit Kugelgraphit: Größeneffekte unter dem Einfluss von Defekten

Krajewski Pawel Grzegorz
Experimentelle Simulation der Rissbildung im Temperaturbereich des zweiten Duktilitätsminimums von Stählen

Leitner Martin
Local fatigue assessment of welded and high frequency mechanical impact treated joints

Maderbacher Hermann
Erstellung einer geschlossenen Simulationskette zur Optimierung der Schwingfestigkeit von geschmiedeten Bauteilen aus Nickelbasislegierungen

Popov Maxim
The $TiO_2(100)||(0001)Al_2O_3$ interface –
A density-functional study

Reiser Johannes
Strain Localization under Fatigue Loading

Röhrig Sören
Elektrothermische Analyse von planaren PTC-Heizern

Schalk Nina
Synthesis and post-treatment of hard coatings
for cemented carbide cutting tools

Diploma / Master's theses:

Auer Michael
Entwicklung eines Referenzbauteils zur
Prüfung von dickwandigen Großgussbauteilen

Bergmann Philipp
Bauteilnahe Testmethodik für Grenzreibungszustände
von Gleitlagerungen

Dengg Thomas
Thermodynamic properties of NiTiHf:
Cluster Expansion and Monte-Carlo Simulation

Huber Wolfgang
Bruchzähigkeitsmessung von Keramik unter
Mode II-Belastung

Keplinger Andreas
Verbesserung der Zähigkeit von Werkzeugstählen
durch Ausnutzen gezielter Festphasenumwandlungen

Oberndorfer Markus
Untersuchung von mechanischer Schädigung
an LTCC-Materialien

Sharova Eugenia
Bestimmung bruchmechanischer Eigenschaften
als Funktion der Temperatur am Beispiel eines PTC-Werkstoffes

Wagner Claudia Elisabeth
Untersuchung der Entstehung und Umlagerung von
mechanisch und thermisch induzierten Eigenspannungen
für die Nickelbasis-Legierung Inconel® 718

We would like to offer our graduates our hearty congratulations on their achievements and degrees. Their work has made an important contribution to achieving the aims of the research programme.

D. Completed projects

A total of 7 COMET projects were successfully concluded in 2013:

A1.8 "Prozesskettensimulation für die Fertigung von Maschinenelementen für Hochdruckanwendungen – Teil 1: Vorblock > Warmumformung > Wärmebehandlung > Tieflochbohren"

Robert Bosch GmbH, voestalpine Stahl Donawitz GmbH & Co KG, Stahl Judenburg GmbH, Montanuniversität Leoben, Österreichische Akademie der Wissenschaften, Materials Center Leoben Forschung GmbH

A2.14 Post-treatment of hard coatings

Ceratizit Austria Gesellschaft mbH, Ceratizit Luxembourg S.à.r.l., Montanuniversität Leoben, Materials Center Leoben Forschung GmbH

A3.11 Eigenspannungsoptimiertes Richten von Eisenbahnschienen

voestalpine Schienen GmbH, voestalpine Stahl Donawitz GmbH & Co KG, Montanuniversität Leoben, Materials Center Leoben Forschung GmbH

A6.3 Technological influences from processing and manufacturing on the operational properties of structural aerospace components

BÖHLER Schmiedetechnik GmbH & Co KG, Ingenieurbüro Fiedler GmbH, Montanuniversität Leoben, Materials Center Leoben Forschung GmbH

A6.13 Topologieoptimierung von Großgusskomponenten für Windkraftanlagen unter Berücksichtigung der lokalen Schwingfestigkeiten

AMSC Windtec GmbH, SHW Casting Technologies GmbH, Montanuniversität Leoben, Materials Center Leoben Forschung GmbH

A7.9 Constitutive material law for piezoelectric materials including ferroelectric and ferroelastic behaviour: Validation and case studies

Montanuniversität Leoben, Karlsruher Institut für Technologie (KIT), Materials Center Leoben Forschung GmbH

A7.10 Electrical properties of PTC ceramics under voltage load

EPCOS OHG, Montanuniversität Leoben, Materials Center Leoben Forschung GmbH

The non-COMET project "A3plus/Thermoelektrisches Modul zur Restwärmenutzung" (funded by FFG) was also successfully concluded.

E. Patents

Patents are key indicators of the innovative strength of a competence centre. The focus of the COMET research programme has so far been on establishing fundamental knowledge, but will increasingly shift towards application in the next few years.

MCL and COMET researchers were involved in the following patent applications filed in 2013:

- "Ferritic alloys and methods for preparing the same", UK patent application 2013
- "Metal Material", international patent application 2013

Additional patent applications are in preparation and will be filed in 2014.

INTELLECTUAL CAPITAL REPORT APPENDIX

PUBLIKATION

Publications in refereed journals

Conference papers

Posters

Technological journals

13

Appendix

A) Publications in refereed journals

Author Co-author	Title	Journal	Edition/ Year
Ahmadi, M.; Sonderegger, B.; Povoden-Karadeniz, E.; Falahati, A. & Kozeschnik, E.	**Precipitate strengthening of non-spherical precipitates extended in <100> or {100} direction in fcc crystals**	Materials Science and Engineering: A	published online (2013)
Angerer, P.; Lackner, J.M.; Wießner, M. & Maier, G.	**Chromium/Chromium nitride multilayers during thermal treatment: An X-ray diffraction study**	International Journal of Refractory Metals and Hard Materials	36 (2013) 101-105
Appel, F.; Herrmann, D.; Fischer, F.D.; Svoboda, J. & Kozeschnik, E.	**Role of vacancies in work hardening and fatigue of TiAl alloys**	International Journal of Plasticity	42 (2013) 83-100
Bartosik, M.; Daniel, R.; Mitterer, C.; Matko, I.; Burghammer, M.; et al	**Cross-sectional X-ray nanobeam diffraction analysis of a compositionally graded CrN_x thin film**	Thin Solid Films	542 (2013) 41730
Bermejo, R.; Supancic, P.; Krautgasser, C.; Morrell, R. & Danzer, R.	**Subcritical crack growth in low temperature Co-fired ceramics under biaxial loading**	Engineering Fracture Mechanics	100 (2013) 108-121
Daniel, R.; Keckes, J.; Matko, I.; Burghammer, M. & Mitterer, C.	**Origins of microstructure and stress gradients in nanocrystalline thin films: The role of growth parameters and self-organization**	Acta Materialia	61 (2013) 6255-6266
Dippenaar, R.; Bernhard, C.; Schider, S. & Wieser, G.	**Austenite grain growth and the surface quality of continuously cast steel**	Metallurgical and Materials Transactions B	published online (2013)
Drabik, M.; Galikova, L.; Billik, P.; Maier, G. & Kosednar-Legenstein, B.	**Macro defect free materials; mechanochemical activation of raw mixes as the intensifying tool of the entire MDF synthesis**	Ceramics - Silikaty	57 (2013) 120-125
Eck, S.; Ossberger, H.; Ossberger, U.; Marsoner, S. & Ebner, R.	**Comparison of the fatigue and impact fracture behaviour of 5 different steel grades used in the frog of a turnout**	Journal of Rail and Rapid Transit	published online (2013)

Author Co-author	Title	Journal	Edition/ Year
Eßl, W.; Antretter, T. & Parteder, E.	**An efficient algorithm for modeling the thermo-mechanical material response of heavy steel plates during accelerated cooling**	Key Engineering Materials	554-557 (2013) 749-763
Fischer, F.D.; Mori, G. & Svoboda, J.	**Modelling the influence of trapping on hydrogen permeation in metals**	Corrosion Science	76 (2013) 382-389
Fischer, F.D. & Svoboda, J.	**Formation of bubbles by hydrogen attack and elastic-plastic deformation of the matrix**	International Journal of Plasticity	published online (2013)
Fischer, F.D.; Svoboda, J. & Kozeschnik, E.	**Interstitial diffusion in systems with multiple sorts of traps**	Modelling and Simulation in Materials Science and Engineering	21 (2013) 025008 (13pp)
Fischlschweiger, M.; Antretter, T. & Cailletaud, G.	**Transformation hardening and kinetics for stress assisted and temperature driven martensitic transformation in steels**	Mechanics Research Communications	47 (2013) 84-88
Garcia, L.F.; Danninger, H. & Ponemayr, H.	**Laser cladding of low alloy steel substrates with carbon-free tool steels Fe-Co-Mo/W**	Powder Metallurgy Progress	13 (2013) 44501
Gholizadeh, H.; Ambrosch-Draxl, C. & Puschnig, P.	**The influence of interstital carbon on the y-surface in austenite**	Acta Materialia	61 (2013) 341-349
Golesorkhtabar, R.; Pavone, P.; Spitaler, J.; Puschnig, P. & Ambrosch-Draxl, C.	**ElaStic: A tool for calculating second-order elastic constants from first principles**	Computer Physics Communications	184 (2013) 1861-1873
Grün, F.; Summer, F.; Pondicherry, K.; Godor, I.; Offenbecher, M. & Laine, E.	**Tribological functionality of aluminium sliding materials with hard phases under lubricated conditions**	Wear	298-299 (2013) 127-134
Hackl, K.; Fischer, F.D.; Klevakina, K.; Renner, J. & Svoboda, J.	**A variational approach to grooving and wetting**	Acta Materialia	61 (2013) 1581-1591
Kaiser, R.; Hatzenbichler, T.; Buchmayr, B. & Antretter, T.	**Simulation of the roller straightening process with respect to residual stresses and the curvature trend**	Materials Science Forum	published online (2013)

Author Co-author	Title	Journal	Edition/ Year
Keckes, J.; Daniel, R.; Mitterer, C.; Matko, I.; Sartory, B.; Köpf, A.; Weißenbacher, R. & Pitonak, R.	**Self-organized periodic soft-hard nanolamellae in polycrystalline TiAlN thin films**	Thin Solid Films	545 (2013) 29-32
Kubin, W.; Pletz, M.; Daves, W. & Scheriau, S.	**A new roughness parameter to evaluate the near-surface deformation in dry rolling/sliding contact**	Tribology International	67 (2013) 132-139
Leitner, M.; Stoschka, M. & Eichlseder, W.	**Fatigue enhancement of thin-walled high-strength steel joints by high frequency mechanical impact treatment**	Weld World	58 (2013) 29-39
Lowndes, R.; Deluca, M.; Azough, F. & Freer, R.	**Probing structural changes in $Ca_{(1-x)}Nd_{2x/3}TiO_3$ ceramics by Raman spectroscopy**	Journal of Applied Physics	113 (2013) 044115
Maderbacher, H.; Oberwinkler, B.; Gänser, H.P.; Tan, W.; Rollett, M. & Stoschka, M.	**The influence of microstructure and operating temperature on the fatigue endurance of hot forged Inconel® 718 components**	Materials Science and Engineering A	585 (2013) 123-131
Nicoleau, L.; Gädt, T.; Chitu, L.; Maier, G. & Paris, O.	**Oriented aggregation of calcium silicate hydrate platelets by the use of comb-like copolymers**	Soft Matter	9 (2013) 4864-4874
Orthaber, M.; Antretter, T. & Gänser, H.P.	**On the selection of active slip systems in rate independent crystal plasticity**	Key Engineering Materials	554-557 (2013) 1147-1156
Pletz, M.; Daves, W.; Yao, W. & Ossberger, H.	**Rolling contact fatigue of three crossing nose materials - Multiscale FE approach**	Wear	published online (2013)

Author Co-author	Title	Journal	Edition/ Year
Povoden-Karadeniz, E.; Lang, P.; Öksüz, K.; Jun, W.; Rafiezadeh, S.; Falahati, A. & Kozeschnik, E.	**Thermodynamics integrated simulation of precipitate evolution in Al-Mg-Si-alloys**	Materials Science Forum	765 (2013) 476-480
Preis, W. & Sitte, W.	**Modeling of electrical properties of grain boundaries in n-conducting barium titanate ceramics as a function of temperature and dc-bias**	Solid State Ionics	published online (2013)
Presoly, P.; Pierer, R. & Bernhard, C.	**Identification of defect prone peritectic steel grades by analyzing high temperature phase transformations**	Metallurgical and Materials Transactions A	44 (2013) 5377-5388
Schalk, N.; Mitterer, C.; Czettl, C.; Sartory, B.; Penoy, M. & Michotte, C.	**Dry-blasting of α- and κ-Al_2O_3 CVD hard coatings: Friction behaviour and thermal stress relaxation**	Tribology Letters	52 (2013) 147-154
Schalk, N.; Mitterer, C.; Letofsky-Papst, I.; Czettl, C.; Sartory, B.; Penoy, M. & Michotte, C.	**Friction reduction by thermal treatment of arc evaporated TiAlTaN coatings in methane**	Tribology International	67 (2013) 54-60
Schileo, G.; Luisman, L.; Feteira, A.; Deluca, M. & Reichmann, K.	**Structure–property relationships in $BaTiO_3$–$BiFeO_3$–$BiYbO_3$ ceramics**	Journal of the European Ceramic Society	33 (2013) 1457-1468
Schwaab, H.; Deluca, M.; Supancic, P. & Kamlah, M.	**Effect of the electric conductivity on the modeling of the poling process of ferroelectric components**	Journal of the Mechanics and Physics of Solids	61 (2013) 504-516
Stefenelli, M.; Todt, J.; Riedl, A.; Ecker, W.; Müller, T.; Daniel, R.; Burghammer, M. & Keckes, J.	**X-ray analysis of residual stress gradients in TiN coatings by a laplace space approach and cross-sectional nanodiffraction: A critical comparison**	Journal of Applied Crystallography	46 (2013) 1378-1385

Author Co-author	Title	Journal	Edition/ Year
Stoschka, M.; Leitner, M.; Posch, G. & Eichlseder, W.	**Effect of high-strength filler metals on the fatigue behaviour of butt joints**	Welding in the World	57 (2013) 85-96
Svoboda, J.; Fischer F.D., & Schillinger, W.	**Formation of multiple stoichiometric phases in binary systems by combined bulk and grain boundary diffusion - Experiments and model**	Acta Materialia	61 (2013) 32-39
Svoboda, J. & Fischer, F.D.	**A new computational treatment of reactive diffusion in binary systems**	Computational Materials Science	78 (2013) 39-46
Svoboda, J.; Shan, Y.V.; Kozeschnik, E. & Fischer, F.D.	**Determination of depths of traps for interstitials from thermodynamic data: A new view on carbon trapping and diffusion**	Modelling and Simulation in Materials Science and Engineering	21 (2013) 065012
Viola, G.; Ning, H.; Wei, X.; Deluca, M.; Adomkevicius, A.; Khaliq, J.; Reece, M.J. & Yan, H.	**Dielectric relaxation, lattice dynamics and polarization mechanisms in $Bi_{0.5}Na_{0.5}TiO_3$-based lead-free ceramics**	Journal of Applied Physics	114 (2013) 014107 (9pp)
Zechner, J.; Janko, M. & Kolednik, O.	**Determining the fracture resistance of thin sheet fiber composites - Paper as a model material**	Composites Science and Technology	74 (2013) 43-51
Zechner, J. & Kolednik, O.	**Paper multilayer with a fracture toughness of steel**	Journal of Materials Science	48 (2013) 5180-5187
Zechner, J. & Kolednik, O.	**Fracture resistance of aluminum multilayer composites**	Engineering Fracture Mechanics	110 (2013) 489-500
Povoden-Karadeniz, E.; Cirstea, D.C.; Lang, P.; Wojcik, T. & Kozeschnik, E.	**Thermodynamics of Ti-Ni shape memory alloys**	CALPHAD: Computer Coupling of Phase Diagrams and Thermochemistry	41 (2013) 128-139
Povoden-Karadeniz, E.; Lang, P.; Warczok, P.; Falahati, A.; Jun, W. & Kozeschnik, E.	**CALPHAD modeling of metastable phases in the Al-Mg-Si system**	CALPHAD: Computer Coupling of Phase Diagrams and Thermochemistry	43 (2013) 94-104

B) Conference papers

Author Co-author	Title	Conference title	Conference
Bermejo, R.; Supancic, P.; Krautgasser, C. & Danzer, R.	**Evaluation of subcritical crack growth in low temperature co-fired ceramics**	Proceedings of the 37th International Conference on Advanced Ceramics and Composites (ICACC)	37th International Conference on Advanced Ceramics and Composites (ICACC)
Bohacek, J.; Kharicha, A. & Ludwig, A.	**Modeling of Centrifugal Casting**	Special Symposium: Advanced Simulation of Processes and Phenomena: Activities at Montanuniversitaet Leoben	Special Symposium: Advanced Simulation of Processes and Phenomena: "Activities at Montanuniversitaet Leoben"
Eck, S.; Ossberger, H.; Ossberger, U.; Marsoner, S. & Ebner, R.	**Comparison of the fatigue and impact fracture behavior of 5 different steel grades used in the frog of a turnout**	Proceedings of the 10th international Heavy Haul Association Conference	10th international Heavy Haul Association Conference
Garcia, L.F.; Danninger, H. & Ponemayr, H.	**Laser deposition of precipitation hardening carbon-free tool steel powder**	Proceedings Euro PM2013	Euro PM2013 Powder Metallurgy Congress and Exhibition
Guttmann, P.; Röper, F. & Pilz, G.	**The impact of time, temperature and media on polymer selction for high demand applications**	Proceedings of the Austrian-Slovenian Polymer Meeting 2013	Austrian-Slovenian Polymer Meeting 2013
Kainzinger, P.; Guster, C.; Severing, M. & Ballmes, H.	**Bewertung des Einflusses von Defekten auf die Schwingfestigkeit von Gusseisen mit Kugelgraphit**	DVM Bericht	40. Tagung des DVM-Arbeitskreises Betriebsfestigkeit (DVM-Tagung)
Kainzinger, P.; Guster, C.; Severing, M. & Wolf, A.	**Influence of micro-shrinkage on the fatigue behavior of ductile iron**	Proceedings of the 13th International Conference on Fracture	13th International Conference on Fracture (ICF13)
Lang, P.; Povoden-Karadeniz, E.; Mayer, W.; Falahati, A. & Kozeschnik, E.	**The bustling nature of vacancies in Al alloys**	Proceedings of the 8th Pacific Rim International Congress on Advanced Materials and Processing	8th Pacific Rim International Congress on Advanced Materials and Processing

Author Co-author	Title	Conference title	Conference
Leitner, M.; Stoschka, M. & Eichlseder, W.	**Assessment of HFMI post-treated joints by the notch stress approach**	Proceedings of the 13th International SF2M Spring Meeting	13th International SF2M Spring Meeting
Ludwig, A.	**Simulation of horizontal centrifugal casting: Mold filling and solidification/Simulation of electro-slag-remelting**	Proceedings of CSSCR2013	3rd International Symposium on Cutting Edge of Computer Simulation of Solidification, Casting and Refining (CSSCR2013)
Macurova, K.; Kharicha, A.; Pletz, M.; Mataln, M.; Bermejo, R.; Schöngrundner, R.; Krivec, T.; Antretter, T.; Maia, W.; Morianz, M. & Brizoux, M.	**Multi-physics simulation of the component attachment within embedding process**	Proceedings of the14th International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems	14th International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE 2013)
Maier, B.; Guster, C.; Tichy, R. & Ecker, W.	**Influence of different microstructures of the welding zone on the fatigue crack growth behaviour of HSLA steels**	Proceedings of the 13th International Conference on Fracture	13th International Conference on Fracture (ICF13)
Maier, B.; Guster, C.; Tichy, R. & Ecker, W.	**Different microstructures in the HAZ of double submerged arc welded pipelines and how they influence the fatigue crack growth**	Proceedings of the ASME 2013 Pressure Vessels & Piping Division Conference	International Conference on Pressure Vessels and Piping (PVP 2013)
Mikl, M.; Antretter, T. ; Gimpel, M.; Pittino, G.	**Determination of uniaxial tensile strength of rock materials with numerical methods**	Proceedings of the 3rd International Conference on Computational Methods in Tunnelling and Subsurface Engineering	3rd International Conference on Computational Methods in Tunnelling and Subsurface Engineering
Mikl, M.; Tichy, R.; Ecker, W.; Antretter, T.; Pittino, G.	**Development and testing of a technique for the simulation of the rock cutting process**	5th International Conference on Structural Engineering, Mechanics and Computation	5th International Conference on Structural Engineering, Mechanics and Computation

Author Co-author	Title	Conference title	Conference
Orthaber, M.; Antretter, T. & Gänser, H.P.	**Maximum dissipation crystal plasticity – An approach to select active slip systems**	Proceedings of the 13th International Conference on Computational Mechanics (CM13)	13th International Conference on Computational Mechanics (CM13)
Ossberger, U.; Pletz, M.; Eck, S. & Daves, W.	**Validation of a finite element crossing model using measurements at an instrumented turnout**	Proceedings of 23rd International Symposium on Dynamics of Vehicles on Roads and Tracks	23rd International Symposium on Dynamics of Vehicles on Roads and Tracks
Pondicherry, K.; Grün, F.; Summer, F.; Godor, I.; Lainé, E. & Offenbecher, M.	**Comprehensive study of ZDDP-tribofilms formed under soft contact conditions**	5th World Tribology Congress	5th World Tribology Congress
Pondicherry, K.; Schöberl, T.; Grün, F.; Godor, I.; Lainé, E. & Offenbecher, M.	**Nano-mechanical and chemical characterisation of tribfilms formed under conformal contact conditions**	69th Society of Tribologists and Lubrication Engineers Annual Meeting and Exhibition	69th Society of Tribologists and Lubrication Engineers Annual Meeting and Exhibition
Ragger, K.; Kaiser, R.; Hatzenbichler, T.; Buchmayr, B.; Paal, J. & Fluch, R.	**3D finite element simulation of pilger mill rolling**	Proceedings of the 9th International and 6th European Rolling Conference 2013	9th International and 6th European Rolling Conference 2013
Reiser, J.; Maier, B.; Guster, C. & Gänser, H.P.; Pippan, R.	**A testing apparatus for SEM in-situ fatigue testing of small scale specimens and a derived application**	Proceedings of the ASME 2013 Pressure Vessels and Piping Division Conference	International Conference on Pressure Vessels and Piping (PVP 2013)
Schemmel, M.; Wießner, M.; Schöngrundner, R.; Ecker, W. & Antretter, T.	**Modellierung von Multiphasenumwandlungen in Warmarbeitsstählen während des Härteprozesses**	Proceedings Simulationsforum 2013 - Schweißen und Wärmebehandlung	Simulationsforum 2013
Schnitzer, R.; Rauch, R.; Ernst, W.; Wagner, J.; Baumgartner, S.; Leitner, M.; Stoschka, M.; Schlagradl, T.; Schneider, R. & Bernhard, C.	**Comprehensive investigations of new filler materials for welding of high strength steels**	Proceedings of the 3rd International Conference on High Strength Steels for Hydropower Plants	3rd International Conference on High Strength Steels for Hydropower Plants

Author Co-author	Title	Conference title	Conference
Schöngrundner, R.; Cordill, M.J.; Berger, J.; Krückl, H.P.; Fellner, K.; Krivec, T.; Kurz, M.; Fuchs, P.F. & Maier, G.A.	**Adhesion of printed circuit boards with bending and the effect of reflow cycles**	Proceedings of the14th International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems	14th International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE 2013)
Stoschka, M.; Leitner, M. & Barsoum, Z.	**Study of the local notch stress HFMI master S/N-curve approach on high-strength steel joints**	Proceedings of the 2nd Swedish conference on design and fabrication of welded structures	2nd Swedish Conference on Design and Fabrication of Welded Structures
Stoschka, M.; Ottersböck, M. & Leitner, M.	**Studie des transienten Verfestigungsverhaltens für ein- und mehrlagige Verbindungen**	Simulationsforum FWS	Simulationsforum Schweißen und Wärmebehandlung (FWS)
Teppernegg, T.; Klünsner, T.; Tritremmel, C.; Czettl, C.; Keckes, J.; Wroblewski, T.; Ebner, R. & Pippan, R.	**Spatial correlation of tensile residual stress and thermal fatigue damage in coated cemented carbide milling inserts**	Proceedings of the 18th International Plansee Seminar	18th International Plansee Seminar

C) Posters

Author Co-author	Title	Conference
Deluca, M.; Galassi, C.; Taniguchi, H. & Mitoseriu, L.	**Temperature-dependent Raman analysis of the ferroelectric-antiferroelectric crossover in La-doped lead zirconate titanate ceramics**	WG3 Conference COST MP0904 Action Single- and Multiphase Ferroics and Multiferroics with Restricted Geometries
Deluca, M.; Schütz, D.; Aksel, E.; Picht, G.; Foronda, H.M.; Feteira, A.; Reichmann, K.; Webber, K.G. & Jones, J.L.	**Raman spectroscopy of Sodium Bismuth Titanate (BNT) ceramics**	International Symposium on the Applications of Ferroelectrics – Piezoresponse Force Microscopy Workshop
Hofer, J.; Preis, W. & Sitte, W.	**Characterization of donor-doped barium titanate by impedance spectroscopy as a function of temperature and dc bias**	15th Austrian Chemistry Days
Lang, P.; Weisz, T.; Ahmadi, M.R.; Povoden-Karadeniz, E.; Falahati, A. & Kozeschnik, E.	**Thermo-kinetic simulation of the yield strength Evolution of an Al-Zn-Mg-Cu alloy during natural aging**	THERMEC' 13 International Conference on Processing and Manufacturing of Advanced Materials
Mühlbacher, M.; Sartory, B.; Keckes, J.; Lu, J.; Hultman, L. & Mitterer, C.	**Diffusion studies in epitaxial TiN/Cu layers on MgO(001)**	Annual Meeting of the Nordic Microscopic Society
Riedl, A.; Todt, J.; Daniel, R.; Stefenelli, M.; Holec, D.; Krywka, C.; Mitterer, C. & Keckes, J.	**Bias- and temperature-dependent strain evolution across nanocrystalline TiAlN films studied by X-ray nanodiffraction**	8th European NESY Winter-School & Symposium on Neutrons and Synchrotron Radiation
Stechauner, G. & Kozeschnik, E.	**Simulation of Cu precipitation in the Fe-Cu binary system**	THERMEC' 13 International Conference on Processing and Manufacturing of Advanced Materials

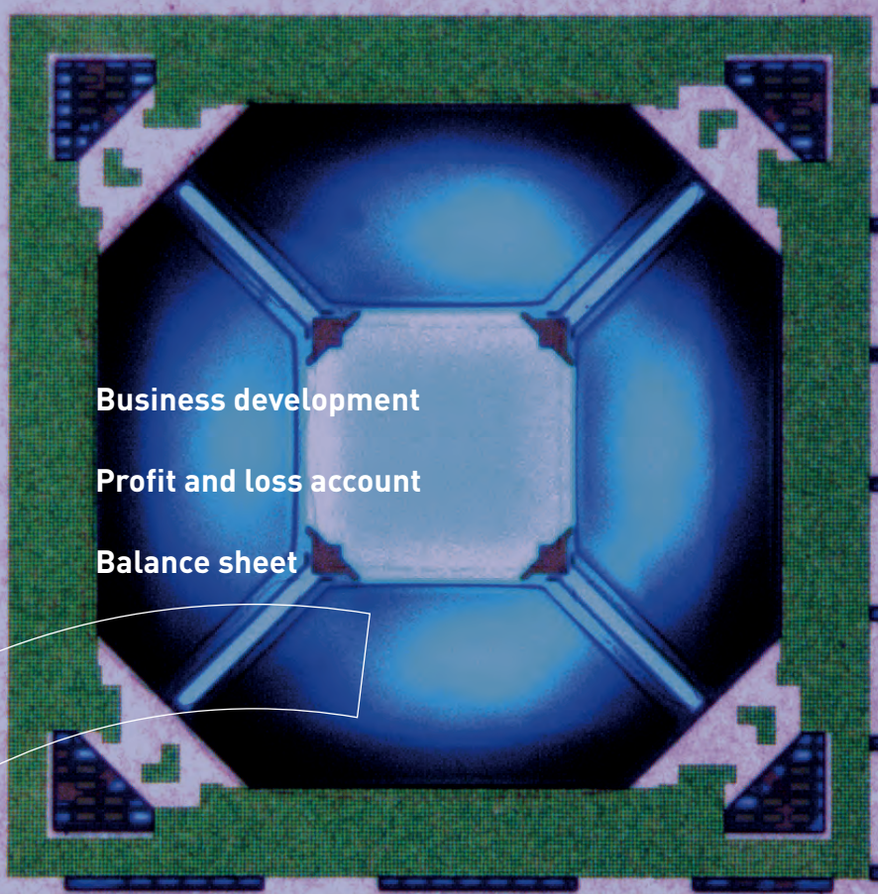
Author Co-author	Title	Conference
Tkadletz, M.; Mitterer, C.; Keckes, J.; Rebelo de Figueiredo, M.; Hosemann, P.; Burghammer, M.; Sartory, B. & Czettl, C.	**Advanced cross-sectional characterization of hard coatings**	18th International Plansee Seminar
Treml, R.; Schöngrundner, R.; Brunner, R. & Kiener, D.	**Residual stress measurement in thin films using the ion beam layer removal method**	GDRI CNRS Mecano General Meeting on the Mechanics of Nanoobjects

D) Books / technological journals

Autor Co-Autor	**Titel**	Buch / Fachzeitschrift	Ausgabe/ Jahr
Antretter, T.; Hasenhütl, E.; Eßl, W.; Hofmann, A.; Ecker, W.; Heiß, C.; Galler, R. & Parteder, E.	**Some examples for advanced numerical solutions pushing the limits of commercial software**	BHM	2013
Galler, R.; Volderauer, C.; Marcher, T.; Kargl, H.; Gimpel, M.; Mikl, M.; Ecker, W.; Tichy, R.; Antretter, T.; Gschwandtner, G.; Pittino, G.; Entacher, M.; Lorenz, S.; Schuller, E. & Mödlhammer, H.	**Numerical simulation in the field of geotechnics and underground engineering - Examples of research and development projects**	BHM	2013
Krajewski, P.; Bernhard, C.; Pierer, R.; Schneller, F. & Schaden, T.	**IMC-B - ein neuer Ansatz zur Untersuchung der Oberflächenrissbildung im Stranggießprozess**	BHM	2013
Lang, P.; Lang, M.C.; Falahati, A. & Kozeschnik, E.	**The effect of Si on the precipitation behaviour in Al-Mg-Si alloys studied by thermo-kinetic simulation and DSC experiments**	BHM	2013
Ludwig, A.; Wu, M.; Kharicha, A.; Vakhrushev, A.; Bohacek, J.; Kemminger, A. & Karimi-Sibaki, E.	**Process simulation for the metallurgical industry: New insights into invisible phenomena**	BHM	2013
Mikl, M.; Tichy, R.; Ecker, W.; Antretter, T.; Gimpel, M.; Kargl, H.; Pittino, G. & Galler, R.	**Entwicklung und Test einer Methode zur Simulation des Gesteinschneidens mit der Finiten Elemente Methode**	BHM	2013

Autor Co-Autor	**Titel**	Buch / Fachzeitschrift	Ausgabe/ Jahr
Schider, S.; Gamsjäger, E.; Michelic, S. & Bernhard, C.	**In-situ Beobachtung von Phasenumwandlungen in Stählen**	Sonderband der Praktischen Metallographie	2013
Simunek, D.; Leitner, M. & Stoschka, M.	**Numerical simulation loop to investigate the local fatigue behaviour of welded and HFMI-treated joints**	IIW-Document	2013
Stoschka, M.; Leitner, M. & Barsoum, Z.	**An alternative HFMI master S/N-curve approach**	IIW-Document	2013

BUSINESS FIGURES 2013



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Business development

Profit and loss account

Balance sheet

Business Development

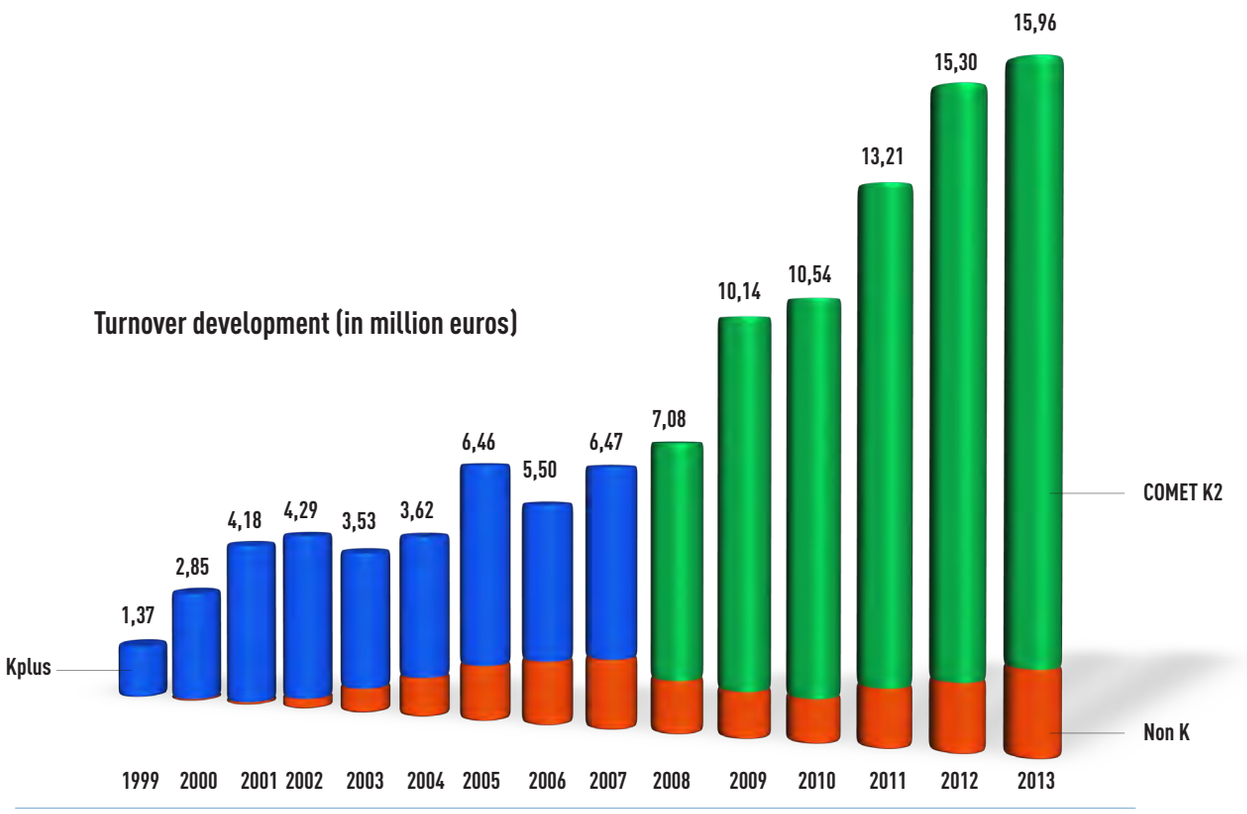
Business development

The 2013 financial year was the first year of the second funding period (1/1/2013 to 31/12/2017) of the COMET K2 Centre for Integrated Research in Materials, Processing and Product Engineering (MPPE).

A project volume of € 59,500,000 was approved for COMET Phase II, resulting in an annual average amount of € 11,900,000. This level was significantly exceeded in the 2013 financial year with the costs in the COMET area amounting to € 13,935,102 (previous year (PY): k€ 13.801).

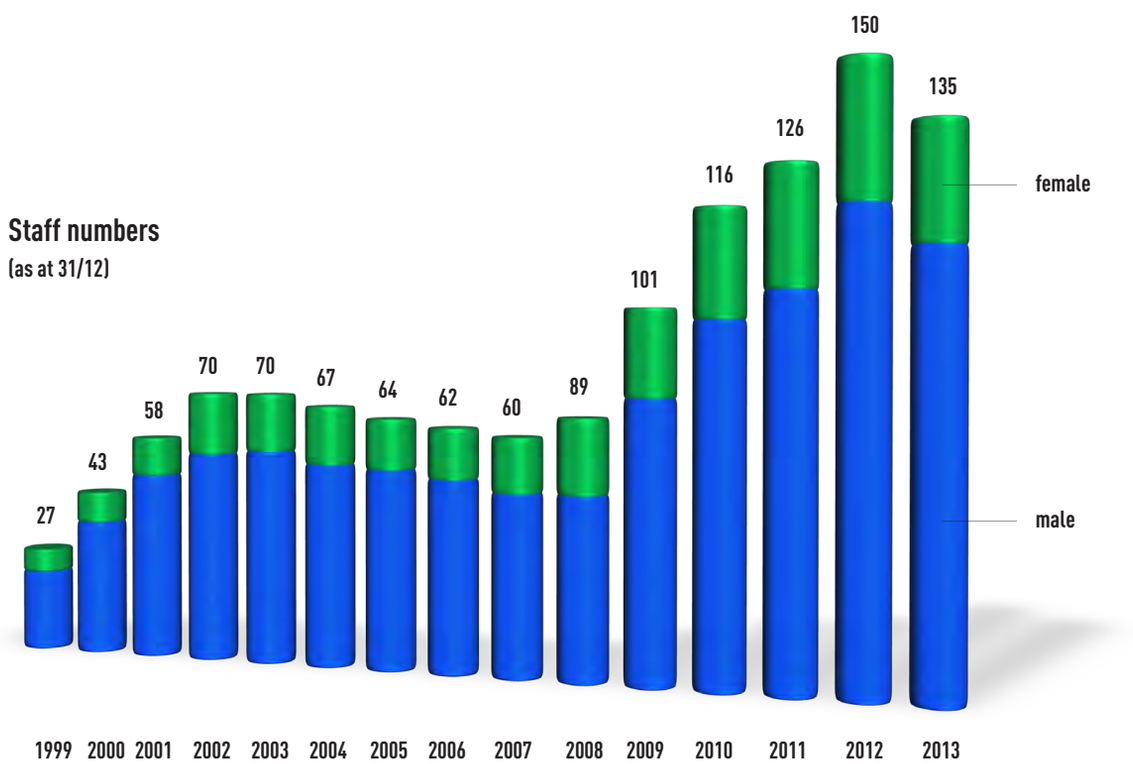
The project volume in the non-COMET area was € 399,917 (PY: k€ 410) for nationally funded projects and € 77,028 (PY: k€ 9) for internationally funded projects, which is also an increase compared to the previous year.

A turnover of € 1,549,733 was generated in the non-funded area (PY: k€ 1,125), representing a 38% increase over the previous year.



Staff development

As at 31/12/2013 the company had an average of 135 employees / full time equivalent: 105.7 (PY: 150 / FTE 108.9). This staff decrease in the 2013 financial year is due to the fact that an increasing number of personnel working at universities or research institutions were registered as employees of the relevant university or research institution.



Financial and earnings position

Earnings position

Materials Center Leoben Forschung GmbH reported a net income of € 463,647.30 (PY: k€ 788) in the 2013 financial year.

The balance sheet profit – composed of the loss for the year of € 185,778.47 (PY profit for the year: k€ 192) plus profit carried forward of € 846,840.57 (PY: k€ 655) – thus amounts to € 661,062.10 (PY: k€ 847). An amount of € 649,425.77 (PY: k€ 596) was allocated to the profit reserve in the 2013 financial year.

Turnover mainly includes contributions of € 7,037,467.02 (PY: k€ 5.907) from the COMET partners and non-COMET project revenue of € 1,680,083.65 (PY: k€ 1,383). COMET and non-COMET funding together amounted to € 5,900,638.06 (PY: k€ 7,310). Other operating income, including the release of investment allowances and provisions amounted to € 1,047,478.15 (PY: k€ 1,810). Overall revenue (items 1 to 5 of the profit and loss account) including other operating income and changes in work in progress amounted to € 15,634,279.11 (PY: k€ 16,399) in the 2013 financial year.

Raw material expenses and expenditure for services received amounted to € 7,215,608.08 (PY: k€ 7,643), and staff expenses amounted to € 5,641,368.02 (PY: k€ 5,481).

Depreciation and amortisation in the 2013 financial year amounted to € 969,857.70 (PY: k€ 1,015). The other operating expenses were substantially reduced to € 1,336,947.11 (PY: k€ 1,485).

The financial result amounted to € 6,881.18 (PY: k€ 61).

Asset position

The book value of fixed assets rose to € 2,446,808.82 (PY: k€ 2,314) in the 2013 financial year. This increase is mainly due to investments in the research areas "Materials Engineering" and "Materials for Microelectronics".

An amount of € 649,425.77 (PY: k€ 596) of the net income was allocated to profit reserves, which thus total € 3,454,384.56 (PY: k€ 2,805) as at 31/12/2013 and serve to secure the development of research projects and activities in the future. The company thus reports a balance sheet profit of € 661,062.10 (PY: k€ 847), which will be allocated to unappropriated profit reserves or carried forward to new account.

Capital and reserves increased to € 4,407,446.66 (PY: k€ 3,944) in the 2013 financial year. Due to the high level of trust assets as at the end of 2013 and a concomitant substantial increase in total capital, the company has an equity ratio of 24.41% (PY: 38.79%) as at 31/12/2013, determined in accordance with Sec. 23 of the Austrian Company Reorganisation Act (URG).

Financial position

The 2013 financial year brought a substantial increase in net cash flow from ordinary activities to k€ 5,229 (PY: k€ -2,325) and in net cash flow from operating activities to k€ 5,215 (PY: k€ -2,340). Net cash flow from investment activities was € -1,102 (PY: k€ -1.230), while net cash flow from financing activities decreased to k€ -17 (PY: k€ 957) due to the investment allowances. Changes in cash and equivalents totalled k€ 4,096 (PY: k€ -2,613) in the 2013 financial year, bringing the value of cash and equivalents as at 31/12/2013 to k€ 7,676 (PY: k€ 3,580). This change is mainly due to the trust assets.

Outlook for 2014

In 2014, the COMET area will be slightly reduced to k€ 13,253 (2013: k€ 13,935) due to the limited project volume in COMET Phase II. In the non-COMET area, turnover is expected to remain at k€ 1,543 (2013: k€ 1,550) for non-funded projects, while a substantial increase to k€ 1,390 (2013: k€ 477) is planned for funded research projects.

Profit and Loss Account as at 31/12/2013 Materials Center Leoben Forschung GmbH

Profit and Loss Account

		€	2013 €	2012 T €
1.	**Turnover**		**1,680,083.65**	**1,383**
2.	**Services not yet billable**		**-31,387.77**	**-11**
3.	**Income from cash and in-kind contributions by partners**		**7,037,467.02**	**5,907**
4.	**Public funding and allowances**			
	a) income funding and allowances COMET K2	5,526,399.54		7,204
	b) income funding and allowances Non Comet K2	374,238.52		106
			5,900,638.06	**7,310**
5.	**Other operating income**			
	a) release of investment allowances	16,657.70		768
	b) income from additions to fixed assets	139.00		5
	c) income from the reversal of accruals	521,822.14		371
	d) other	508,859.31		665
			1,047,478.15	**1,810**
6.	**Material expense and expenditure for services received**			
	a) material expense	1,048,962.29		987
	b) expenditure for services received	6,166,645.79		6,655
			7,215,608.08	**7,643**
7.	**Staff expenses**			
	a) Wages	26,977.00		26
	b) Salaries	4,313,893.06		4,190
	c) Employee income provision fund	64,295.41		61
	d) Expenses for social security payment prescribed by law as well as taxes and mandatory contributions dependent on compensation	1,191,041.15		1,155
	e) Expenses for other employee benefits	45,161.40		49
			5,641,368.02	**5,481**
8.	**Amortization**			
	a) of fixed assets		**969,857.70**	**1,015**
9.	**Other operating expenses**			
	a) taxes, in so far as they are not on income or on revenue	13,777.92		11
	b) other	1,323,169.19		1,474
			1,336,947.11	**1,485**
10.	**Operating result**		**470,498.20**	**775**
11.	Other interest income and similar income		6,881.18	61
12.	**Financial result**		**6,881.18**	**61**
13.	**Profit from operating activities**		**477,379.38**	**836**
14.	Taxes on income and revenue		13,732.08	48
15.	**Net income**		**463,647.30**	**788**
16.	Allocation to profit reserves			
	a) other reserves (free reserves)		649,425.77	596
17.	**Profit for the year**		**-185,778.47**	**192**
18.	Profit carried forward from the previous years		846,840.57	655
19.	**Balance sheet profit**		**661,062.10**	**847**

Balance Sheet

Balance Sheet as at 31/12/2013 Materials Center Leoben Forschung GmbH

as at 31/12	€	2013 €	2012 T €
Assets			
A. Fixed Assets			
I. Intangible Assets			
1. Licences and software		55,778.02	30
II. Tangible Assets			
1. Equipment	2,002,985.82		1,947
2. Tools, fixtures and fittings	368,094.98		337
3. Payments made on account	19,950.00		0
		2,391,030.80	2,284
		2,446,808.82	**2,314**
B. Current Assets			
I. Inventories			
1. Services not yet billable	80,010.10		111
2. Payments made on account	40,000.00		46
		120,010.10	158
II. Receivables and other Assets			
1. Receivables arising from deliveries and services	564,835.66		388
2. Receivables of cash and in-kind contributions from partner companies	1,101,748.29		905
3. Receivables from subsidies und project subsidies	142,686.77		1,884
4. Other receivables and assets	663,182.89		889
		2,472,453.61	4,065
III. Cash on hand and bank deposits		7,675,890.73	3,580
		10,268,354.44	**7,803**
C. Trust assets		**5,281,871.08**	**0**
D. Prepaid expenses, deferred charges		**66,266.32**	**71**
Total Assets		**18,063,300.66**	**10,189**

Balance Sheet as at 31/12/2013 Materials Center Leoben Forschung GmbH

as at 31/12/	€	2013 €	2012 T €
Liabilities and Shareholders' Equity			
A. Capital and Reserves			
I. Share capital		292,000.00	292
II. Revenue reserves			
1. Other reserves (free reserves)		3,454,384.56	2,805
III. Balance sheet profit		661,062.10	847
thereof profit carried forward from the previous years		846,840.57	655
		4,407,446.66	**3,944**
B. Investment Allowances		6,081.89	23
C. Accruals			
1. Tax accruals	0,00		46
2. Other accruals	836,054.00		1,138
		836,054.00	**1,184**
D. Liabilities			
1. Payments received on account for orders	0,00		37
2. Liabilities arising from deliveries and services	2,550,241.31		2,622
3. Other liabilities	150,945.36		156
thereof taxes	10,109.06		10
thereof social security	124,405.85		127
		2,701,186.67	**2,815**
E. Trust assets		**5,281,774.40**	**0**
F. Prepaid expenses, deferred charges		**4,830,757.04**	**2,223**
Total Liabilities and Shareholders' Equity		**18,063,300.66**	**10,189**
Contingent Liability		**5,744.00**	**0**

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COMET Competence Centers for Excellent Technologies

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FFG

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