MATERIALS CENTER LEOBEN
FORSCHUNG GMBH

ANNUAL REPORT 2012

Competence Centers for
Excellent Technologies

COMET K2 Centre MPPE

Integrated Research in Materials, Processing and Product Engineering

The strategic objectives of COMET are: developing new expertise by initiating and supporting long-term research co-operation between science and industry in top-level research, and establishing and securing the technological leadership of companies. By advancing and concentrating existing strengths and by integrating international research expertise Austria is to be strengthened as a research location for the long term.

MPPE is grateful for funding from the Austrian Federal Government (especially the Federal Ministry for Transport, Innovation and Technology and the Federal Ministry of Economy, Family and Youth) represented by the Austrian Research Promotion Agency (FFG) and from the Styrian Regional Government represented by the Styrian Business Promotion Agency (SFG).

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 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 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

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THE COMPANY

Univ.-Prof. Dr. Reinhold Ebner
Managing Director

Successful evaluation of the COMET K2 centre MPPE to 2017

2012 was an important milestone in the history of MCL - the year in which the extension of the COMET K2 Competence Centre was secured until 2017. The application for the second funding phase from 2013 to 2017 had already been submitted in 2011. The research results achieved so far as well as future research activities were presented to an international jury during the site visit at MCL on 15 and 16 March 2012. The positive results of the evaluation and the extension of the Competence Centre until 2017 were announced on 16 March together with the gratifying confirmation that the project volume of € 53 million in Phase I is to be increased to € 59.5 million in Phase II. This was followed by the conclusion of funding contracts with the Austrian Research Promotion Agency (FFG), the Styrian Business Promotion Agency (SFG) and the Business Promotion Agency Tyrol (Standortagentur Tirol) ensuring that the projects can be continued without interruption in 2013. Work also began on the relevant adaptation of the Agreement and coordination with the company partners.

Strategic goals for COMET Phase II primarily include the strengthening of expertise along the value chain, further enhancing international cooperation and increasing innovative strength.

New research area: "Materials for Microelectronics"

At the Supervisory Board meeting in March it was decided that the new area "Materials for Microelectronics" should be established with immediate effect based on the detailed business development plans. The microelectronics team moved into the new facilities at Kerpelystrasse 2 in Leoben as early as December 2012. Prior to the move, work concentrated on recruiting new staff, developing and submitting new projects, renting and adapting new facilities and procuring new equipment (CT scanner, acoustic microscope and atomic force microscope). Thanks to the dedication and commitment of all involved it was possible to have the new research area up and running very quickly so that new projects and analytical work could be started before the end of 2012. Following extensive preparations the laboratory was officially opened on 13 March 2013 at a celebratory event attended by Regional Minister Dr. Christian Buchmann, CTO Heinz Moitzi (AT&S AG) and Rector Univ.-Prof. Dr. Wilfried Eichlseder (Montanuniversitaet Leoben). The creation of this new research area is an important step in shaping the future of MCL.

Business performance in 2012

The COMET project volume was again increased from € 11.8 million in 2011 to € 12.2 million in 2012, taking into account the unused investment grants from COMET Phase I of € 1.6 million. The effective COMET project volume for 2012 thus totals € 13.8 million, which represents a significant increase compared with the previous year. The reasons for this increase are mainly due to the launch of a number of projects for COMET Phase II. MCL services remained relatively steady at € 1.1 million, while non-COMET projects increased from € 0.25 million to € 0.4 million. This was accompanied by an increase in the average number of staff from 122 in 2011 to 137 in 2012 creating the need for more space. The 300m² facilities opened at the Roseggerstrasse 17 premises in autumn 2011 for the "Materials Simulation" team were extended by further 150m² at Roseggerstrasse 15 in March 2013. The new research area "Materials for Microelectronics" also received new office and laboratory facilities of some 500m² at Kerpelystrasse 2 and additional laboratory equipment.

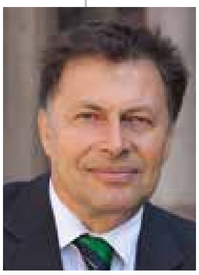
Outlook for 2013

2013 is the first year of COMET Phase II. As many of the Phase II projects were launched in the first funding phase there will be a smooth transition. The budgeted project volume in the COMET area will reach its peak in 2013 at € 15.3 million. In subsequent years the COMET project volume will then be reduced while the budget in the non-COMET areas will continue to increase. This means, for example, that in 2013 the project volume in the MCL services area will increase to € 1.4 million and non-COMET projects to € 0.5 million with the focus being on the acquisition of EU projects. It is anticipated that this will also lead to a further increase in the number of employees at MCL.

We believe that Austrian industry will continue to face new challenges in the materials science sector over the coming years. The extension of the COMET K2 Competence Centre and the successful expansion of the new research area "Materials for Microelectronics" pave the way for meeting these challenges with high quality research and development.

Dr. Richard Schanner
Managing Director

Shareholder Statement



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

Successful evaluation for COMET Phase II as the basis for extending the research portfolio

Following the successful site visit and evaluation on 15 and 16 March 2012, MCL can look forward with confidence to the coming years of research and continue to further develop and extend its research areas. The approved project volume for Phase II was also increased from € 53 million to € 59.5 million, with the funding rate remaining at 55%. This significant increase in the approved project volume opens up opportunities for taking on more industrial projects in order to generate innovation in companies and further extend MCL's portfolio of research services. The research area "Materials Simulation" has developed very well over the past few years and in 2011/12 new premises were opened to accommodate around 40 employees at Roseggerstrasse 15/17. The new research area "Materials for Microelectronics" is expected to develop just as positively – as indicated by initial projects and results. In December 2012, the new research area went into operation at its new facilities at Kerpelystrasse 2, where about 30 highly qualified research staff will work in the medium-term. Overall, the shareholders are very pleased with MCL's development although of course there remains some room for improvement in the framework conditions for research. The provision of a 5% contribution based on the total COMET project volume poses a major challenge for the scientific partners. The 20% limit on overheads causes further problems as the actual overheads incurred are in fact considerably higher and the full costs are thus not covered in line with statutory stipulations.

Report from the General Meeting

The Management Board and the Supervisory Board reported to two General Meetings held in 2012. The annual accounts for 2012 were unanimously approved and the Management Board and the Supervisory Board were formally discharged for 2012. The shareholders would like to thank the members of both boards for their excellent work. Overall the shareholders are very pleased with MCL's positive development. This includes both the financial results and the competence centre's scientific achievements, which are documented in the Intellectual Capital Report. The General Meeting also approved the budget for 2013, which again provides for further growth.

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

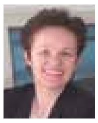
From the Supervisory Board

Successful evaluation of the COMET K2 centre MPPE

The successful evaluation of the COMET K2 centre MPPE for the next funding period is an important milestone for the competence centre. The Supervisory Board congratulates the staff at MCL as well as the scientific and industrial partners on this resounding success. Despite this positive development the Supervisory Board is, however, also concerned about a number of issues. Providing contributions to the value of 5% of the total project volume poses serious financial difficulties for universities. Furthermore, the total costs for the universities are not recognised in full but only at a rate of 20%. There is great concern that the interest of universities in participating in the research programme will be severely jeopardised by this stipulation. It is not acceptable that universities only participate to provide in-kind contributions. The competence centres have the task of generating innovations, inventions and patents. In accordance with the EU Framework for state aid for research, development and innovation (2006/C 32/01), these patents are to be licensed at market prices. Fewer and fewer companies are, however, willing to pay such prices. The competence centres find themselves having to deal with an ever increasing range of administrative issues and thus have less and less time and resources available for their key task - research.

Strategic further development in microelectronics and promotion of the non-COMET area

In October 2011, work started on a detailed planning process for the new MCL research area "Materials for Microelectronics" with the aim of focusing on core themes within this extensive research field and developing a realistic start-up schedule. In future, MCL will focus on the two future-oriented research fields of "Packaging" and "3D Integration". Despite the rather ambitious timetable, the goals for 2012 were successfully achieved. Thanks to timely staff recruitment, project acquisition and investments in infrastructure and facilities the area became operational in December. The Supervisory Board congratulates all those involved on this achievement. The strategy for the non-COMET area was also developed and approved. This area provides services to make better use of MCL's state-of-the-art facilities and to make the results from the research programme available to companies addressing individual scientific problems. The non-COMET area is a very important source of funding for MCL, which it plans to extend in the future through participation in other funding initiatives. The aim is to achieve greater involvement in EU projects and funding lines run by the Austrian Research Promotion Agency (FFG), for example in the field of intelligent production. Overall, the financing of MCL should become more diversified and use a range of different funding sources.



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

Dr. **Bruno Hribernik**
Deputy Chair
elected 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

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

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

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

From the COMET K2 Programme Committee

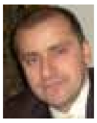
Univ.-Prof. Dr. **Helmut Antrekowitsch**
Montanuniversitaet Leoben

Dr. **Christian Auer**
Epcos OHG

Univ.-Prof. Dr. **Franz Dieter Fischer**
Montanuniversitaet Leoben

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

DI **Josef Hagler**
voestalpine Stahl GmbH

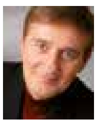


Dr. **Christian Hinteregger**
MAGNA Powertrain AG & Co KG

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

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

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



Univ.-Prof. Dr. **Andreas Ludwig**
Montanuniversitaet Leoben

Dr. **Christian Majcenovic**
RHI AG

Dr. **Raimund Ratzi**
Miba AG

Univ.-Prof. Dr. **Werner Sitte**
Montanuniversitaet Leoben

Dr. **Axel Sormann**
voestalpine Stahl
Donawitz GmbH & Co KG

Large project volume in the Programme Committee

A large number of projects were acquired and planned in 2011 in preparation for COMET Phase II. Due to strong interest from the companies involved, many of the projects included in the application were already started in 2012. In the 2012 financial year, a total of 21 project applications with a project volume of € 20.4 million were submitted to the Programme Committee. Of these, 18 projects with a total project volume of € 18 million were recommended for inclusion in the COMET Programme. Requirements imposed for some of the projects have meanwhile been implemented. Two of the three rejected projects have been completely revised and will be resubmitted to the Programme Committee.

Future tasks of the COMET K2 Programme Committee

Due to the appointment of an International Scientific Advisory Board, the COMET K2 Programme Committee has been assigned new tasks and will in future also be responsible for the approval of projects. Previously the members of the Programme Committee carried out a detailed evaluation of the projects and made a recommendation to the COMET K2 Board. This recommendation frequently included comprehensive requirements for revision of the project application in order to enhance the quality of the applications. Drawing on the expertise of its highly qualified and extensively experienced members, the Programme Committee has thus made an important contribution to the scientific excellence of the competence centre.

The assignment of new tasks in COMET Phase II also necessitates the reappointment of the Programme Committee, which will be made up of members from the old Programme Committee and the COMET K2 Board as well as of new members. These changes will also take into account the establishment of the new research area "Materials for Microelectronics".

From the COMET K2 Board

Successful application for COMET Phase II

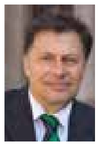
The competence centre has developed extremely well over the last few years as reflected in the successful application for extension and the increased project volume. This provides a secure basis for the competence centre to continue its research over the coming years, building on the sustained strong support from industry and science. MCL is thus on track for a successful future. The research programme will continue to develop and provide solutions to key questions in the field of materials science. These include, for example, the functionalisation of materials, new and smart process technologies, innovative products based on new materials, materials made from recycled products as well as energy and resource efficient manufacturing processes.

International Scientific Advisory Board

A key condition for MCL in COMET Phase II is international orientation as well as the appointment of an international scientific board. The Supervisory Board and the shareholders also expressed the need to simplify the board structure and eliminate multiple responsibilities. The General Meeting therefore adopted a decision to appoint an International Scientific Advisory Board consisting of members from different countries, which will meet at least once a year. The currently existing COMET K2 Board will thus be disbanded. The decisions on the projects will now be taken by the Programme Committee, which will also assume additional tasks. Responsibility for the strategic tasks of the COMET K2 Board will be passed to the Supervisory Board. The very first board meeting – at the time still within the framework of Kplus – took place on 13 October 1999 and was chaired by Prof. Dr. Hellmut Fischmeister. A total of 48 board meetings have been held since the competence centre was founded, 28 of them in the Kplus phase. The COMET K2 Board has thus supported MCL from the very beginning and is very proud of its development.

We would like to take this opportunity to thank all those involved for their active participation and valuable support in ensuring the continued positive development of the competence centre. The primary focus in Phase II will be on generating innovation for companies and thus further enhancing the competitiveness of Austrian industry. We wish the members of the new International Scientific Advisory Board much success in meeting their future challenges.

Univ.-Prof. Dr. **Herbert Mang**
Chair
Austrian Academy of Sciences,
Vienna University of Technology



Magn. Univ.-Prof.
Dr. **Wilfried Eichlseder**
Deputy Chair
Montanuniversitaet Leoben

Univ.-Prof. Dr. **Bruno Buchmayr**
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Univ.-Prof. Dr. **Herbert Danninger**
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Univ.-Prof. Dr. **Robert Danzer**
Montanuniversitaet Leoben

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

Dr. **Heinrich Kestler**
Plansee SE

DI **Hubert Lenger**
Böhler Edelstahl GmbH & Co KG

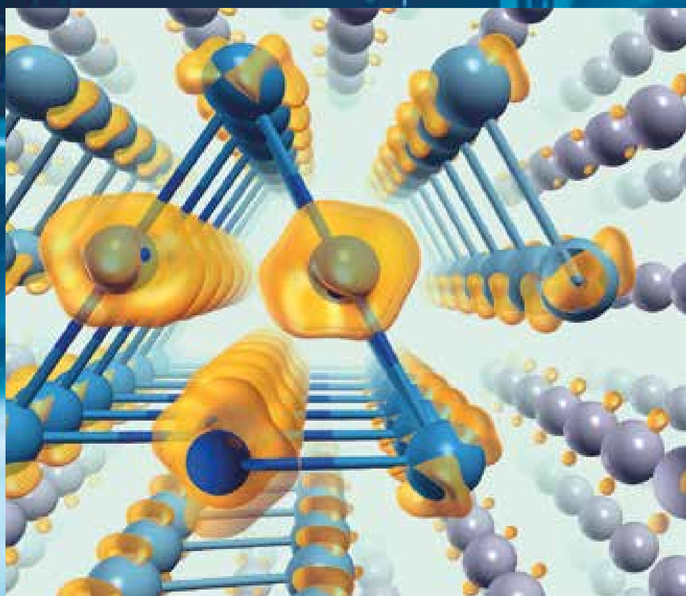
Univ.-Prof. Dr. **Christian Mitterer**
Montanuniversitaet Leoben

Dr. **Kurt Rabitsch**
Treibacher Industrie AG

DI **Herbert Adolf Schifferl**
voestalpine Stahl
Donawitz GmbH & Co KG

Ing. **Josef Seyrkammer**
Miba Sinter Austria GmbH

RESEARCH PROGRAMME COMET K2 MPPE



Presentation of COMET K2 MPPE

Review of COMET Phase I

Highlights:

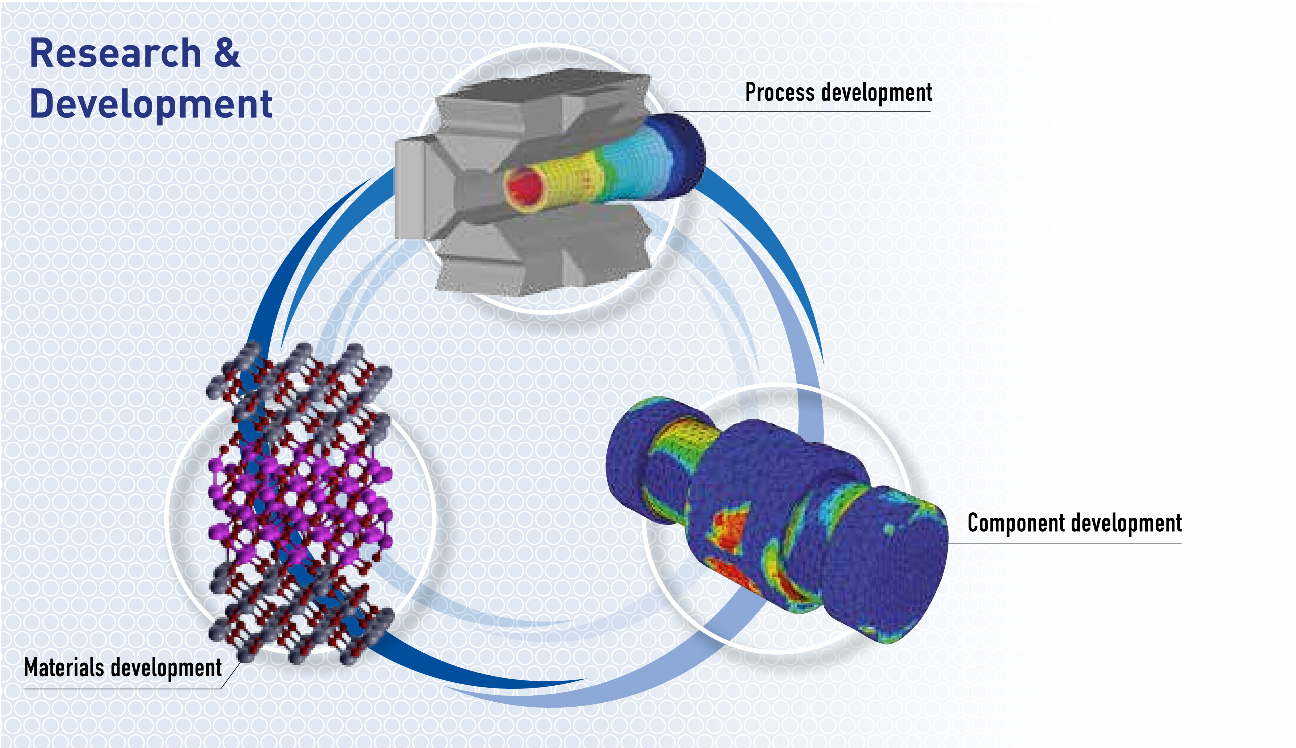
- Exploring the plasticity of metals
- Virtual accelerated cooling of heavy steel plates
- New machining potentials for hard metals
- How to stop small drills from breaking
- Chains for low temperatures and hot conditions
- Lightweight and safe through damage tolerant design
- Enhancing the reliability of miniaturised microelectronic components

Innovation through integrated research in materials, processing and product engineering

RESEARCH PROGRAMME
COMET K2 MPPE

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 research in materials, processes 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 the 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.

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

The participating companies gain access to the latest scientific findings as well as state-of-the-art simulation and experimental methods and can 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 basic research projects.

The long-term strategic projects are designed to provide a sustainable basis for the future research and development portfolio.

COMET research activities carried out in long-term projects account for slightly over 80% of MCL turnover. Around 10% of turnover comes from direct contract research and development or research carried out as part of other national and international projects and the remaining 10% from the provision of services.

Review of COMET Phase I:

Phase I of the research programme ran from 2008 to 2012 and involved a COMET project volume of around € 48.3 million.

MCL and the scientific partners accounted for about € 38.6 million of the project volume. The company partners provided in-kind contributions of € 9.6 million and have thus made an essential contribution to the success of the projects and also to the implementation of the project results within the participating companies. It should be noted that these € 9.6 million only include the contributions claimed; the actual contributions are significantly higher.

The project volume of around € 48.3 million can be divided as follows: public funding was around € 24.0 million, in-kind contributions provided by the scientific partners amounted to € 2.4 million and the company partners contributed € 21.8 million, of which € 12.2 million were in cash and € 9.6 million in kind.

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

Period	**2008 to 2012**
COMET project volume (€ million):	**48.3**
of which MCL and scientific partners	38.7
of which company partners	9.6
COMET financing (€ million):	
Federal funding	16.1
Provincial funding	8.0
In-kind contributions by scientific partners	2.4
Cash contributions by company partners	12.2
In-kind contributions by company partners	9.6

Staff development:

The number of employees increased from 60 to 150 in COMET Phase I.

Despite intensive efforts, the percentage of female employees did not increase significantly and remained at an average of 23%. Nevertheless the efforts made here have proved successful in some individual areas, as demonstrated by the 50% proportion of female researchers in the area of microelectronics. 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.

MCL has increasingly recruited experts from abroad over the past few years. As at the end of the first funding period MCL staff included 35 international employees from 18 countries, which represents a percentage of 23%. Our team members with an international background are a substantial enrichment for MCL and extend the range of experience and expertise offered by MCL.

Staff development:	**Total**
Number of employees at 1 Jan 2008	60
Scientists	47
Engineers/Technicians	8
Administration / Facility Management	5
Number of employees at 31 Dec 2012	150
Scientists	131
Engineers/Technicians	10
Administration / Facility Management	9

Projects and project development:

A total of 53 projects were completed in the reporting period from 01/2008 to 12/2012 (including projects continued from Kplus). Another 43 projects were still ongoing at the end of COMET Phase I and transferred to COMET Phase II. 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 euros. Both the volume and the complexity of the projects have increased substantially over the past five years.

Projects:	
- completed in Phase I (2008 to 2012)	53
- ongoing at the end of Phase I (2008 to 2012) (transferred to Phase II [2013 to 2017])	43

Publications and patents:

A total of 473 publications resulted from COMET Phase I, of which 380 appeared in refereed journals. The annual number of publications has increased from around 60 to around 100 over the past five years with a marked increase in contributions to refereed journals.

Applications for three patents were filed in the first funding period. The number of patents is expected to increase substantially in the next funding period, as the competence centre has reached a higher level of maturity.

Publications:	**473**
- of which in refereed journals	380
- of which in conference proceedings etc.	93
Patents:	**3**

Degree theses:

The number of academic degree theses has successively increased in COMET Phase I. While an annual average of 7 doctoral theses were completed in the first funding phase, the number will roughly double in the next few years. The same applies for diploma, master's and bachelor's theses.

Doctoral theses:	**90**
- completed in Phase I (2008 to 2012)	36
- ongoing at the end of Phase I (2008 to 2012)	54
Diploma/Master's theses:	**53**
- completed in Phase I (2008 to 2012)	45
- ongoing at the end of Phase I (2008 to 2012)	8
Bachelor's theses:	**9**
- completed in Phase I (2008 to 2012)	9
- ongoing at the end of Phase I (2008 to 2012)	0

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. Materials processing into parts and functional components
4. Design and testing of parts and functional components
5. Behaviour of materials in service

The COMET K2 Center carries out multidisciplinary projects 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: Tool Technology for Advanced Processing
Area 6: Fatigue-Proof Design
Area 7: Design and Reliability of Components with Functional Properties

The scientific objectives have been updated and re-defined for COMET Phase II (2013 to 2017). Areas 3 and 6 were substantially modified and renamed as follows:

- Area 3 (in Comet Phase II): Advanced Manufacturing Processes
- Area 6 (in Comet Phase II): Smart Concepts for Structural Components

The research activities will be illustrated by some examples.

- Simulation based materials engineering: Exploring the plasticity of metals
- Simulation based process engineering: Virtual accelerated cooling – the key to efficient process development of high-strength heavy steel plates
- Integrated process and tool engineering: New machining potentials for hard metals
- Integrated materials, process and product engineering: Chains that resist low temperatures and hot environments
- Smart product engineering for structural components: Lightweight and safe through damage tolerant design
- Reliability of microelectronic components: Enhancing the reliability of miniaturised components

RESEARCH PROGRAMME
COMET K2 MPPE
Highlights

Exploring the plasticity of metals

Understanding the structure of dislocations using an innovative simulation method

Plasticity is a key characteristic of metals. Metals therefore have a high potential for plastic deformation. This property may however vary strongly – from very high to very low ductility, similar to glass. Many alloys with body-centred cubic crystal structure, e.g. many steels, tungsten and molybdenum, may become brittle under unfavourable conditions and break without deformation.

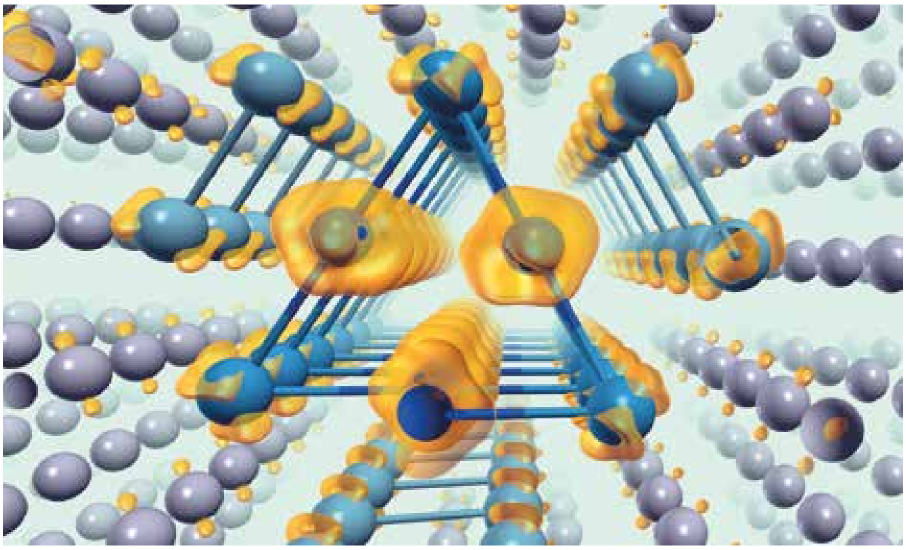
The way in which materials deform and break depends on their atomic structure. It determines the cohesion of atoms within a crystal and between the crystals of a solid, while also influencing the movement of dislocations which act as deformation carriers. Dislocations may be lattice defects which move through the crystal in metals subjected to sufficiently high stresses. The simultaneous movement of millions of dislocations leads to a macroscopic deformation of the crystals.

The dislocation structure determines the sliding and deformation properties of metals

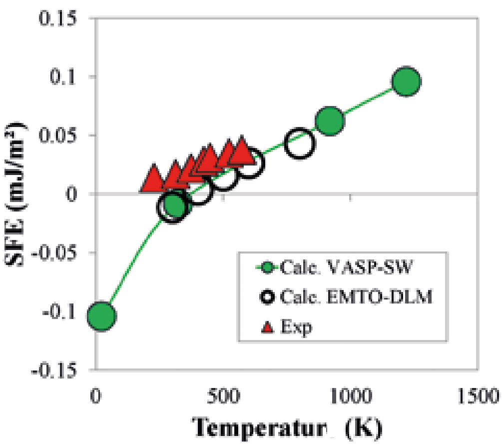
The sliding properties of dislocations are determined by their geometrical structure. Atomistic calculations are the only way to describe and predict the structure of dislocations in detail. Density functional theory (DFT) calculations in particular provide a valuable insight into dislocation structures.
Materials scientists are keen to understand how alloying elements influence the movement of dislocations. Several factors play a role in this context: the critical stress required to move dislocations, the question along which planes the dislocations can move and how easily they can change from one slip plane to another. Detailed knowledge of the atomic structure of a dislocation is required to be able to directly modify this structure and develop materials characterised by high plasticity and ductility and thus high break resistance.

Tungsten-rhenium alloys have been used to show that the structure of the dislocation core and plasticity can be modified by adding rhenium to tungsten.

Atomistic modelling: the key to alloy design at the atomic level
MCL places a special focus on the 'atomistic' description of alloys. This includes efficient modelling of alloys, lattice defects such as vacancies, dislocations and interfaces and their effects. The main aim is to advance the spin-wave method for the description of paramagnetic states. Research and development activities in the field of atomistic modelling are complemented by research into the functional properties of materials.



Interior view of a screw dislocation in a body-centred cubic crystal



Temperature dependence of an alloy's stacking fault energy (SFE), (green and black: calculated values using different models, red: experimental results from literature)

Impact

These novel theoretical methods enable completely new insights into the atomic structure of materials and their properties at this length scale and thus provide the basis for new development approaches to enhance the plasticity and break resistance of alloys. MCL already uses atomistic modelling for the design of steels and refractory metals.

RESEARCH PROGRAMME
COMET K2 MPPE

Highlights

Virtual accelerated cooling of heavy steel plates

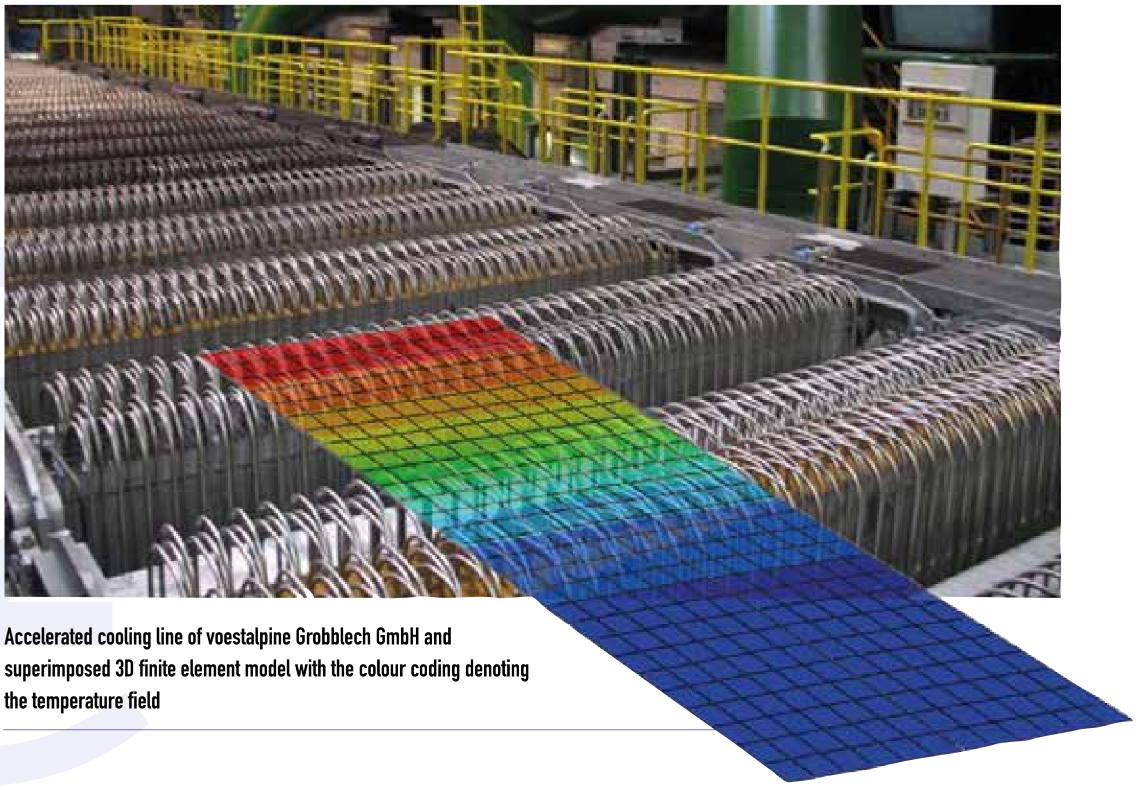
The challenge for heavy steel plates: uniform properties and flatness

Thermomechanically rolled steel plates are manufactured in a four-step process, which includes slab heating, rolling, accelerated cooling and levelling. The process step of accelerated cooling in particular is decisive in adjusting the mechanical/ technological properties of the plates. Their strength and ductility can be adjusted by varying the cooling rate and the cooling stop temperature. The main challenge in process engineering is to achieve well defined mechanical properties and a high degree of flatness prior to levelling.

Numeric modelling replaces experimental optimisation

The large number of influencing parameters to be considered in optimising the cooling process necessitates large-scale experiments and correspondingly high costs. This is where virtual methods come in, since varying the process parameters on the computer is significantly easier. The challenge is to develop computer models that describe the production step both qualitatively and quantitatively as detailed as possible, while at the same time reducing computation times in order to enable parameter studies.

The special challenge in the case of accelerated cooling of heavy steel plates was to provide an efficient numerical description of the mechanical behaviour of the entire structure during the cooling process. This behaviour is primarily characterised by a phase transformation (lattice transformation), which depends on a range of factors such as the microstructure prior to accelerated cooling and the cooling rate of the steel plate. The phase transformation not only transforms austenite into more stable product phases but also leads to an increase in volume. Another phenomenon associ-

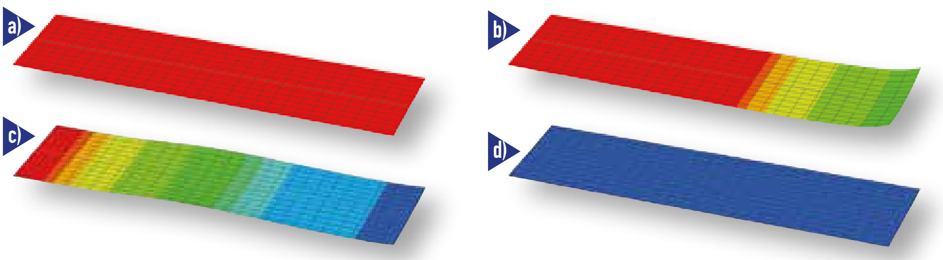


Accelerated cooling line of voestalpine Grobblech GmbH and superimposed 3D finite element model with the colour coding denoting the temperature field ated with phase transformation is the occurrence of transformation-induced plasticity (TRIP). The physically correct description of all these phenomena is an essential prerequisite for reliable virtual process simulations.

No matter how thick and strong – the steel plates must be as flat as possible

A comprehensive 3D finite element model and a computationally efficient 1D model for real-time simulation of the accelerated cooling step were developed by Montanuniversitaet Leoben and the Materials Center Leoben in close cooperation with voestalpine Grobblech GmbH. This model provided important findings on the evolution of plate geometry and mechanical properties during the cooling process and led to a significant reduction in process development times.

Accelerated cooling line in operation



The numerical simulation model makes it possible to view even the slightest deformations and temperatures (red=hot, blue=cold) during the cooling process through a virtual lens: (a) initial condition of hot plate, (b) right end of plate enters the cooling line, (c) right end of plate leaves the cooling line, (d) plate after accelerated cooling.

Impact

The simulation models enable a more reliable adjustment of the desired properties within narrow tolerances, which is an essential quality criterion and thus represents a key factor in enhancing the competitiveness of voestalpine Grobblech GmbH.

Machining – new potentials for hard metals

RESEARCH PROGRAMME
COMET K2 MPPE

Highlights

Tailored tool solutions for the machining of new materials

Manufacturers often seek to improve the energy efficiency of their products, e.g. vehicles, by increasing the strength of the materials used or by integrating composite materials with high hard phase content. This, in turn, results in higher loads on the tools used for machining these new materials.

As a consequence, the tools must meet increasing demands in terms of hardness, toughness and wear resistance. Modern tools are therefore often made from advanced composites. Hard metals, which demonstrate a high degree of hardness and sufficient toughness, are ideal substrate materials for wear-resistant hard coatings. The substrate material must be sufficiently hard to prevent it from plastically deforming upon contact with the workpiece, while the coatings are designed to protect the tool from wear due to adhesion, abrasion or oxidation.

Hard metals are extremely resistant composites with a ceramic hard phase and a metallic binding matrix, providing a unique combination of hardness, toughness and resistance to wear. The stress required to deform a hard metal is up to twice that for the strongest steels currently available. The high resistance against plastic deformation enables higher tool load and opens up new applications for hard metal tools.

Knowledge-based tool design

The cutting edges of tools are exposed to high temperatures as well as mechanical and tribological loads. Local temperatures and mechanical stresses are the decisive influencing parameters for the substrate material.

Numerical simulations of the cutting process provide the basis for a detailed analysis of the temperatures and stresses within the tool. Many tools show plastic deformation near the cutting edge, which in turn leads to the build-up of residual stress. In order to describe these phenomena quantitatively the physical and mechanical properties must be known in detail, i.e. as a function of temperature and strain rate.

The Materials Center Leoben has developed sophisticated testing methods for determining the mechanical material properties of hard metals over recent years. These methods are used in numerical models to predict how the hard metal substrate will react to stresses occurring during the cutting process.

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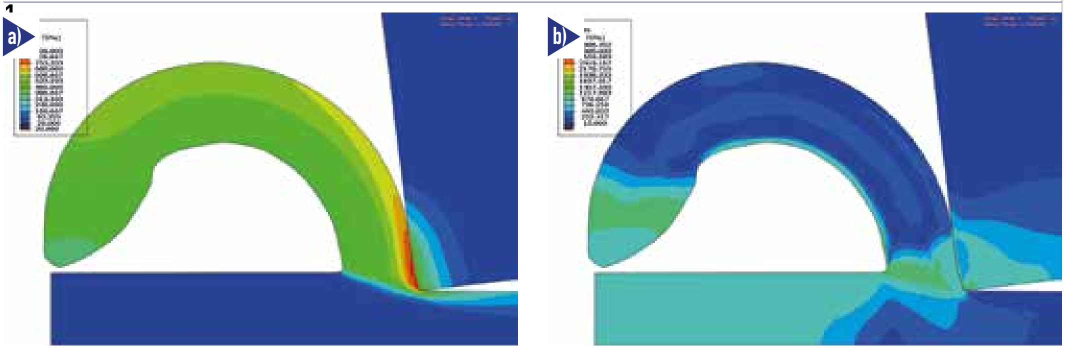
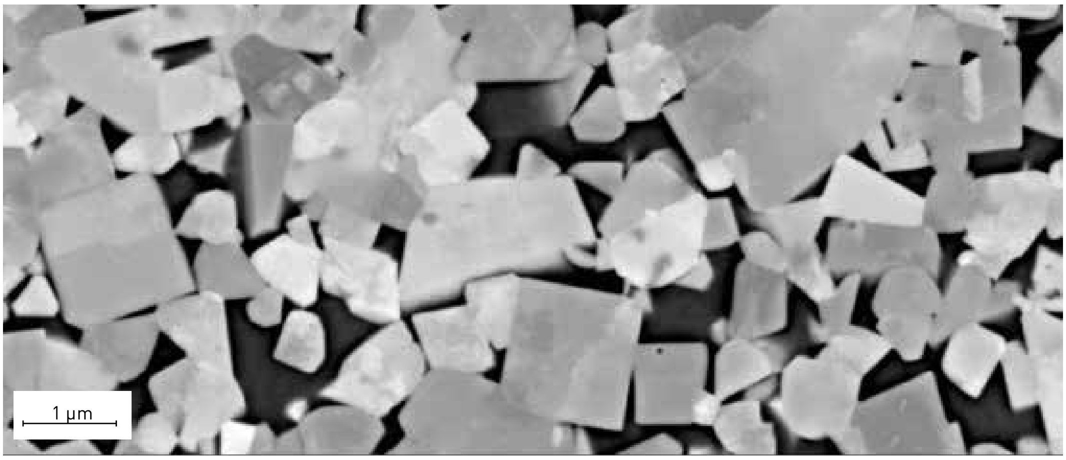
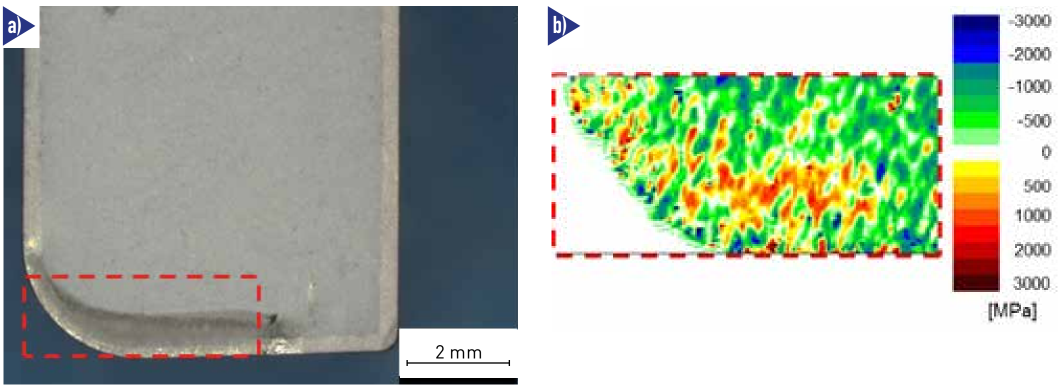


a) Temperature and b) strain distribution in the chip and in the tool



Microstructure of a hard metal



Load-induced residual stress in a hard metal cutting edge, a) specimen, b) residual stress distribution in hard metal substrate

Impact

The combined experimental and numerical development approach provides new findings for a knowledge-based design of cutting tools and enables substantial increases in productivity, new processes and new applications.

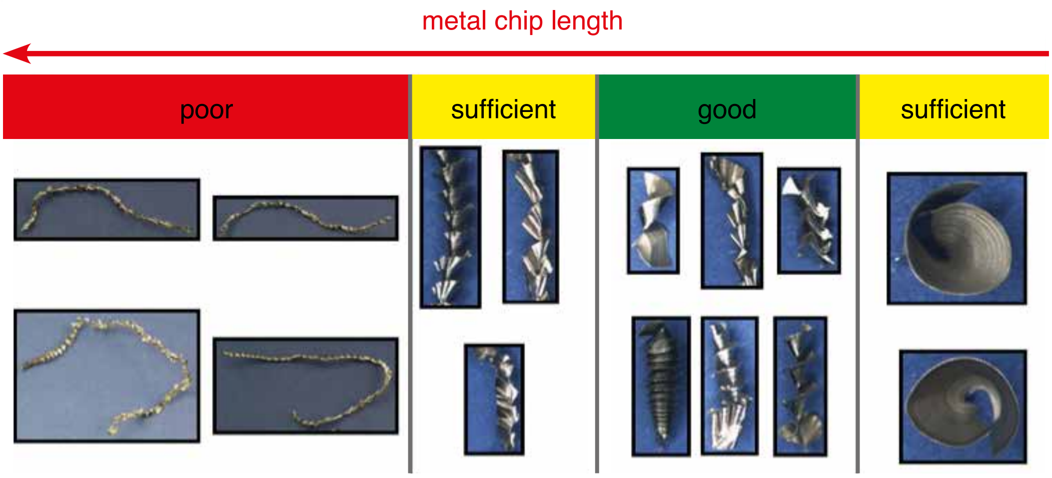
The new findings have already produced positive results in selecting suitable hard metal types for specific cutting applications.

RESEARCH PROGRAMME
COMET K2 MPPE

Highlights

How to stop small drills from breaking

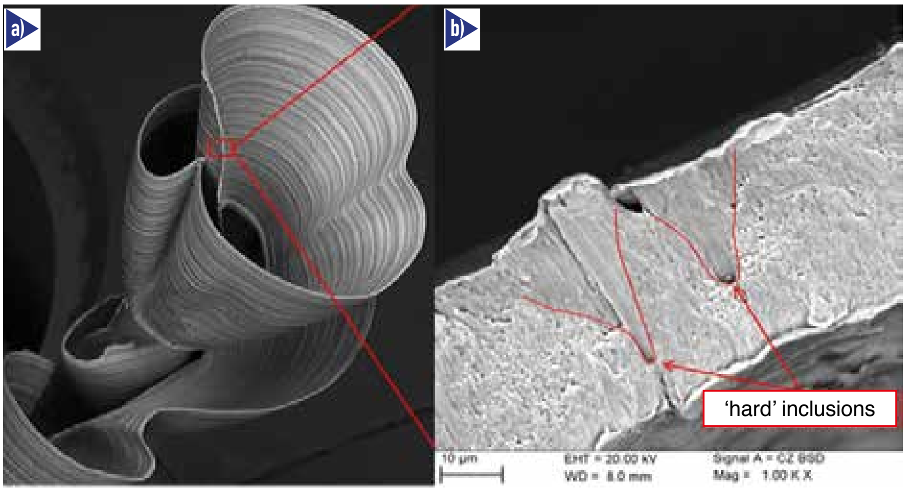
The smaller the drill bit, the more likely it is to break. This is what every DIY enthusiast discovers at some point, meaning a trip to the hardware store to pick up a replacement. While this is annoying for the handyman, in industry it is a serious financial consideration. The Materials Center Leoben (MCL) set about searching for solutions for drills which operate under extreme conditions. Diesel injection nozzles made of heat treatable steel, for example, have holes drilled over 100 mm deep yet only 2 mm in diameter. When these injection nozzles are produced on a large scale, tool failure impacts on the unit cost of the fabricated item in two ways: firstly, manufacturing special drills is costly and secondly, changing tools is time consuming and reduces productivity.



Chip lengths achieved from drilling a bore of 2 mm diameter and 100 mm length. Chip width always corresponds to the bore diameter, i.e. 2 mm. Left: chips of several cm, or 'dangerous' chips, right: very short chips, or 'helical' chips

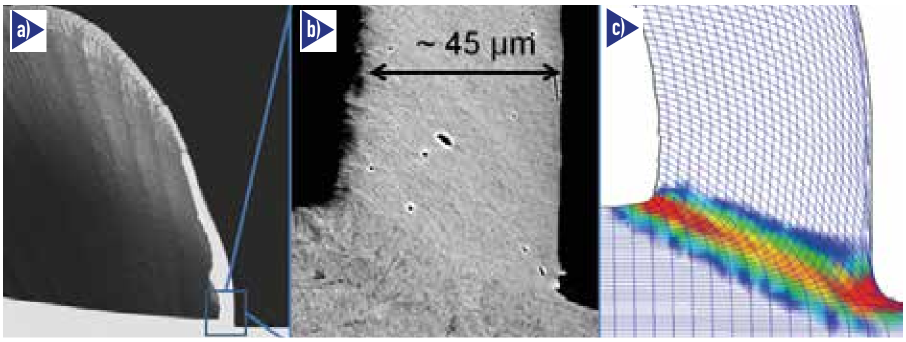
MCL's materials research revealed that the determining factor for whether or not a drill fractures is the length of the chips. At their narrowest point these chips are only ~ 40 µm thick (about half the thickness of a human hair) and up to several centimetres long. If chips are too long they become entangled in the drill hole and obstruct the drill, which then inevitably breaks.

But why does the length of the chips vary? The question was solved by conducting experimental investigations and checking the results through high resolution SEM images. The steel in which the holes are drilled has microscopically small inclusions of non-metallic materials which arise during steel production. Many of these inclusions are harder than the surrounding steel matrix and it is precisely these particles which help cause the chips to break as desired.



a) chip, b) high-resolution SEM image of chip fracture surface shows material separations originating from inclusions

Using finite element simulation of the process of chip formation, it was possible to observe the individual effects of drill geometry (state of wear), friction between the chip and drill (tool coating) and process parameters (cutting speed and advance) on the chip geometry produced (chip thickness) and the stress imposed on the drill (local stresses and temperatures, global forces). Combined with specific experimental investigations, this method of analysis provided a better understanding of the critical process parameters for chip formation and breakage.



SEM analysis of a chip root produced using a quick-stop device: a) chip root, b) detail of chip root,
c) calculated ~5-10µm thick primary shear zone of chip root as one of the results from FE simulation

Impact

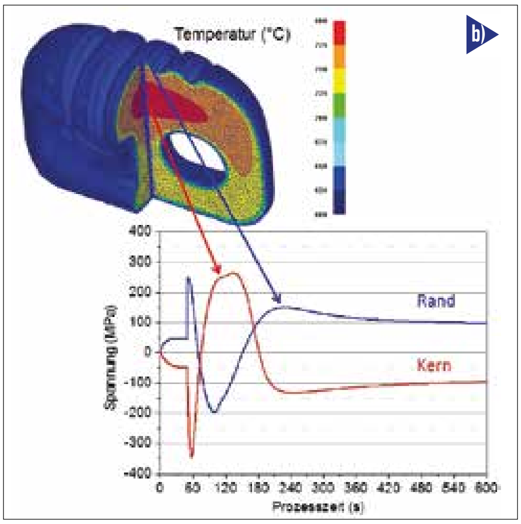
The detailed understanding of the most significant influencing parameters in deep hole drilling now enables the targeted selection of materials and drilling parameters in order to enhance process reliability.

Chains for low temperatures and hot conditions

Tyre protection chains

Conventional rubber tyres often cannot stand up to the harsh conditions found in steelworks and mining. The rough unforgiving ground combined with the considerable weight of machines such as wheeled loaders and dumper trucks would destroy the rubber tyres within a few days. An economically viable service life can only be achieved by using tyre protection chains. The Austrian chain specialist pewag austria GmbH produces this type of chain in the premium sector under the brand name Tycoon.

Tyre protection chains are designed to protect the face and side walls of the tyre from hostile elements such as high temperatures when driving through hot steel slag or from huge solid rocks and sharp scrap metal. Consequently these chains are made of a flexible close chain mesh in heat treatable steel. The individual chain links are connected with welded rings to form a chain mesh that safely transfers the high loads and adapts to tyre deformations in service.



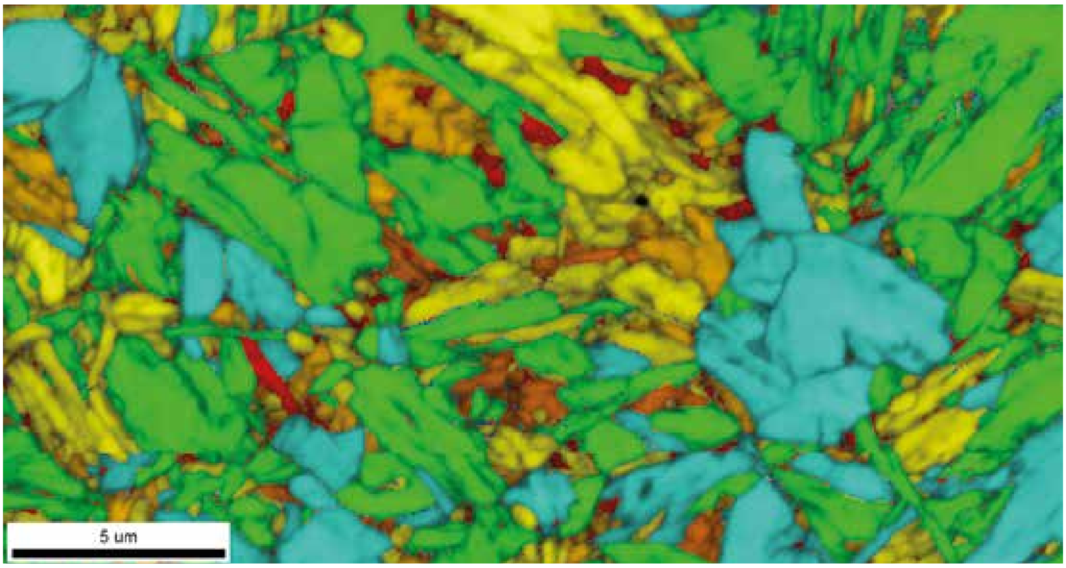
a) Structure of a tyre protection chain and operation under severe conditions, b) FE simulation of the temperature field and stress during the hardening of a chain link.

The Materials Center Leoben, Montanuniversitaet Leoben and voestalpine Stahl Donawitz GmbH have supported pewag austria GmbH in the further development of material concepts, process technology and geometry of chain links for tyre protection chains as part of a COMET project. Specific material characterisation experiments and finite element analysis were carried out to investigate the development of damaging stress during the hardening and tempering process. It was discovered that lower levels of stress during heat treatment have a direct positive effect on the durability of the chain. The results of the investigation are being incorporated in the on-going development of tyre protection chains in all quality grades.

Hoist chains

Hoist chains are safety-critical components. They must therefore provide not only high load-bearing capacity, but also extreme material toughness and fracture resistance in service.

Specific requirements of hoist chains include, for example, adequate fracture toughness at cryogenic temperatures down to –40°C or following exposure to temperatures of up to 380°C. Detailed research studies have examined the factors influencing fracture toughness under these extreme conditions in order to produce hoist chains with appropriate microstructures able to withstand such conditions.



Microstructure of a chain link characterised by high toughness

Impact:

Together with research partners Materials Center Leoben, Montanuniversitaet Leoben and voestalpine Stahl Donawitz GmbH, pewag austria GmbH has been able to acquire a detailed understanding of the factors influencing the strength and fracture toughness of high-performance chains, successfully apply this knowledge to improve product characteristics and become a leading supplier in the top quality sector.

The results have also played a part in making the pewag Group a leading manufacturer and global player in the field of high-performance and specialised chains, such as hoist chains and tyre protection chains for use in extreme conditions.

Lightweight and safe through damage tolerant design

'Fitness for purpose' of structural parts and components

What may sound like a health programme in fact denotes the technical usability of components, which represents a key area of research at the Materials Center Leoben. The background: increasing pressure to achieve higher material and energy efficiency across all sectors requires the design of ever lighter structural parts using fewer materials.

This can be achieved through various measures::

- the use of stronger materials,
- the use of lighter materials with a high level of strength,
- improved design and
- optimised production and targeted optimisation of material properties in highly stressed component areas

Materials today are being utilised to their fullest possible potential, pushing them ever closer to their limits. Efficient design can only be achieved without compromising safety if the materials and their properties are well understood and can be exactly described.

The challenge of small defects

One particular challenge is that materials are generally not entirely free from defects and it is not possible to detect all defects, even with state-of-the-art inspection methods. We must therefore assume that all materials and components contain minor unidentified defects which, however, must not lead to failure. These defects are often just pores or tiny cracks which may form the starting point for fatigue cracks in service.

Damage caused by material fatigue is often the result of cyclic stress. Slow crack formation starting with small internal defects is decisive for the lifespan and failure probability of the component. The term 'damage-tolerant design' denotes that these internal defects do not lead to failure during the component's life cycle.

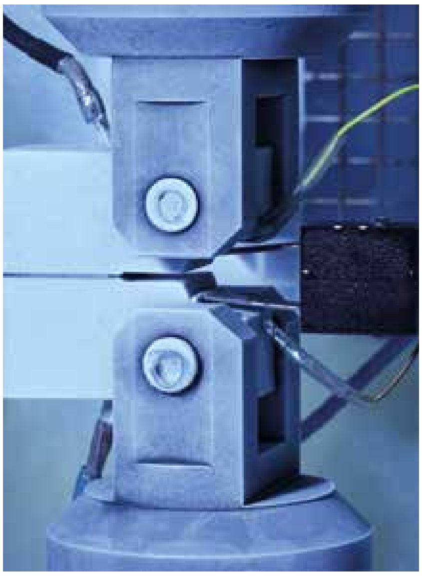
The Materials Center Leoben is undertaking extensive research into the formation of small cracks. Small cracks behave differently to longer cracks and in particular grow more quickly. Sophisticated experimental methods and new calculation methods are required to characterise the behaviour of small cracks and crack development.

Software to calculate the behaviour of small cracks under fatigue stress

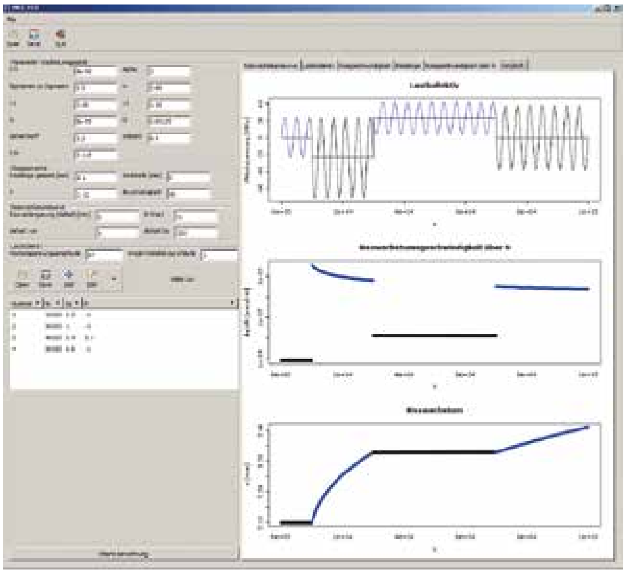
MCL has developed its own software to simulate the behaviour of small cracks. This software can be used to calculate the anticipated lifespan and service intervals of components containing small cracks or components where small cracks must be assumed due to the detection limits of the non-destructive testing methods applied.

By combining simulations of small crack formation with fracture mechanical calculations and critical material parameters (e.g. fracture toughness), the lifespan of components can be predicted much more accurately than was previously possible.

The available experimental and numerical methods now allow MCL to make components 'fit for purpose'.



Fracture mechanical test at low temperatures



MCL software for the description of small crack growth including calculation example

Impact

The new experimental methods and crack formation models are already being used in the first projects. The key applications include concepts for damage tolerant design and establishing inspection intervals for high-stress components in common rail systems, electric generators and railways.

RESEARCH PROGRAMME
COMET K2 MPPE

Highlights

Enhancing the reliability of miniaturised microelectronic components

Advances in microelectronics

Technical devices are getting smaller, while requirements in terms of reliability and function are on the increase. This is presenting developers with more and more new challenges. Microelectronic devices have an impact on virtually all areas of life: they make everyday household tasks easier and enable communication and networking across the world, they control facilities and supply systems for power, oil, gas and water; support car, train and air travel and enable the most complex calculations.

A hidden interior

Microelectronic components always consist of a mix of different materials. And they are getting ever smaller in order to increase performance. One particular challenge for researchers is to characterise the many materials used in miniaturised microelectronic components.

In cooperation with its research partners, MCL is thus developing efficient methods for measuring the structure and properties of materials in very small dimensions.

The focus is on the structure, mechanical and electrical properties and residual stress. Geometric, mechanical and electrical properties of materials and specimens can be determined in the nanometre and micrometre range. The specimen thickness is often less than a tenth of the thickness of a human hair.

Limits of miniaturisation

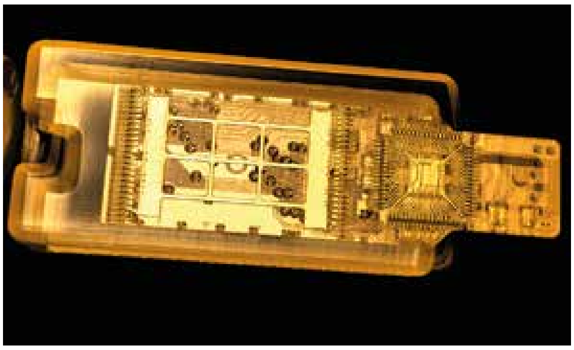
The increasing miniaturisation is naturally raising new issues for developers. One example: many electronic components change when subjected to electric or thermal loads in service. In addition to changes in the material, cracks pose a particular problem because they form and grow when subjected to fluctuating temperatures. Mechanical failure caused by cracks is therefore a key cause of failure in technical devices. MCL has comprehensive expertise to investigate the behaviour of cracks in inhomogeneous materials.

12

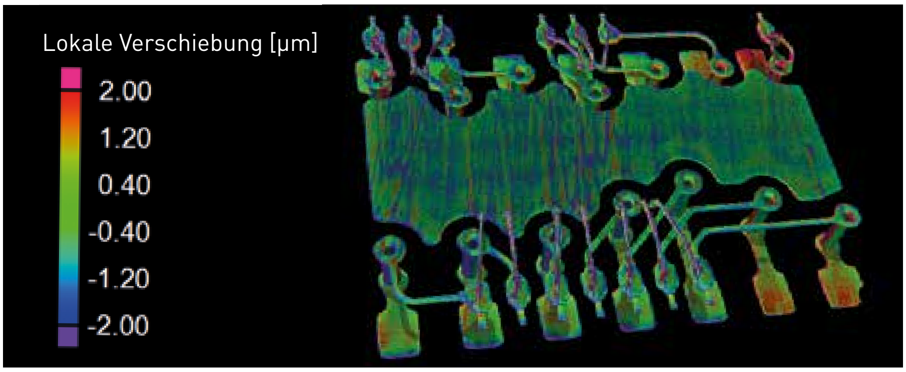
Three dimensional

Last year, MCL invested in state-of-the-art equipment for the characterisation of the three-dimensional structure and damage behaviour of microelectronic components. One of these technical achievements is an acoustic microscope for analysing delamination in electronic components. The new CT scanner enables the analysis of three-dimensional structures with a resolution of up to 0.3 micrometres. The results achieved can be used to detect defects and develop three-dimensional models for finite element calculations.

Delamination (shown in red) in the contact area of a credit card under mechanical stress



CT scan of an USB stick

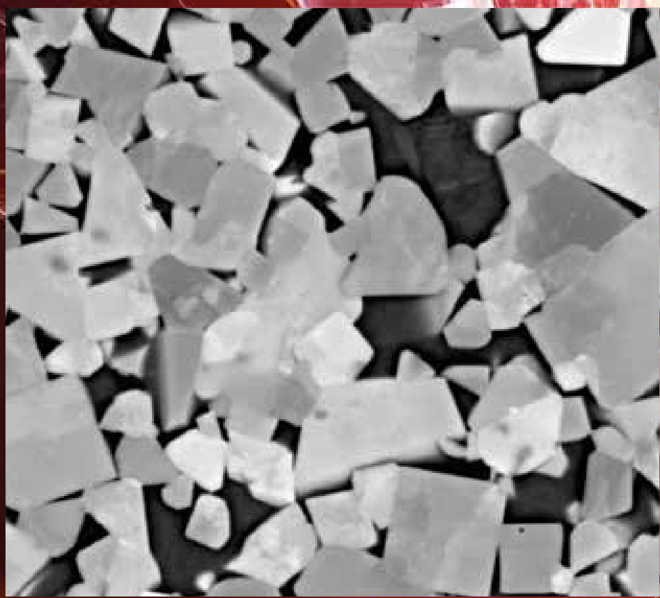


Geometrical changes as a result of thermal cycling determined by in-situ tests (at room temperature and at 150°C)

Impact

The new infrastructure is being used for the development of new analysis methods. The first methods have already been successfully applied in R&D projects and are helping MCL and its partners to gain a detailed understanding of damage processes in microelectronic components. The development of expertise in this area has already led to several EU projects.

INTELLECTUAL CAPITAL REPORT



Intellectual Capital Report

I. Scope, Goals and Strategies

The intellectual capital report has been an integral part of the MCL annual report since 2008. It is modelled on intellectual capital reports for universities and provides an overview of MCL's human, structural and relational assets. Knowledge and expertise are the key factors for the sustainable success of research institutions. The most informative indicators in this context are scientific publications, infrastructure facilities and international networks. Other important factors are output and impact, which are reflected in the number of completed projects or successful innovations in the partner companies.
While the intellectual capital report was just a short chapter in the 2008 Annual Report at the beginning of COMET Phase I, it has gradually expanded in pace with growing research activities. The key achievements of the past five years can be summarised as follows:

- Increase in staff from 60 to 150 employees, including 11 Key Scientists
- Participation of 49 scientific partners and 94 company partners in the COMET Programme
- 53 completed and 43 ongoing COMET research projects
- 36 completed and 54 ongoing doctoral theses, 45 completed and 8 ongoing diploma and master's theses
- 18 awards for scientific work
- 1,035 publications and presentations
- Involvement in 3 patents
- Expansion of research facilities in the following areas: testing of mechanical properties at low and high temperatures, scanning electron microscopy, high-temperature laser scanning confocal microscopy, computed tomography and acoustic microscopy

II. Intellectual Capital

A) Staff

Staff numbers have grown from 126 employees in 2011 to 150 in the reporting year due to a marked rise in the project volume.

This increase has primarily been in qualified scientific staff and junior scientists. We have been able to strengthen and expand the following areas:

- 2 key scientists, researchers with a proven international track record
- 5 senior scientists, experienced researchers with the ability to actively develop specific subject areas
- 15 junior scientists, young researchers currently in training (e.g. students working on their degree theses)

MCL takes the subject of gender very seriously. The proportion of women was 23% in 2012. Female employees at MCL enjoy the same working conditions as their male colleagues. In addition, we offer childcare support and help women returning to work after maternity leave by means of flexible working models. MCL is increasing its efforts to further raise the proportion of female staff members in general, and female doctoral students in particular.

Some further 600 employees of our company and scientific partners are working on projects in the COMET Programme. With a total of around 750 staff, the COMET Programme offers enormous potential for taking on highly complex scientific challenges.

Personnel at MCL/MPPE 2012

as of: 31/12/2012

	Employees		
	male	female	total
Research	**107**	**24**	**131**
Competence Centre Management	1		1
Key scientist	10	1	11
Senior scientists	17	6	23
Junior scientists	79	17	96
Administration	**1**	**8**	**9**
Technicians / Skilled staff	**8**	**2**	**10**
Total MCL	**116**	**34**	**150**

Personnel at COMET Partners

	male	female	total
Company partners	385	36	421
Scientific partners	154	26	180
Total MCL	**539**	**62**	**601**

1. Special research equipment

MCL has established extensive laboratory equipment for its areas of research over the past few years. The infrastructure now available covers the fields of metallography, microscopy, physical/chemical and thermal analysis, mechanical testing, heat treatment and tribology.

The research infrastructure is now being expanded to include instruments for the new area of microelectronics. The investment focus in 2012 was on the characterisation of microelectronic components using computed tomography and acoustic microscopy. These two instruments also allow in-situ loading tests to be carried out on electronic components.

The mechanical testing laboratory was expanded to include an electrodynamic testing system.

These investments in efficient state-of-the-art facilities are designed to put MCL in a position to carry out challenging research projects and provide high-quality services.

Component analysis using the new CT scanner

2. Relational capital

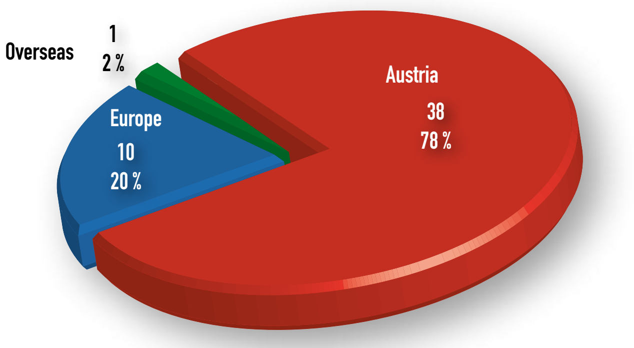
COMET scientific partners

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 49 scientific partners from 28 research institutions and universities were involved in COMET Phase I:

- Aalto University, Department of Materials Science and Engineering
- Academy of Science of the Czech Republic, Institute of Physics of Materials
- ARMINES, Centre des Matériaux, Mines Paris, Paristech
- Austrian Academy of Sciences, Erich Schmid Institute for Materials Science
- Bay Zoltan Foundation of Applied Research
- Centre National de la Recherche Scientifique (CNRS), Orléans
- Ecole Nationale Supérieure de Céramique Industrielle (ENSCI), Groupe d'Étude des Matériaux Hétérogènes (GEMH), Limoges
- Forschungszentrum Karlsruhe GmbH
- Hungarian Academy of Science, Research Institute for Solid State Physics and Optics
- Graz University of Technology, Institute of Materials Science and Welding
- JOANNEUM RESEARCH Forschungsgesellschaft m.b.H, Laser Centre Leoben
- University of Graz, Institute of Physics
- Laboratoire Matériaux Endommagement Fiabilité Ingénierie des Procédés (LAMEFIP)
- Ecole National Supérieure d'Arts et Métiers (ENSAM), Cedex
- LKR Leichtmetallkompetenzzentrum Ranshofen GmbH
- Max Planck Institute of Colloids and Interfaces
- Montanuniversitaet Leoben
  - Chair of Nonferrous Metallurgy
  - Institute of Mechanics
  - Institute of Physics
  - Institute of Structural and Functional Ceramics
  - Chair of General and Analytical Chemistry
  - Chair of Mechanical Engineering
  - Chair of Atomistic Modelling and Design of Materials
  - Chair of Ceramics
  - Chair of Casting Research
  - Chair of Functional Materials and Materials Systems
  - Chair of Material Physics
  - Chair of Physical Metallurgy and Materials Testing
  - Chair of Metallurgy
  - Chair of Simulation and Modelling of Metallurgical Processes
  - Chair of Physical Chemistry
  - Chair of Metal Forming
  - Chair of Economic and Business Management
  - Chair of Materials Science and Testing of Plastics
  - Chair of Subsurface Engineering
- Polymer Competence Center Leoben (PCCL)

- Polish Academy of Sciences, Institute of Metallurgy and Materials Science
- Slovak Academy of Sciences
  - Institute of Physics
  - Institute of Inorganic Chemistry
- Vienna University of Technology
  - Institute of Chemical Technologies and Analytics
  - Institute of Lightweight Design and Structural Biomechanics
  - Institute of Materials Science and Technology
- University of Vienna, Research Group Physics of Nanostructured Materials
- Université d'Orléans, PRISME Laboratoire de Mécanique des Systèmes et des Procédés
- KTH Royal Institute of Technology, Department of Materials Physics, Sweden
- University of Maribor, Faculty of Mechanical Engineering
- University of Wollongong, Australia
- Austrian Foundry Research Institute
- HTL Innsbruck, Testing Laboratory for Mechanical Engineering

COMET Scientific Partners



Number and origin of scientific partners

COMET company partners

In 2012 another 11 industrial enterprises joined the COMET Programme and 24 companies ended their participation as at 31 December 2012. The majority of them are smaller companies which are not able to sustain research projects in a specific field for an extended period of time. A total of 94 companies were involved in COMET Phase I (from 2008 to 2012):

AMAG rolling GmbH

AMSC Windtec GmbH

Andritz AG

Andritz Hydro GmbH

AT&S Austria Technologie & Systemtechnik Aktiengesellschaft

Böhler Edelstahl GmbH & Co KG

BHDT GmbH

Böhler Schmiedetechnik GmbH & CoKG

Böhler Schweißtechnik Austria GmbH

Böhler Uddeholm AG /Voestalpine Edelstahl GmbH

Ceratizit Austria Gesellschaft mbH

Eisenwerk Sulzau-Werfen R. & E. Weinberger AG

Epcos OHG

GFM GmbH

Ingenieurbüro Fiedler GmbH

Komptech Umwelttechnik GmbH

Konrad Forsttechnik GmbH

Krenhof AG

MAGNA Powertrain AG & Co KG

(MCE) Industrietechnik Linz GmbH & CoKG/ BIS VAM Anlagentechnik GmbH

MIBA Gleitlager GmbH

Miba Sinter Austria GmbH

ÖBB Infrastruktur Aktiengesellschaft

Oerlikon Balzers Coating Austria GmbH

OMV Exploration Production GmbH

OMV Gas GmbH

Palfinger Service- u. Beteilungs-GmbH

Panasonic Industrial Devices Materials Europe GmbH

Pankl Racing Systems AG

PEWAG Austria GmbH

Plansee SE

RHI AG

Rohöl-Aufsuchungs Aktiengesellschaft

Rübig GmbH & Co KG

Sandvik Mining and Construction GmbH

Schoeller-Bleckmann Oilfield Technology Ges.m.b.H

Schoeller-Bleckmann Edelstahlrohr GmbH

Siemens Aktiengesellschaft Österreich

Siemens VAI Metals Technologies GmbH & Co

SKF Österreich Aktiengesellschaft

Stahl Judenburg GmbH

Styria Federn Ges.m.b.H.

TCM International Tool Consulting & Management GmbH

Technisches Büro für Maschinenbau

TIWAG Tiroler Wasserkraft AG

Treibacher Industrie AG

VAE GmbH

voestalpine Austria Draht GmbH

voestalpine Grobblech GmbH

voestalpine Krems GmbH

voestalpine Rotec GmbH

voestalpine Schienen GmbH

voestalpine Stahl Donawitz GmbH & CoKG

voestalpine Stahl GmbH

voestalpine Tubulars GmbH Co KG

W&H Dentalwerk Bürmoos GmbH

Wuppermann Engineering GesmbH

FIRE - Federation for International Refractory Research and Education

Pyrotek High-Temperature Industrial Products Inc

Rio Tinto Alcan International Limited

Agie Charmilles

Fritz Schiess AG

Sucotec AG

W. Blösch AG

Georg Fischer Automotive AG

ALMATIS GmbH

Böhler Schweißtechnik Deutschland GmbH

Bruker AXS Analytical X-ray Systems GmbH

Buderus Edelstahl GmbH

Ceratizit Deutschland GmbH

Continental Automotive GmbH (former VDO Automotive AG)

TDK-EPC AG&Co.KG (früher Ernst Herrmann Ing. AG & Co KG)

Europipe GmbH

Faively Transport Witten GmbH

Hegenscheid-MFT GmbH & CO KG

HPTec GmbH

Incoatec GmbH

INMATEC Technologies GmbH

MAN Nutzfahrzeuge Aktiengesellschaft

PPS Pipeline Systems GmbH

Robert Bosch GmbH

SHW Casting Technologies GmbH

SVS Vacuum Coating Technologies GmbH

Kerneos SA

Rio Tinto Alcan

SAS Calderys France

Thales Corporate Services

Valourec Group

TAG s.r.l.

Hilti Aktiengesellschaft

ThyssenKrupp Presta AG

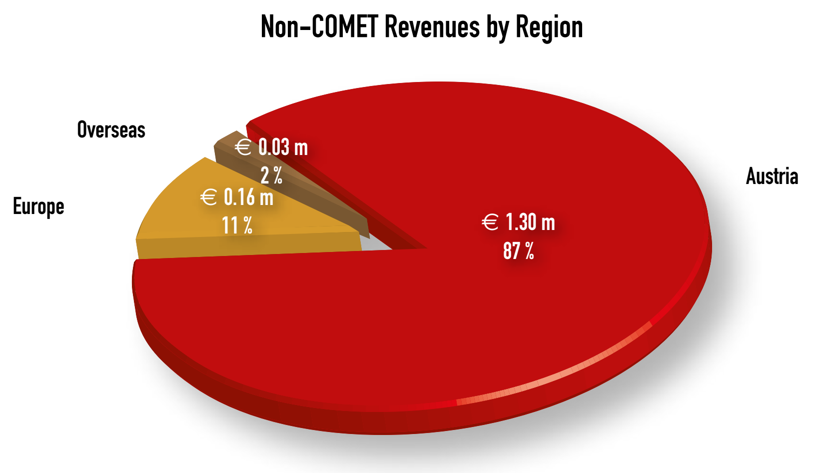
Ceratizit Luxembourg S.a.r.l.

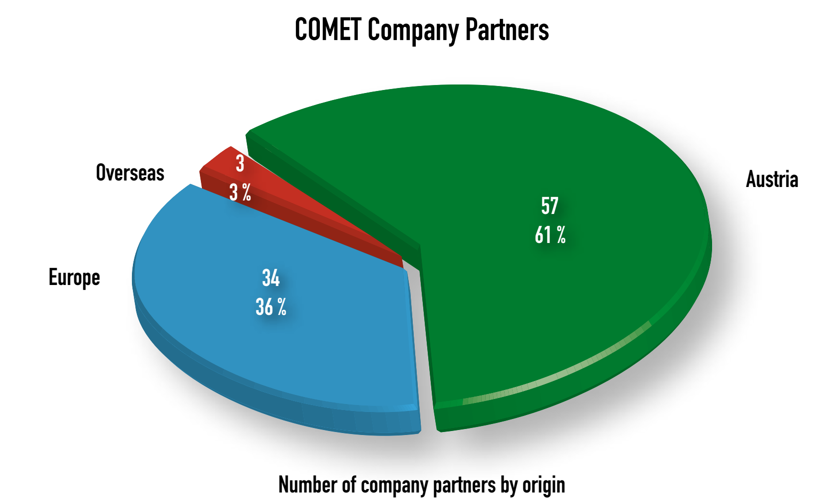
Tata Steel IJmuiden B.V.

Infineum International Limited

Company partners in the non-COMET area

In the non-COMET area, which includes funded projects outside the COMET programme as well as laboratory, computational and advisory services, MCL has a comprehensive customer base of more than 100 companies, which is growing annually. Contract and project volumes for conducting specific analyses or research projects range from several hundred to several hundred thousand euros.





III. Core Processes

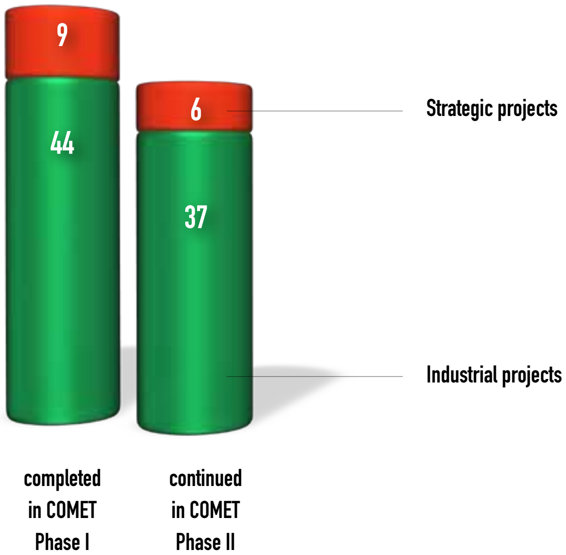
A) Research and development

A total of 53 projects were successfully completed in the period from 2008 to 2012. Some of these projects were started in the Kplus period prior to 2008 and were then continued in the COMET Programme. The 53 projects are divided into 9 strategic and 44 industrial projects.

Another 43 projects – 6 strategic projects and 37 industrial projects – will be continued and completed in COMET Phase II, thus ensuring a smooth transition from COMET Phase I to COMET Phase II

The overall project volume in COMET Phase I was € 48.3 million.

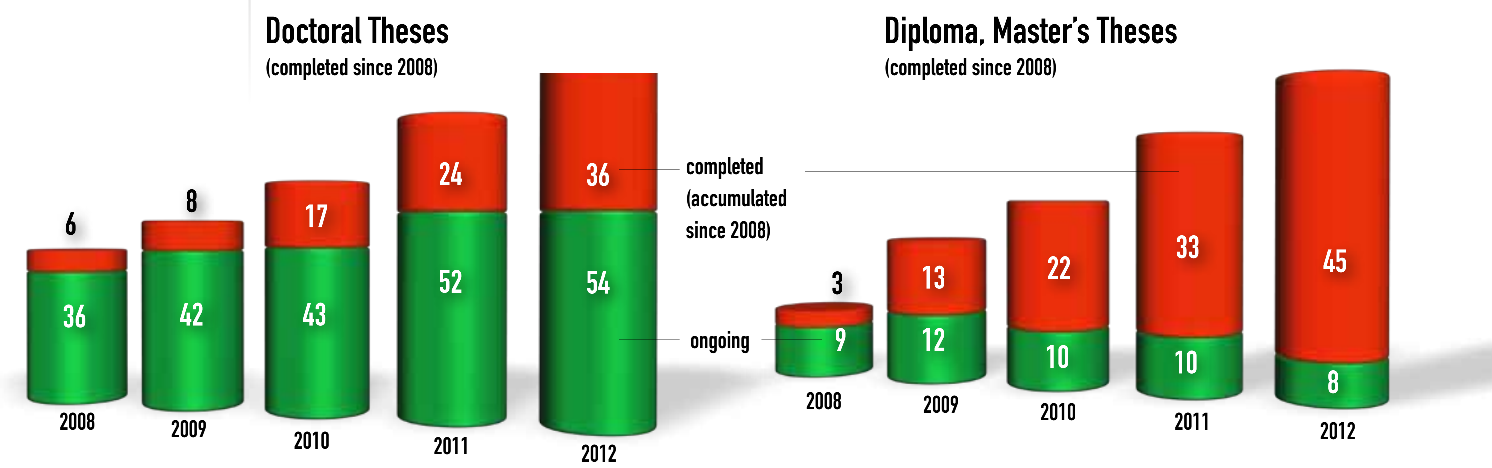
Number of Research Projects



A total of 6 publicly funded non-COMET projects were completed in Phase I; another 4 projects will be continued in Phase II and are scheduled for completion by 2015. In addition, 4 smaller participations in international projects (EU projects) were completed and another project will run until 2014.

B) Doctoral, diploma/master's theses

A total of 90 doctoral theses and 53 diploma and master's theses were carried out and partially completed in COMET Phase I. The competence centre thus makes an indispensable contribution to the education of young scientists and ensures that industry and academia can draw on highly qualified staff with application oriented expertise.



The competence centre has succeeded in further increasing the number of doctoral and diploma/master's theses. A total of 54 doctoral theses are currently being carried out and will be completed in COMET Phase II.

2012 also saw an increase in the number of student employees, who thus gain early insight into current research topics and often write their diploma or doctoral thesis at MCL.

Qualification measures

Some 42 training courses were carried out for MCL employees in the course of 2012, which is 14 more than in the previous year. This figure does not include participation in workshops or congresses or obligatory lectures attended as part of doctoral theses. As research projects become ever larger and more complex, a special focus in 2012 was on completing the training and qualification measures in project management. It is planned to compile a Project Management Manual in 2013, which is designed to support MCL staff in the practical implementation of the knowledge acquired in the training courses.

MCL employees also provide training and education for others. This includes practical training as well as lectures, tutorials and exercises at universities, universities of applied sciences and secondary technical colleges (HTL).

IV. Output & Impact

A) Awards and highlights

1. Awards for MCL/MPPE researchers

DI Florian Summer received the Johann Puch Award for Excellence in Automotive Engineering 2011

MAGNA STEYR has initiated a diploma thesis competition in commemoration of the famous Austrian automotive pioneer Johann Puch. The main goal of the Johann Puch Award for Excellence in Automotive Engineering is to promote young, scientifically and technically talented students in the area of automotive engineering. Eligible are all students of the Universities of Technology in Vienna and Graz, Montanuniversitaet Leoben, Johannes Kepler University Linz, University of Applied Sciences FH Joanneum in Graz as well as the University of Maribor in Slovenia, the Universities of Györ and Miskolc in Hungary, and the Slovak University of Technology in Bratislava.

Tribology of lubricated sliding systems

The winner of the Johann Puch Award for Excellence in Automotive Engineering 2011 is DI Florian Summer from Leoben. His diploma thesis focused on investigating the performance and functionality of aluminium-based tribological systems using tribometric modelling. Tribology seeks to scientifically describe processes of friction, wear and lubrication and to develop technologies for optimised friction processes. The tribological systems investigated are primarily applied in engine technology and the sliding components involved. The tribometric analysis was followed by a comprehensive damage analysis, which provided the basis for developing functional models of selected materials and their sliding systems. These models provide valuable information for optimising the materials for tribological service conditions and the functional design of sliding components. The diploma thesis was carried out as part of a COMET K2 project at the Chair of Mechanical Engineering of Montanuniversitaet Leoben and sponsored by the Styrian Regional Government and the Austrian Research Promotion Agency.

DI Florian Summer won 1st prize at the Johann Puch Awards

Dr. Martin Pletz received Styrian Research Prize for Simulation and Modelling

The young Leoben scientist Dr. Martin Pletz received the Styrian Research Prize for Simulation and Modelling in the category "Industrial Applications" on 20 November 2012. The awards were presented at Montanuniversitaet Leoben by Regional Minister Mag. Kristina Edlinger-Ploder.

Dr. Pletz joined MCL in 2007 where he completed his diploma and doctoral theses and is now working as a postdoc. He received the award for his diploma thesis entitled "Theoretical Investigation of the Embedding of Ceramic Components into Printed Circuit Boards (PCBs)", which he wrote at the Chair of Polymer Processing of Montanuniversitaet Leoben. He carried out his research as part of a COMET K2 project together with industrial partner AT&S and with the support of the Institute for Structural and Functional Ceramics.

The electronic components of electrical devices are mounted on printed circuit boards (PCBs). Scientists seek to enhance functionality and miniaturisation by embedding these components inside the PCBs. The embedding process, however, leads to strong mechanical stresses, which may destroy the brittle ceramic parts. In his prize-winning thesis Martin Pletz simulated the key steps involved in the integration of ceramic components into PCBs (pressing, curing of the resin and subsequent cooling) using physical/mathematical models and determined the mechanical stresses acting on the components. The simulations allowed him to determine the decisive influencing parameters for these stresses and to develop guidelines for the design of the new PCBs. His research helped industrial partner AT&S to become the first PCB manufacturer which successfully implemented the process of embedding ceramic components into PCBs using galvanic contacts in large-scale production. The company also received the Styrian Fast Forward Award 2011 for this new Embedded Component Packaging (ECP) technology. The printed circuit boards produced using the ECP technology can be applied in devices of smaller size, higher efficiency and increased performance such as smartphones, digital cameras, notebooks, hearing aids, etc. ECP also allows the realisation of 3D advanced packaging concepts and thus the production of high-performance modules and transistors.

Prize winner Dr. Martin Pletz, Regional Minister Mag. Kristina Edlinger-Ploder, o.Univ.-Prof. Dr. Robert Danzer (Institute for Structural and Functional Ceramics)

Styrian Sponsorship Award 2012 for Dr. Roland Brunner

Leoben physicist Dr. Roland Brunner (Institute of Physics at Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH) received the Styrian Sponsorship Award 2012 for his publication "Two-Qubit Gate of Combined Single-Spin Rotation and Interdot Spin Exchange in a Double Quantum Dot".

"This publication shows for the first time that logical operations can be carried out not only with one electron spin qubit but also by two coupled qubits. This is of special significance for the computing power of computers because quantum computers can solve problems that would take conventional computers years to complete", said the jury in its decision.

During the prize ceremony at Graz Castle on 7 December 2012, Regional Science Minister Mag. Kristina Edlinger-Ploder congratulated the winners: "Scientists have to do more than just increase their knowledge. They are also tasked with conveying this knowledge to society in an understandable manner. After all, science and research account for two thirds of our wealth. This fact has not yet fully reached public awareness," Edlinger-Ploder said.

Dr. Roland Brunner

Dr. Michael Fischlschweiger wins Award of Excellence of the Federal Ministry of Science and Research

The Federal Ministry of Science and Research has presented the 'Award of Excellence' for exceptional doctoral theses completed at Austrian universities since 2008. The prize honours the achievements of young scientists and aims to increase public awareness of their work. 37 PhD graduates from across Austria who graduated during the 2011/12 academic year received the 'Award of Excellence' and prize money of € 2,500.

Dr. Michael Fischlschweiger from Montanuniversitaet Leoben received the award for his doctoral thesis entitled 'Modeling strategies for structural phase transformation in shape memory alloys and steels'. The prize was presented on 12 December 2012 by the Federal Minister for Science and Research, o.Univ.-Prof. Dr. Karlheinz Töchterle. "The level and scientific depth of the research is very impressive. I am very pleased with the high quality of scientific work conducted at our universities so that the organisers can nominate a number of high calibre theses for the prize each year," the Science Minister said.

Dr. Fischlschweiger completed his studies in Polymer Engineering and Science at Montanuniversitaet Leoben in September 2009 and received his PhD in 2012. He worked at MCL as a student staff member and doctoral student from November 2008 to July 2012. The doctoral thesis was carried out as part of the strategic COMET K2 project "A1.5 Martensite – Fundamentals and Constitutive Equations".

Dr. Michael Fischlschweiger

2. Highlights

Improved rail capacity

Freight trains are transporting ever heavier loads and an increasing number of people are travelling by high speed train. This places rails and crossings under greater strain and poses new challenges for developers. Thanks to research carried out by MCL these products can now be designed with greater capacity and optimum durability allowing them to cope with increasing loads.

The combined rolling/sliding action of a train wheel on rails or crossings, known as rolling contact, concentrates loads of over a tonne on an area no bigger than a coin. This makes extremely complex demands on the materials used. It results in wear and fatigue, especially from stresses such as braking, accelerating and dynamic loads. Using a complete multiscale 3D model of a wheel passing a crossing nose, MCL succeeded in describing the wheel/rail system adequately and was thus able to further develop crossings and rails together with industrial partner voestalpine. The complex 3D model considers the full dynamic load and depicts both macroscopic plastic deformation as well as processes at the level of microscopic surface roughness. This area of development work focuses on contact geometry, local material deformation and heat input.

High-performance rails and crossings
©voestalpine VAE GmbH

Lightweight design for high speed trains

High speed trains reach speeds of up to 360 km/h in normal operation. Despite the resulting extreme conditions, the aim is to keep the trains' weight down to a minimum. This makes lightweight design an important factor, especially for bogies. These highly stressed components are developed and produced by Siemens Mobility in Graz, which is working on reducing their weight in joint research projects with MCL.

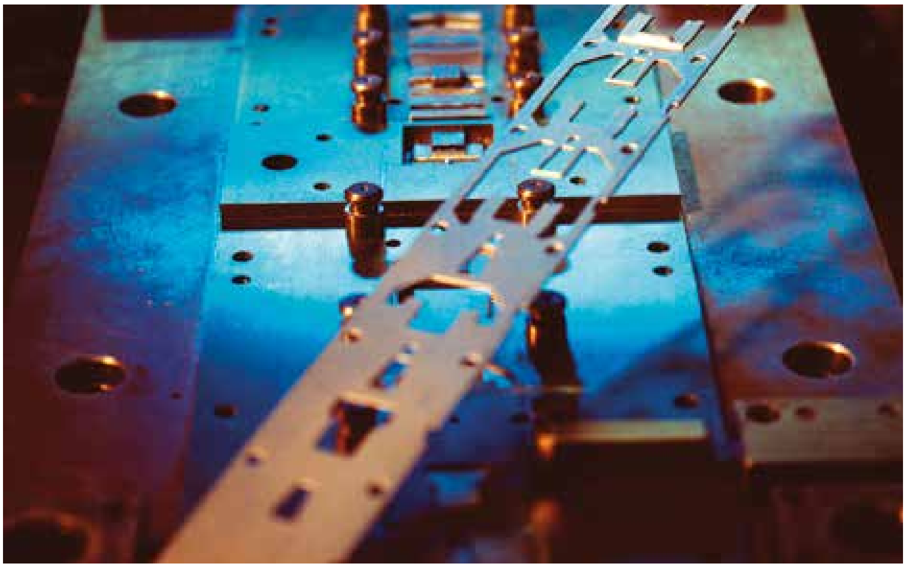
The brakes of high speed trains are subjected to considerable mechanical and thermal loads. Brake disk deformation, microstructural changes and damage caused during emergency braking were studied at MCL using experimental analysis, numerical modelling and simulation. Realistic simulation requires appropriate material models and reliable calculated material parameters. The weight of brake disks can be optimised, above all, through intelligent choice of materials, structural design and improved braking cycles.

Train wheelset axles are manufactured from high-strength materials to improve load-bearing capacity without increasing weight. MCL's work in this area involves processes for strain hardening the surface of wheelset axles. Stone impact on wheelset axles is also considered as the suction wave generated as trains travel at high speeds causes ballast to be ripped up from the track bed. This stone impact occurs with great force and may damage these safety-critical components. The researchers at Leoben apply fracture mechanical concepts in the design of wheelset axles or bogie frames to increase load-bearing capacity while at the same time reducing weight.

High-speed train
© Siemens AG

Powerful tools for automotive engineering

Cars are becoming increasingly safe and injuries to occupants and pedestrians following road traffic accidents are less serious than in the past. This trend is due in part to new high-strength steels which allow continual improvements in bodyshell construction. However, the high-strength steel sheets required present fresh challenges for the tools employed in automotive engineering. In order to improve the durability of these costly tools, the Materials Center Leoben has developed a novel method of determining the damage mechanisms involved. Armed with this information, industrial partner Böhler Edelstahl is able to develop innovative new tool steels which can cope with ever more rigorous demands. The project involved the simulation of the cutting edges of stamping tools subject to high stress in order to examine plastic deformation and damage to these edges. At the same time an edge crush test was developed to reproduce the complex load applied to the tool and to examine the suitability of new steels for use in cutting tools.



Tool steel for the production of high-performance stamping tools
© Böhler Edelstahl GmbH & Co KG

Expertise for great depths

In tunnelling projects and in various types of mines, machines operate under the harshest of conditions at depths of up to 3000 m below ground. The stability of headers and production machinery and their cutting tools is extremely important here. The cutting tools have to drive through extremely hard rock and yet preferably undergo minimal wear in the process. One of the developers and manufacturers of these selective roadheaders is Sandvik Mining and Construction GmbH in Zeltweg. The machines are deployed around the globe in tunnelling and mining - from coal mines in eastern Europe and China through rock salt and potash mines in Canada and Spain and gold mines in South Africa to diamond mines in Siberia. Together with research partners the Materials Center Leoben undertook a research project focussing on the experimental and numerical analysis of rock cutting and tool stress. Above all, the researchers at Leoben were able to contribute their extensive expertise in materials modelling and adapt it to rock. The simulation of rock cutting enhances the understanding of the whole cutting process and enables the investigation of the relationships between cutting forces, cutting geometry and process parameters.

Tunnelling roadheader
© Sandvik Mining and Construction GmbH

Smaller engines require high tech materials

There are constant calls for the automotive industry to reduce fuel consumption and CO2 emissions. Engine downsizing is making a significant contribution towards this goal. Optimised engine acoustics is also becoming an increasingly important part of vehicle development. However the components required for optimising the camshaft and balancer shaft present vehicle developers with particular challenges. Indeed engine downsizing generally leads to significantly higher stress and strain as the engine not only has to be smaller but also lighter. This is where sintered parts reveal their technological virtues in terms of weight and noise level, making them extremely attractive components in engine and drive design. MCL developed a simulation model for Miba AG, enabling robust production processes for sintered parts to be realised for the first time. The resulting parts exhibit steel-like qualities and the perfect blend of material density and resilience.

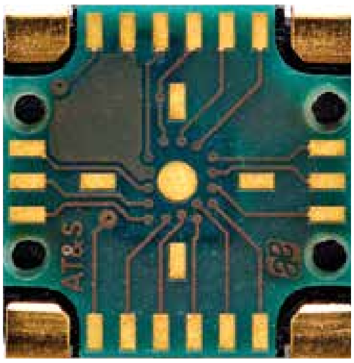
Powder metallurgically produced components
© MIBA AG

Integrating components in circuit boards and electronic devices

Smartphones and many other electronic devices are offering ever more features and are becoming increasingly powerful. The on-going miniaturisation and growing complexity of microelectronic components means that a wide variety of materials such as metals, ceramics and composites are combined in increasingly small spaces and in increasingly thin layers. A significant new advance in miniaturisation is the integration of electronic components inside circuit boards.

One of the largest producers of circuit boards, Leoben-based AT&S Austria Technologie & Systemtechnik AG, draws heavily on the expertise of MCL in the form of research projects. AT&S products are used in virtually all smartphones and tablets. Its recently introduced ECP® (Embedded Component Packaging) technology now makes AT&S one of the leaders in this field.

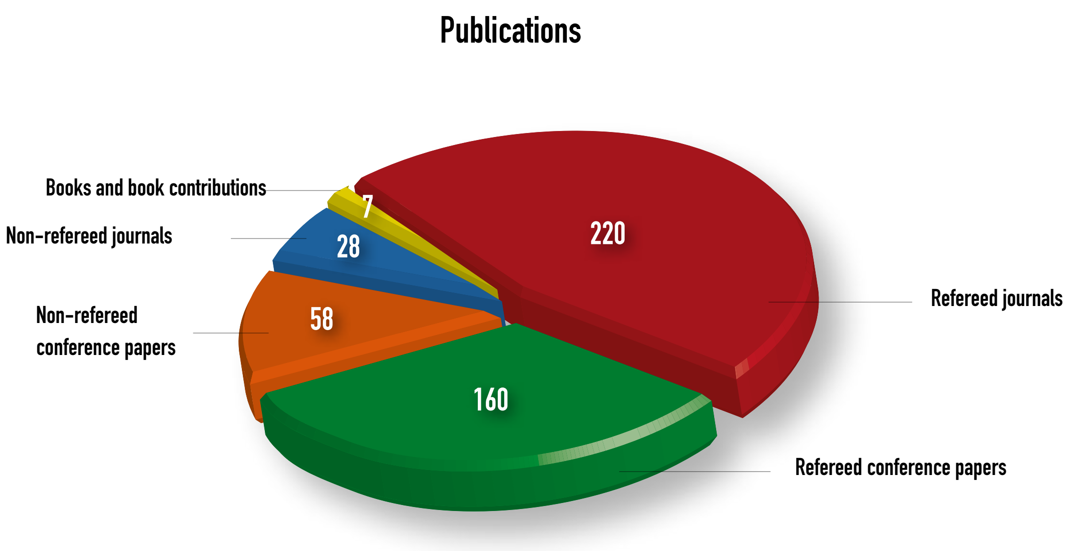
MCL was responsible for developing the important groundwork for introducing this technology.



Component produced using ECP® technology
© AT&S Austria Technologie & Systemtechnik Aktiengesellschaft

B) Publications and presentations

The end of COMET Phase I in 2012 gives us the opportunity to present an overview of the publications and presentations that resulted from this period. The publications include a total of 220 papers in refereed journals, 7 book contributions, 28 articles in non-refereed journals and 218 conference papers - this large number reflects the great scientific expertise of our staff.



Number of publications from 2008 to 2012

C) Final degrees

The following doctoral and diploma theses were completed in 2012:

Doctoral theses:

Böck Barbara
Optimierung der Herstellung lasergeschweißter Fülldrahte für das Schweißen hochfester Stähle, Montanuniversität Leoben, October 2012

Christiner Thomas
Betriebsfestigkeitsmodell von Bauteilen unter komplexen Beanspruchungen, Montanuniversität Leoben, May 2012

Figala Gerald
Ausgewählte fertigungstechnische Methoden zur Verbesserung des Stabilitätsverhaltens von Rechteckplatten, Montanuniversität Leoben, May 2012

Fischlschweiger Michael
Modeling strategies for structural phase transformations in shape memory alloys and steels, Montanuniversitaet Leoben / MINES ParisTech, April 2012

Krampl Herbert
Numerische und versuchstechnische Beurteilung geschmierter Kontakte inhomogener Werkstoffe, Montanuniversität Leoben, August 2012

Pletz Martin
Damage in Railway Crossings – Numerical Models, Montanuniversitaet Leoben, July 2012

Pondicherry Kartik Shanmugham
Study of Interactions between Lubricant Components and Tribomaterial Surfaces, Montanuniversitaet Leoben, October 2012

Schwaab Holger
Nichtlineare Modellierung von Ferroelektrika unter Berücksichtigung der elektrischen Leitfähigkeit, Karlsruhe Institute of Technology, April 2012

Trausmuth Andreas
Oberflächenermüdung von nitrierten, einsatz- und durchgehärteten Werkstoffen, Montanuniversität Leoben, May 2012

Wallner Stefan
Untersuchung der Einsatzmöglichkeiten des Radialschmiedens zur Herstellung rotationssymmetrischer Bauteile mittels Finiter-Elemente-Methoden,
Montanuniversität Leoben, May 2012

Zechner Johannes
Fracture & Fatigue of Inhomogeneous Materials,
Montanuniversitaet Leoben, December 2012

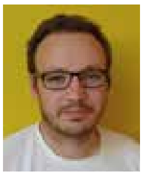
Diploma / Master's theses:

Adlmann Franz Alois
Untersuchungen der Thermoschockbelastungen an keramischen Kugeln und Balken mit künstlichen Defekten, Montanuniversität Leoben, June 2012

Gassner Martina
Synthese, Charakterisierung und Immobilisierung von Gold-Nanopartikeln auf photoreaktiven Polymeren, Graz University of Technology, April 2012

Gruber Marina
Mikrostruktur und mechanische Eigenschaften der AerMetR 100 Legierung, Montanuniversität Leoben, September 2012

Hasenhütl Eva
A finite element unit cell model describing transformation induced plasticity, Montanuniversität Leoben, September 2012



Katinger Martin
Versuche zur Ermittlung der Zugfestigkeit und der spezifischen Bruchenergie mittels einem neuartigen thermomechanischen Prüfverfahren, Montanuniversität Leoben, July 2012

Krautgasser Clemens
Bestimmung der Festigkeit einer LTCC Keramik in Abhängigkeit der Umgebungsbedingungen, Montanuniversität Leoben, June 2012

Kompatscher Arno
Phase transformations in Ni-Mn-Ga ferromagnetic shape memory alloys subjected to high pressure torsion, University of Vienna, July 2012

Prethaler Andreas
Untersuchung der Sauergasbeständigkeit geschweißter Pipeline Stähle, Montanuniversität Leoben, December 2012

Rohr Jürgen
Akustische Detektion von Erstschädigung in Siliziumnitrid, Montanuniversität Leoben, January 2012

Schemmel Manuel
2D-Modellierung von thermomechanischen Ermüdungsvorgängen in Hochleistungsbremsscheiben für Bahnsysteme, Montanuniversität Leoben, September 2012

Stanojevic Aleksandar
Automatisierte Parameterermittlung von thermo-mechanisch beanspruchten Proben, Montanuniversität Leoben, March 2012

Strickner Georg
EEntwicklung eines Simulationsmodells zum Pilgerschrittwalzen, Montanuniversität Leoben, March 2012

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 23 COMET projects were successfully concluded in 2012.

A1.1: Numerical investigations on dendritic mushy zones; Böhler Edelstahl GmbH & Co KG, Siemens VAI Metals Technologies GmbH & Co, voestalpine Stahl GmbH, voestalpine Stahl Donawitz GmbH & CoKG, Hungarian Academy of Sciences, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A1.2: Simulation of horizontal centrifugal casting; Eisenwerk Sulzau-Werfen, R.&E. Weinberger Aktiengesellschaft, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A1.4: Combining solidification with deformation/forming and with heat treatment/ fatigue simulations; strategic project, Montanuniversitaet Leoben, Graz University of Technology, Materials Center Leoben Forschung GmbH

A1.5: Modelling and simulation of simultaneous diffusion and precipitation in heterogeneous materials during surface treatment; strategic project, Vienna University of Technology, Montanuniversitaet Leoben, Academy of Sciences of the Czech Republic, Materials Center Leoben Forschung GmbH

A2.3: Methods for interface engineering; strategic project, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A2.12: Development of new components for X-ray diffraction and a novel (GI)SAXS instrument; Bruker Analytical X-ray Systems GmbH, Incoatec GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A3.1: In-situ observation of metallurgical processes by means of high-temperature laser scanning confocal microscopy; voestalpine Stahl GmbH, voestalpine Stahl Donawitz GmbH & CoKG, Siemens VAI Metals Technologies GmbH, University of Wollongong, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A3.4: Optimierte Prozessrouten beim Radialschmieden und Untersuchung neuer Einsatzgebiete, Böhler Edelstahl GmbH & Co KG, GFM GmbH, voestalpine Rotec GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A3.10: Laser welded flux cored wires; Böhler Schweißtechnik Austria GmbH, voestalpine Krems GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A4.1: Characterisation of phase transformation and damage during the solidification of steel; Siemens VAI Metals Technologies GmbH & Co, voestalpine Stahl GmbH, Montanuniversitaet Leoben, Austrian Academy of Sciences, Austrian Foundry Institute - Association for Practical Foundry Research, Materials Center Leoben Forschung GmbH

A4.7: Mechanical testing of refractories; RHI AG, voestalpine Stahl GmbH, Pyrotek High-Temperature Industrial Products Inc., Montanuniversitaet Leoben, Groupe d'Étude des Matériaux Hétérogènes - ENSCI - Ecole Nationale Supérieure de Céramique Industrielle, Materials Center Leoben Forschung GmbH

A4.9: Simulation of the mechanical behavior of refractories; RHI AG, voestalpine Stahl GmbH, Pyrotek High-Temperature Industrial Products Inc., Montanuniversitaet Leoben; Université d'Orléans, Institut Pluridisciplinaire de Recherche en Ingénierie des Systèmes, Mécanique, Energétique (Institut PRISME), Polytech Orléans; Groupe d'Étude des Matériaux Hétérogènes, ENSCI - Ecole Nationale Supérieure de Céramique Industrielle; Materials Center Leoben Forschung GmbH

A4.11: Damage evolution – experiments and simulation from micro to macro scale; strategic project, Austrian Academy of Sciences, Montanuniversitaet Leoben, University of Maribor, Max Planck Institute of Colloids and Interfaces, Materials Center Leoben Forschung GmbH

A4.12: Numerical optimisation of wheel rail crossing interactions; voestalpine Schienen GmbH, VAE GmbH, Montanuniversitaet Leoben, Austrian Academy of Sciences, Materials Center Leoben Forschung GmbH

A5.1: Lebensdaueroptimierung von Gießwerkzeugen (Phase II); Georg Fischer Verwaltungs GmbH, Böhler Edelstahl GmbH & Co KG, Montanuniversitaet Leoben, Austrian Foundry Institute - Practical Foundry Research, Austrian Academy of Sciences, Materials Center Leoben Forschung GmbH

A5.2: Forming tools – analysis of loading condition, material behaviour and damage evolution of cold forging, warm forging, and punching tools; strategic project, Austrian Academy of Sciences, Montanuniversitaet Leoben, Centre des Matériaux P.M. Fourt (CNRS) - Ecole Nationale Supérieure des Mines de Paris (ENSMP), Graz University of Technology, Materials Center Leoben Forschung GmbH

A5.4: LCF- und Kurzrisswachstums-Verhalten von Werkzeugstählen für Kaltarbeitsapplikationen; Böhler Edelstahl GmbH & Co KG, HILTI AG, ThyssenKrupp Presta AG, Austrian Academy of Sciences, Materials Center Leoben Forschung GmbH

A5.6: Einfluss der Mikrostruktur auf das zyklische Werkstoffverhalten von WC-Co-Hartmetallen; Ceratizit Austria Gesellschaft mbH, AT&S AG, HPTec GmbH, Fritz Schiess AG, Austrian Academy of Sciences, Materials Center Leoben Forschung GmbH

A6.6: Methodenentwicklung zur Charakterisierung der Schwingfestigkeit von Schweißnahtenden hochfester Stähle; Siemens Aktiengesellschaft Österreich, Komptech Umwelttechnik GmbH, Konrad Forsttechnik GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A6.8: Advanced models and simulation methods for the assessment of mechanical engineering components subjected to fatigue and lubricated contact loading; strategic project, Ecole Nationale Supérieure d'Arts et Métiers, Montanuniversitaet Leoben, Austrian Academy of Sciences, Materials Center Leoben Forschung GmbH

A6.9: The influence of complex loadings on the fatigue behaviour of high-pressure components; BHDT GmbH, Oerlikon Balzers Coating Austria GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A6.11: Tribological boundary layers of journal bearing materials; Miba Gleitlager GmbH, Infineum International Ltd., Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A7.6: Re-oxidation kinetics of grain boundary regions in PTC ceramics; EPCOS OHG, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

The non-COMET projects "Nanocoat" (funded by FWF and FFG), "Atomat" and "Calculation of highly stressed pole fasteners for electric motor generators" (both funded by FFG) were also successfully concluded.

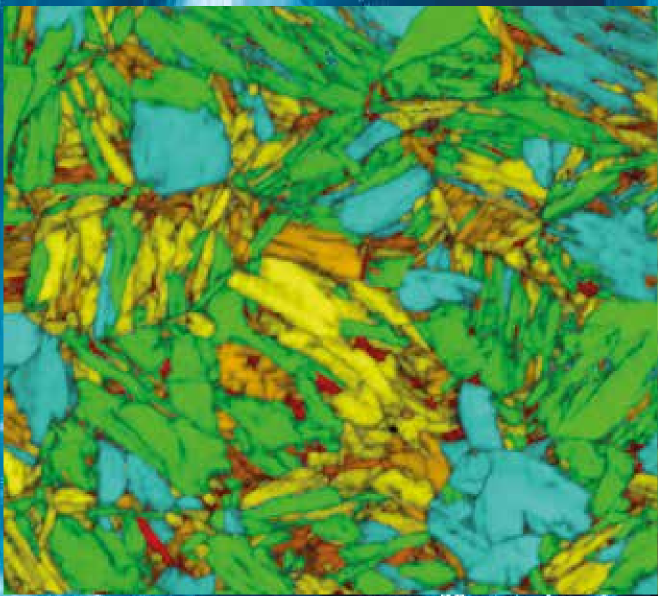
E) Patents

Patents are key indicators for 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 patents:

- "Röntgenanalysegerät mit einkristalliner Röntgenblende und Verfahren zur Herstellung einer einkristallinen Röntgenblende, Scatterless X-ray Pinholes", patent application 2012, patent owner: Incoatec GmbH, former MCL researcher involved: DI Josef Kreith
- "Karbidaushärtender Stahl für Dieseleinspritzsysteme", patent application 2012, patent owner: Robert Bosch AG, MCL researchers involved: Prof. Reinhold Ebner and Dr. Stefan Marsoner
- "Vorrichtung zum Verdichten eines Sinterbauteils", patent application 2012, subsequent inventor registration 2012, patent owner: Miba Sinter Austria GmbH, former MCL researchers involved: Dr. Thomas Hatzenbichler, Dr. Florian Planitzer

INTELLECTUAL CAPITAL REPORT APPENDIX



- Publications in refereed journals
- Conference papers
- Posters
- Technological journals

12

Appendix

A) Publications in refereed journals

Author Co-author	Title	Journal	Edition/ Year
Aksel, E.; Forrester, J.; Kowalski, B.; Deluca, M.; Damjanovic, D. et al.	**Structure and properties of Fe-modified $Na_{0.5}Bi_{0.5}TiO_3$ at ambient and elevated temperature**	Physical Review B	85 (2012) 1-11 (024121)
Bartosik, M.; Daniel, R.; Zhang, Z.; Deluca, M.; Ecker, W. et al.	**Lateral gradients of phases, residual stress and hardness in a laser heated $Ti_{0.52}Al_{0.48}N$ coating on hard metal**	Surface and Coatings Technology	206 (2012) 4502-4510
Bermejo, R.; Supancic, P.; Aldrian, F. Danzer, R.	**Experimental approach to assess the effect of metallization on the strength of functional ceramic components**	Scripta Materialia	66 (2012) 546-549
Bilik, C.; Pahr, D.H.; Rammerstorfer, F.G.	**A bead laying algorithm for enhancing the stability and dynamic behaviour of thin walled structures**	Acta Mechanica	223 (2012) 1621-1631
Bohacek, J.; Kharicha, A.; Ludwig, A.; Wu, M.	**Shallow water model for horizontal centrifugal casting**	Materials Science and Engineering	33 (2012) 41518
Curecheriu, L.P.; Deluca, M.; Mocanu, Z.V.; Pop, M.V.; Nica, V. et al.	**Investigation of the ferroelectric-relaxor crossover in Ce-doped $BaTiO_3$ ceramics by impedance spectroscopy and Raman study**	Phase Transitions	published online (2012)
Deluca, M.; Bermejo, R.; Pletz, M.; Wießner, M.; Supancic, P. et al.	**Influence of deposited metal structures on the failure mechanisms of silicon-based components**	Journal of the European Ceramic Society	32 (2012) 4371-4380
Deluca, M.; Curecheriu, L.P.; Neagu, A.; Apachitei, M.T.; Buscaglia, M. et al.	**Raman spectroscopic study of layered quaternary ferrite $Ba_{12}Fe_{28}Ti_{15}O_{84}$**	Phase Transitions	published online (2012)
Deluca, M.; Stoleriu, L.; Curecheriu, L.P.; Horchidan N.; A.C., Ianculescu et al.	**High-field dielectric properties and Raman spectroscopic investigation of the ferroelectric-to-relaxor crossover in $BaSn_xTi_{1-x}O_3$ ceramics**	Journal of Applied Physics	111 (2012) 1-13 (084102)

Author Co-author	Title	Journal	Edition/ Year
Deluca, M.; Vasilescu, C.A.; Ianculescu, A.C.; Berger, D.C.; Ciomaga, C.E. et al.	**Investigation of the composition-dependent properties of $BaTi_{1-x}Zr_xO_3$ ceramics prepared by the modified Pechini method**	Journal of the European Ceramic Society	32 (2012) 3551-3566
Domitner, J.; Hölzl, C.; Kharicha, A.; Wu, M.; Ludwig, A. et al.	**3D simulation of interdendritic flow through a Al-18wt.%Cu structure captured with X-ray microtomography**	Materials Science and Engineering	27 (2012) 12016
Eck, S.; Ishmurzin, A.; Wlanis, T.; Ebner, R.; Planitzer, F. et al.	**A finite element model for carburisation of surface densified PM components**	International Journal of Computational Materials Science and Surface Engineering	5 (2012) 16-30
Fischer, F.D.; Predan, J.; Fratzl, P.; Kolednik, O.	**Semi-analytical approaches to assess the crack driving force in periodically heterogeneous elastic materials**	International Journal of Fracture	173 (2012) 57-70
Fischer, F.D.; Simha, N.K.; Predan, J.; Schöngrundner, R.; Kolednik, O.	**On configurational forces at boundaries in fracture mechanics**	International Journal of Fracture	174 (2012) 61-74
Fischer, F.D.; Svoboda, J.; Hackl, K.	**Modelling the kinetics of a triple junction**	Acta Materialia	60 (2012) 4704-4711
Fischlschweiger, M.; Cailletaud, G.: Antretter, T.	**A mean-field model for transformation induced plasticity including backstress effects for non-proportional loadings**	International Journal of Plasticity	37 (2012) 53-71
Fischlschweiger, M.; Ecker, W.; Pippan, R.	**Verification of a continuum mechanical explanation of plasticity-induced crack closure under plain strain conditions by means of finite element analysis**	Engineering Fracture Mechanics	96 (2012) 762-765
Grasset-Bourdel, R.; Alzina, A.; Huger, M.; Chotard, T.; Gruber, D. et al.	**Influence of thermal damage occurrence at microstructural scale on the thermomechanical behaviour of magnesia-spinel refractories**	Journal of the European Ceramic Society	32 (2012) 989-999

Author Co-author	Title	Journal	Edition/ Year
Janko, M.; Ecker, W.; Pinter, G.; Kolednik, O.	**Numerical simulation of crack growth in polyethylene composites by means of the cohesive zone model**	Macromolecular Symposia	311 (2012) 41487
Jin, S.; Gruber, D.; Harmuth, H.; Frechette, M.H.; Li, Y.	**Thermo-mechanical modelling of steel ladle process cycles**	Refractories Manual	1 (2012) 37-41
Keckes, J.; Bartosik, M.; Daniel, R.; Mitterer, C.; Maier, G. et al.	**X-ray nanodiffraction reveals strain and microstructure evolution in nanocrystalline thin films**	Scripta Materialia	67 (2012) 748-751
Leitner, M.; Stoschka, M.	**Influence of steel grade on the fatigue strength enhancement by high frequency peening technology on longitudinal fillet weld gusset**	Journal of Engineering and Technology	1 (2012) 80-90
Leitner, M.; Stoschka, M.; Schanner, R.; Eichlseder, W.	**Influence of high frequency peening on fatigue of high-strength steels**	FME Transactions	40 (2012) 99-104
Makarovic, K.; Bencan, A.; Hrovat, M.; Holc, J.; Malic, B. et al.	**The effect of phase composition on the mechanical properties of LTCC material**	International Journal of Applied Ceramic Technology	published online (2012)
Oberaigner, E.R.; Leindl, M.	**Statistical physics concepts for the explanation of effects observed in martensitic phase transformations**	Smart Materials and Structures	published online (2012)
Pletz, M.; Daves, W.; Ossberger, H.	**A wheel set / crossing model regarding impact, sliding and deformation - Explicit finite element approach**	Wear	294-295 (2012) 446-456
Pletz, M.; Daves, W.: Ossberger, H.	**A wheel passing a crossing nose: Dynamic analysis under high axle loads using finite element modelling**	Journal of Rail and Rapid Transit	226 (2012) 603-611

Author Co-author	Title	Journal	Edition/ Year
Pondicherry, K.; Grün, F.; Godor, I.; Bertram, R.; Offenbecher, M.	**Applicability of ring-on-disc and pin-on-plate test methods for Cu-steel and Al-steel systems for large area conformal contact**	Lubrication Science	published online (2012)
Popov, M.; Spitaler, J.; Mühlbacher, M.; Walter, C.; Keckes, J. et al.	**The TiO_2(100)/Al_2O_3 (0001) interface: A first-principles study supported by experiment**	Physical Review B	86 (2012) 41275
Presoly, P.; Pierer, R.; Bernhard, C.	**Linking up of HT-LSCM and DSC measurements to characterize phase diagrams of steels**	Materials Science and Engineering	33 (2012) 12064
Rafailovic, L.D.; Gammer, C.; Kleber, C.; Rentenberger, C.; Angerer, P. et al.	**Synthesis and characterization of electrodeposited hierarchical nanodendritic NiCoFe alloy powders**	Journal of Alloys and Compounds	543 (2012) 167-171
Raninger, P.; Ecker, W.; Antretter, T.; Leindl, M.; Ebner, R.	**Interaction of heat checks in aluminum pressure casting dies and their effect on fatigue life**	Key Engineering Materials	488-489 (2012) 626-629
Reyes-Huamantinco,A.; Puschnig, P.; Ambrosch-Draxl, C.; Peil, O.; Ruban, A.	**Stacking-fault energy and anti-Invar effect in FeMn alloys from first principles**	Physical Review B	86 (2012) 41395
Riedl, A.; Daniel, R.; Stefenelli, M.; Schöberl, T.; Kolednik, O. et al.	**A novel approach for determining fracture toughness of hard coatings on the micrometer scale**	Scripta Materialia	67 (2012) 708-711
Riedl, A.; Schalk, N.; Czettl, C.; Sartory, B.; Mitterer, C.	**Tribological properties of Al_2O_3 hard coatings modified by mechanical blasting and polishing post-treatments**	Wear	289 (2012) 42614
Röhrig, S.; Supancic, P.	**New self-regulating ceramic PTC thermistor heating elements with strongly improved performance**	Ceramic Forum International	89 (2012) 25-29

Author Co-author	Title	Journal	Edition/ Year
Schalk, N.; Mitterer, C.; Keckes, J.; Penoy, M.; Michotte, C.	**Influence of residual stresses and grain size on the spinodal decomposition of metastable $Ti_{1-x}Al_xN$ coatings**	Surface and Coatings Technology	209 (2012) 190-196
Schütz, D.; Deluca, M.; Krauss, W.; Feteira, A.; Jackson, T. et al.	**Lone pair-induced covalency as the cause of temperature and field-induced instabilities in Bismuth Sodium Titanate**	Advanced Functional Materials	22 (2012) 2285-2294
Sonderegger, B.; Kozeschnik, E.	**Particle strengthening in fcc crystals with prolate and oblate precipitates**	Scripta Materialia	66 (2012) 52-55
Sonderegger, B.; Kozeschnik, E.; Sommitsch, C.	**Modeling particle distances of coherent prolate- and oblate-shaped precipitates in bcc systems**	Materials Science Forum	706-709 (2012) 1521-1526
Stoschka, M.; Fössl, T.; Leitner, M.; Posch, G.	**Effect of high-strength filler metals on fatigue**	Welding in the World	56 (2012) 20-29
Strickner, G.; Ragger, K.; Hatzenbichler, T.; Buchmayr, B.	**3D finite element simulation of cold pilgering over the whole productive time**	Steel Research International	(2012) 71-74
Strobl, S.; Supancic, P.; Lube, T. ; Danzer, R.	**Surface crack in tension or in bending - A reassessment of the Newman and Raju formula in respect to fracture toughness measurements in brittle materials**	Journal of the European Ceramic Society	32 (2012) 1491-1501
Strobl, S.; Supancic, P.; Lube, T.; Danzer, R.	**Toughness measurement on ball specimens. Part I: Theoretical analysis**	Journal of the European Ceramic Society	32 (2012) 1163-1173
Supancic, P.; Schöpf, H.	**Exact implementation of subcritical crack growth into a Weibullian strength distribution under constant stress rate conditions**	Journal of the European Ceramic Society	32 (2012) 4031-4040
Svoboda, J.; Fischer, F.D.	**Modelling for hydrogen diffusion in metals with traps revisited**	Acta Materialia	60 (2012) 1211-1220

INTELLECTUAL
CAPITAL REPORT
APPENDIX

A) Publications in refereed journals

Author Co-author	Title	Journal	Edition/ Year
Svoboda, J.; Fischer, F.D. ; Abart, R.	**Modeling the role of sources and sinks for vacancies on the kinetics of diffusive phase transformation in binary systems with several stoichiometric phases**	Philosophical Magazine Letters	92 (2012) 67-76
Svoboda, J.; Fischer, F.D.; McDowell, D.L.	**Derivation of the phase field equations from the thermodynamic extremal principle**	Acta Materialia	60 (2012) 396-406
Warczok, P.; Zenisek, J.; Kozeschnik, E.	**Atomistic and continuums modeling of cluster migration and coagulation in precipitation reactions**	Computational Materials Science	60 (2012) 59-65
Weirather, T.; Fian, A.; Sartory, B.; Caliskanoglu, D.; Kölker, W.; Mitterer, C.	**Duplex processing for increased adhesion of sputter deposited $Ti_{1-x}Al_xN$ coatings on a Fe-25%Co-15%Mo tool material**	Surface and Coatings Technology	206 (2012) 3601-3606
Yang, B.; Motz, C.; Rester, M.; Dehm, G.	**Yield stress influenced by the ratio of wire diameter to grain size - A competition between the effects of specimen microstructure and dimension in micro-sized polycrystalline copper wires**	Philosophical Magazine	92 (2012) 3243-3256

B) Conference papers

Author Co-author	Title	Conference
Antretter, T.; Fischlschweiger, M. & Cailletaud, G.	**Macro-, meso- scale modeling of TRIP - Nonlinear scale transition rules**	International Symposium on Plasticity 2012
Ebner, R.; Ecker, W.; Marsoner, S.; Eck, S.; Gruber, P. et al.	**Methodology for advanced tool load analysis and lifetime prediction of tools**	Tool 2012
Eck, S.; Marsoner, S.; Ebner, R.	**Wechselwirkung Werkstoff und Werkzeug bei der Zerspanung mit Fokus auf Randzonen- und Spanausbildung**	Tooling Days Kapfenberg
Gerster, P.; Leitner, M.; Stoschka, M.	**Praktische Anwendungen eines höherfrequenten Hämmerverfahrens (PIT) in der Industrie**	Fachkongress Join-Ex
Hofer, F.; Kuss, M.; Wallner, S.; Buchmayr, B.; Harrer, O.	**Lightweight design by radial forged gear box components**	International VDI Congress "Drivetrain for Vehicles"
Jin, S.; Gruber, D.; Harmuth, H.; Soudier, J.; Meunier, P. et al.	**Thermomechanical modelling of a channel induction furnace**	ALAFAR Congress 2012
Kainzinger, P.; Guster, C.	**Estimating the Local Fatigue Strength of EN-GJS-400**	3rd Fatigue Symposium
Kainzinger, P.; Guster, C.; Severing, M.; Wolf, A.	**Abschätzung der lokalen Wöhlerlinie von Gusseien mit Kugelgraphit aus der Gießsimulation**	39. Tagung des DVM-Arbeitskreises Betriebsfestigkeit (DVM Tagung)
Kaiser, R.; Hatzenbichler, T.; Buchmayr, B.	**A new concept to design drawing tools with respect to central damage**	14th International Conference on Metal Forming 2012
Krajewski, P.; Pierer, R.; Bernhard, C.; Schaden, T.; Illie, S.	**Experimental investigations into surface crack formation under continuous casting conditions**	5th International Congress of the Science and Technology of Steelmaking
Krampl, H.; Grün, F.; Godor, I.	**Numerical and experimental investigation of non-conformal lubricated contacts**	15th Nordic Symposium on Tribology - Nordtrib 2012

Author Co-author	Title	Conference
Lang, P.; Mohn, P.; Falahati, A.; Kozeschnik, E.	**Ab initio simulations of vacancy-solute clusters in Al-Mg-Si and Al-Zn-Mg alloys**	13th International Conference on Aluminium Alloys (ICAA 13)
Leitner, M.; Stoschka, M.; Barwart, S.	**Local fatigue behaviour of welded joints**	3rd Fatigue Symposium
Leitner, M.; Stoschka, M.; Eichlseder, W.	**Contribution to the fatigue enhancement of thin-walled, highstrength steel joints by high frequency mechanical impact treatment**	International Conference of the International Institute of Welding
Maderbacher, H.; Wagner, C.; Oberwinkler, B.; Gänser, H.P.; Riedler, M.	**Topology and shape optimization of a mount link considering local microstructure-dependent fatigue properties obtained from forming simulation**	10th World Congress on Computational Mechanics (WCCM2012)
Maier, B.; Oberwinkler, B.; Tichy, R.; Ecker, W.	**Development of a FE-based fracture mechanical method for fatigue life assessment of double-submerged welded pipelines considering residual stresses and local microstructures**	19th European Conference on Fracture (ECF19)
Maierhofer, J.; Pippan, R.; Gänser, H.P.	**Schadenstolerante Auslegung von Antriebskomponenten unter Berücksichtigung kleiner Defekte und Bauteileigenspannungen**	44. Tagung des DVM-Arbeitskreises Bruchvorgänge (DVM-Tagung)
Maierhofer, J.; Pippan, R.; Gänser, H.P.	**Fitness-for-purpose assessment of drivetrain components considering small defects and residual stresses**	3rd Fatigue Symposium
Maierhofer, J.; Pippan, R.; Gänser, H.P.	**Improvement of fatigue performance by residual stresses: A fracture mechanics approach**	19th European Conference on Fracture (ECF19)
Orthaber, M.; Antretter, T.; Ecker, W.	**Crystal plasticity using the principle of maximum dissipation**	8th European Solid Mechanics Conference
Orthaber, M.; Antretter, T.; Gänser, H.P.; Ecker, W.	**Active slip systems in crystal plasticity and the principle of maximum dissipation**	5th International Conference from Scientific Computing to Computational Engineering (IC-SCCE)
Pierer, R.; Rauter, W.; Bernhard, C.	**The importance of solidification structure with respect to hot tearing during continuous casting of steels**	2012 TMS Annual Meeting & Exhibition - Defects and Properties of Cast Metals

Author Co-author	Title	Conference
Pletz, M.; Daves, W.; Yao, W.; Kubin, W.; Scheriau, S.	**Multi-scale finite element model to describe wear and rolling contact fatigue in the wheel-rail test rig**	9th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2012)
Pletz, M.; Daves, W.; Yao, W.; Ossberger, H.	**Prediction of rolling contact fatigue in crossings multicscale Fe model**	9th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems (CM2012)
Pondicherry, K.; Grün, F.; Summer, F.; Godor, I.; Krampl, H. et al.	**Synergy between secondary phases in aluminium based tribomaterials and lubricant additives**	15th Nordic Symposium on Tribology - Nordtrib 2012
Presoly, P.; Pierer, R.; Bernhard, C.	**Identification of defect prone peritectic steel grades by analyzing the high temperature phase transformations**	2012 TMS Annual Meeting & Exhibition - Defects and Properties of Cast Metals
Raninger, P.; Marsoner, S.; Ecker, W.; Ebner, R.; Antretter, T.	**Characterization of damage at the friction surface of wheel mounted brake disks for railway applications**	EuroBrake2012
Raninger, P.; Schemmel, M.; Ecker, W.; Antretter, T.	**Experimental and numerical investigation of damage due to thermo-mechanical fatigue of brake disks for railway applications**	3rd Fatigue Symposium
Reiser, J.; Maier, B.; Gänser, H.P.; Guster, C.; Pippan, R.	**New approach for testing and modelling of fatigue behaviour**	10th World Congress on Computational Mechanics (WCCM2012)
Reiser, J.; Maier, B.; Gänser, H.P.; Guster, C.; Pippan, R.	**A new SEM in-situ fatigue testing apparatus and its application for evaluation of fatigue damage at higher load cycles**	19th European Conference on Fracture (ECF19)
Schöngrundner, R.; Ecker, W.; Marsoner, S.; Gruber, P.; Ebner, R.	**Development of a simulation aided design strategy for casting die frames**	Tool 2012

Author Co-author	Title	Conference
Sherstnev, P.; Lang, P.; Kozeschnik, E.	**Treatment of simultaneous deformation and solid-state precipitation in thermo-kinetic calculations**	6th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS)
Stoschka, M.; Leitner, M.; Schnitzer, R.; Schörghuber, M.	**Quality testing of high-strength filler metals in regard to technical cracking - Part 1**	International Conference of the International Institute of Welding
Taschauer, M.; Pschera, R.; Wieser, V.; Schramhauser, S.; Buchmayr, B.	**Prediction of residual stresses during the heat treatment of large forgings**	1st International Conference on Ingot Casting
Taschauer, M.; Wieser, V.; Schramhauser, S.; Hatzenbichler, T.; Buchmayr, B.	**Die Wärmebehandlung der Stähle unter Einbeziehung des Selbstanlassens**	XXXI Verformungskundliches Kolloquium

C) Posters

Author Co-author	Title	Conference
Deluca, M.; Krautgasser, C.; Bermejo, R.; Foronda, H.M.; Jones, J.L. et al.	**Effect of combined thermo-mechanical loading on the domain texture and the fracture resistance of lead zirconate titanate (PZT) ceramics**	Electroceramics XIII
Kainzinger, P.; Wohlfahrt, M.	**Effizientere Windkraftanlagen durch eine optimierte Auslegung unter Ausnutzung des vollständigen Werkstoffpotentials**	WerWasWo.Forschung@ MUL
Kaiser, R.; Hatzenbichler, T.; Buchmayr, B.; Antretter, T.	**Simulation of the roller straightening process with respect to residual stresses and the curvature trend**	9th International Conference on Residual Stresses
Krajewski, P.	**Oberflächenrissbildung beim Stranggießen von Stahl**	WerWasWo.Forschung@ MUL
Lang, P.; Povoden-Karadeniz, E.; Ahmadi, M.; Falahati, A.; Kozeschnik, E.	**Through-process precipitation modeling in Al alloys**	Fachkongress Join-Ex
Preis, W.; Waldhäusl, J.; Sitte, W.	**Electrical properties of grain boundaries in n-type barium titanate ceramics under voltage load**	MRS Spring Meeting 2012
Presoly, P.	**Thermische Analyse neuer Stähle**	WerWasWo.Forschung@ MUL

Author Co-author	Title	Conference
Presoly, P.; Pierer, R.; Bernhard, C.	**Linking up of HT-LSCM and DSC measurements to characterize phase diagrams of steels**	13th Modeling of Casting, Welding, and Advanced Solidification Processes (MCWASP XIII)
Röhrig, S.; Ihle, J.; Supancic, P.	**Effect of current direction on the performance of free-shaped self-regulating heating elements based on barium titanate**	Electroceramics XIII
Stefenelli, M.; Riedl, A.; Bartosik, M.; Daniel, R.; Mitterer, C. et al.	**Thermally treated hard coatings characterized by XRD coupled with four-point bending**	9th International Conference on Residual Stress (ICR)
Taschauer, M.; Wieser, V.; Schramhauser, S. Hatzenbichler, T.; Buchmayr, B.	**Influences on residual stress distribution during the heat treatment of large forgings**	Tool 2012

D) Books / technological journals

Author Co-author	Title	Books / technological journals	Edition/ Year
Schwaab, H.	**Nichtlineare Modellierung von Ferroelektrika unter Berücksichtigung der elektrischen Leitfähigkeit**		2012
Barwart, S.; Leitner, M. & Oberwinkler, C.	**Herstellung von Panzerschichten mit Hartstoffpartikeln auf MSG-Basis**	Tribologie + Schmierungstechnik	2012
Jin, S.; Gruber, D.; Harmuth, H.; Frechette, M.H.	**Thermomechanical steel ladle simulation including a Mohr-Coulomb plasticity failure**	RHI Bulletin	2012
Kainzinger, P.; Guster, C.; Severing, M.; Wolf, A.	**Zum Einfluss überlagerter Mittelspannung und Temperatur auf das zyklische Materialverhalten von Gusseisen mit Kugelgraphit**	Gießereirundschau	2012
Krampl, H.; Grün, F. & Godor, I.	**Rechnerische und experimentelle Untersuchung der Schmierfilmbildung in Tribokontakten mittels kommerzieller Softwarepakete**	Tribologie + Schmierungstechnik	2012
Kuss, M.; Wallner, S.; Harrer, O. & Buchmayr, B.	**Analyse des Axial-Radial-Umformens mittels Finite-Elemente-Methode**	BHM	2012
Leitner, M.; Stoschka, M.; Fössl, T. & Eichlseder, W.	**Schwingfestigkeit hochfester Stähle an geschweißten Strukturen**	Schweiss- und Prüftechnik	2012
Pletz, M.; Daves, W. & Ossberger, H.	**Understanding the loading of turnout crossings**	Railway Gazette International	2012

BUSINESS FIGURES 2012

Business development

Profit and loss account

Balance sheet

12

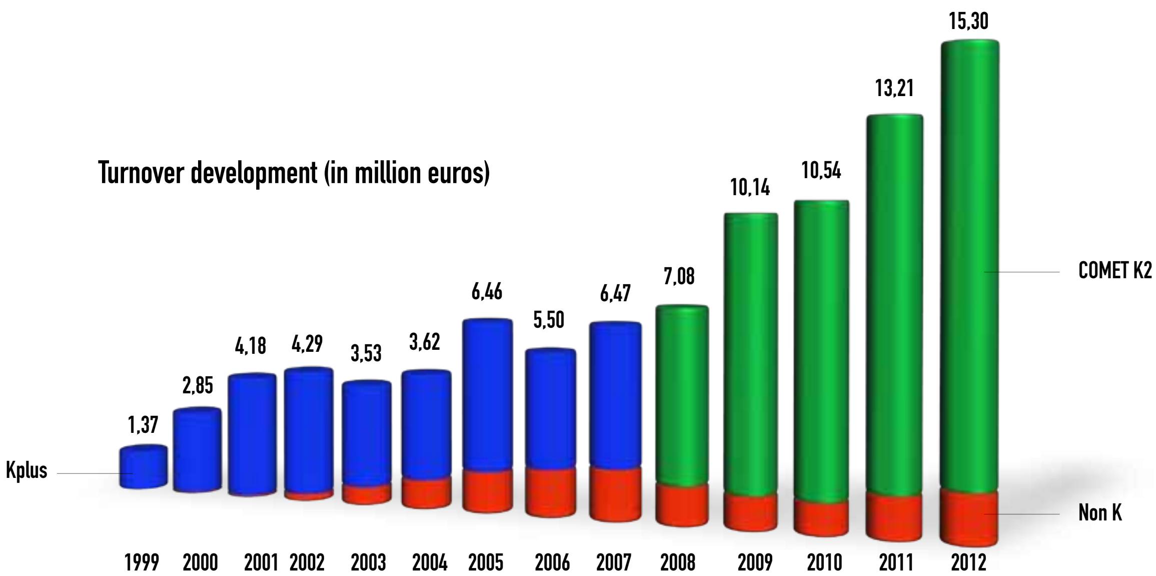
Business development

Business development and staff development

The COMET project volume for the 2012 financial year amounted to € 12,168,080 (previous year [PY]: k€ 11,814), taking into account the repayment of the investment subsidies of € 1,632,866.87 for the previous years due upon expiry of the first funding period. The project volume including the investment subsidies was € 13,800,946.87, thus meeting the objective of a substantial increase in the COMET volume.

MCL services generated a turnover of € 1,124,534.72 (PY: k€ 1,143).

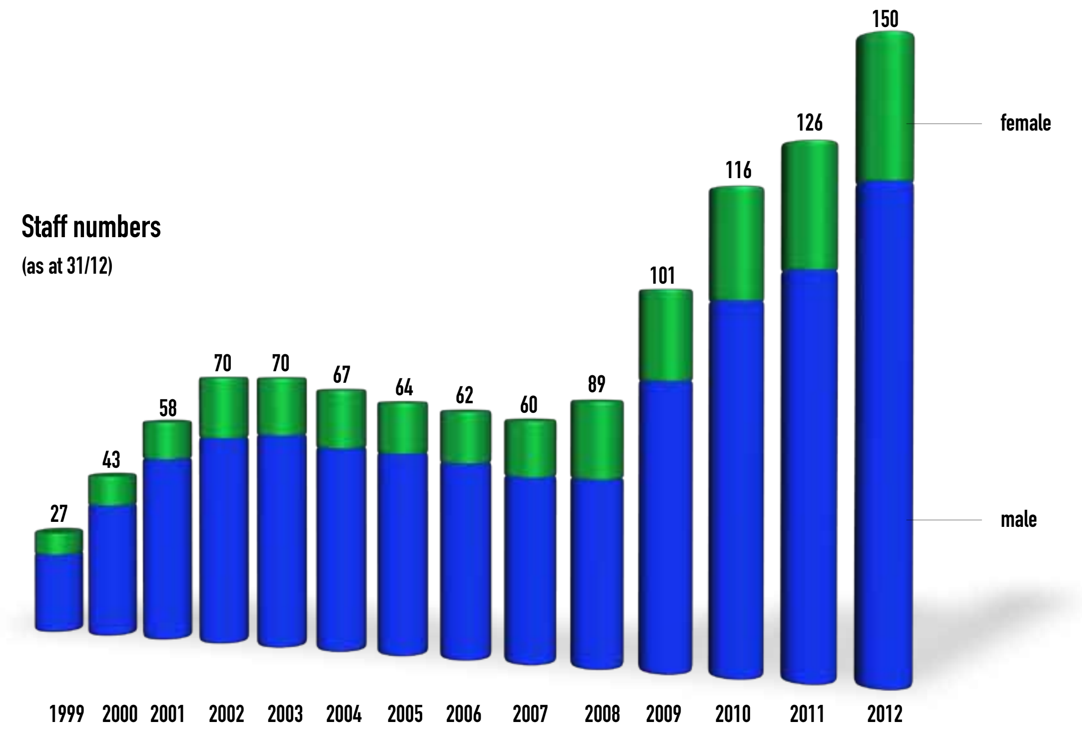
The volume of non-COMET projects was € 409,726.85 (PY: k€ 252), and EU and international projects amounted to € 8,533.93 (PY: k€ 21), which is also an overall increase from the previous year.



BUSINESS FIGURES

Staff development

As at 31/12/2012 the company had 150 employees / full time equivalent: 108.9 (PY: 126 / FTE 92.2). This staff increase compared to the previous reporting period reflects the competence centre's successful efforts to generate new projects.



Financial and earnings position

Earnings position

Materials Center Leoben Forschung GmbH reported a net income of € 787,703.31 (PY: k€ 597) in the 2012 financial year.

The balance sheet profit, i.e. profit for the year of € 191,621.46 (PY: k€ 116) plus profit carried forward of € 655,219.11 (PY: k€ 539), thus amounts to € 846,840.57 (PY: k€ 655). An amount of € 596,081.85 (PY: k€ 480) was allocated to the profit reserve in the 2012 financial year.

Turnover mainly includes contributions of € 5,906,757.06 (PY: k€ 6,091) from the company and scientific partners in the COMET area and non-COMET project revenue of € 1,385,787.44 (PY: k€ 1,188). COMET and non-COMET funding together amounted to € 7,307,883.06 (PY: k€ 5,249). Other operating income, including the release of investment allowances and provisions amounted to € 1,809,592.14 (PY k € 1,596).

Material expenses and expenditure for services received amounted to € 7,642,656.05 (PY: k€ 6,589) and staff expenses amounted to € 5,481,082.86 (PY: k€ 4,599). The increase in these expenditure items corresponds to the increase in activities in the reporting period.

Amortisation in the 2012 financial year amounted to € 1,015,326.81 (PY: k€ 992). The other operating expenses rose modestly to € 1,485,164.82 (PY: k€ 1,453) in keeping with the overall increase in project volume.

The financial result amounted to € 61,299.52 (PY: k€ 72).

Asset position

The book value of fixed assets rose to € 2,314,250.19 (PY: k€ 2,084) in the 2012 financial year. This increase is mainly due to investments in the research area "Materials for Microelectronics".

An amount of € 596,081.85 (PY: k€ 481) of the net income was allocated to profit reserves, which thus total € 2,804,958.79 (PY: k€ 2,209) as at 31/12/2012 and serve to secure the development of research projects and activities in the future. The company thus reports a balance sheet profit of € 846,840.57 (PY: k€ 655), which will be allocated to unappropriated profit reserves or carried forward to new account.

Capital and reserves increased to € 3,943,799.36 (PY: k€ 3,156) in the 2012 financial year. Due to a substantial increase in total capital, the company has an equity ratio of 38.71% (PY: 28.78%) as at 31/12/2012, determined in accordance with Sec. 23 of the Austrian Company Reorganisation Act (URG).

Financial position

Cash flow from operating activities was € 800,421.48 (VJ: k€ 761) as at 31/12/2012. Net cash flow from operating activities was -2,340,412.03 (PY: k€ 2,199), which is a substantial decrease from the previous year. Changes in cash and equivalents totalled € 2,613,282.63 (PY: k€ 1,963) in the 2012 financial year, bringing the value of cash and equivalents as at 31/12/2012 to € 3,580,246.35 (PY: k€ 6.194). This decrease is due to the outstanding final payment of € 1,774,261.56 from FFG and SFG for COMET Phase I. Another reason is the repayment of the investment subsidies for the depreciation balance for investments made in COMET Phase I, which amounted to € 1,632,866.87.

Outlook for 2013:

MCL plans to further expand its activities in 2013 and has budgeted the following values for its three core areas: COMET k€ 15,336 (2012: k€ 13,927), services k€ 1,425 (2012: k€ 1,225), and other funded research projects k€ 530 (2012: k€ 422).

Profit and Loss Account

Profit and Loss Account as at 31/12/2012 Materials Center Leoben Forschung GmbH

	2012 in EUR	2011 in EUR
1. Turnover	**1,385,787.44**	**1,187,972.48**
2. Services not yet billable	**-11,171.86**	**34,967.25**
3. Income from cash and in-kind contributions by partners	**5,906,757.06**	**6.091,149.49**
4. Public funding and allowances	**7,307,883.06**	**5,249,981.99**
5. Other operating income		
a) release of investment allowances	768,255.07	829,807.26
b) income from the reversal of accruals	371,200.73	113,922.24
c) other	670,136.35	651,927.32
	1,809,592.15	**1,595,656.82**
6. Material expense and expenditure for services received		
a) material expense	987,439.30	903,563.47
b) expenditure for services received	6,655,216.75	5,685,365.38
	7,642,656.05	**6,588,928.85**
7. Staff expenses		
a) Wages	25,937.97	19,681.52
b) Salaries	4,190,431.87	3,528,408.91
c) Employee income provision fund	60,762.96	51,692.12
d) Expenses for social security payment prescribed by law as well as taxes and mandatory contributions dependent on compensation	1,155,387.43	958,551.73
e) Expenses for other employee benefits	48,562.63	40,967.59
	5,481.082.86	**4,599,301.87**
8. Amortization		
a) of fixed assets	**1.015,326.81**	**992.029.54**
9. Other operating expenses		
a) taxes, in so far as they are not on income or on revenue	11.042.79	9,601.34
b) other	1,474,122.03	1,443,262.59
	1,485,164.82	**1,452,863.93**
10. Operating result	**774,617.31**	**526,603.84**
11. Other interest income and similar income	**61,299.52**	**72,401.96**
12. Interest and similar expenses	**0.00**	**8.95**
13. Financial result	**61,299.52**	**72,393.01**
14. Profit from operating activities	**835,916.83**	**598,996.85**
15. Taxes on income and revenue	**48,213.52**	**1,746.86**
16. Net income	**787,703.31**	**597,249.99**
17. Allocation to profit reserves		
a) other reserves (free reserves)	**596.081.85**	**480,840.16**
18. Profit for the year	**191,621.46**	**116,409.83**
19. Profit carried forward from the previous years	**655,219.11**	**538,809.28**
20. Balance sheet profit	**846,840.57**	**655,219.11**

Balance Sheet

BUSINESS FIGURES

Balance Sheet as at 31/12/2012 Materials Center Leoben Forschung GmbH

as at 31/12	2012 in EUR	2011 in EUR
Assets		
A. Fixed Assets		
I. Intangible Assets		
1. Licences and software	30,207.63	37,551.35
II. Tangible Assets		
1. Equipment	1,946,811.26	1,568,267.59
2. Tools, fixtures and fittings	337,231.30	210,882.54
3. Payments made on account	0.00	267,575.91
	2,284,042.56	2,046,726.91
	2,314,250.19	**2,084,277.39**
B. Current Assets		
I. Inventories		
1. Services not yet billable	111,397.87	122,569.73
2. Payments made on account	46,217.92	146,769.92
	157,615.79	269,339.65
II. Receivables and other Assets		
1. Receivables arising from deliveries and services	387,807.87	232,126.92
2. Receivables of cash and in-kind contributions from partner companies	904,977.92	847,226.58
3. Receivables from subsidies und project subsidies	1,883,582.59	99,984.47
4. Other receivables and assets	889,118.60	1,065,374.80
	4,065,482.98	2,244,712.77
III. Cash on hand and bank deposits	3,580,246.35	6,193,528.98
	7,803,349.12	**8,707,581.40**
C. Trust assets	**0.60**	**169,824.40**
D. Prepaid expenses, deferred charges	**71,188.62**	**38,040.64**
Total Assets	**10,188,788.53**	**10,999,723.83**

Balance Sheet as at 31/12/2012 Materials Center Leoben Forschung GmbH

as at 31/12	2012 in EUR	2011 in EUR
Liabilities and Shareholders' Equity		
A. Capital and Reserves		
I. Share capital	292,000.00	292,000.00
II. Revenue reserves		
1. Other reserves (free reserves)	2,804,958.79	2,208,876.94
III. Balance sheet profit	846,840.57	655,219.11
thereof profit carried forward from the previous years	655,219.11	538,809.28
	3,943,799.36	**3,156,096.05**
B. Investment Allowances	22,739.59	677,164.21
C. Accruals		
1. Tax accruals	46,404.59	13,271.86
2. Other accruals	1,137,715.00	1,114,854.04
	1,184,119.69	**1,128,126.77**
D. Liabilities		
1. Payments received on account for orders	36,680.84	36,680.84
2. Liabilities arising from deliveries and services	2,622,257.59	2,428,161.32
3. Other liabilities	155,708.18	1,170,291.59
thereof taxes	10,289.80	8,432.16
thereof social security	127,458.96	105,024.03
	2,814,646.61	**3,635,133.75**
E. Trust assets	**0.00**	**169,824.40**
F. Prepaid expenses, deferred charges	**2,223,483.28**	**2,233,378.65**
Total Liabilities and Shareholders' Equity	**10,188,788.53**	**10,999,723.83**

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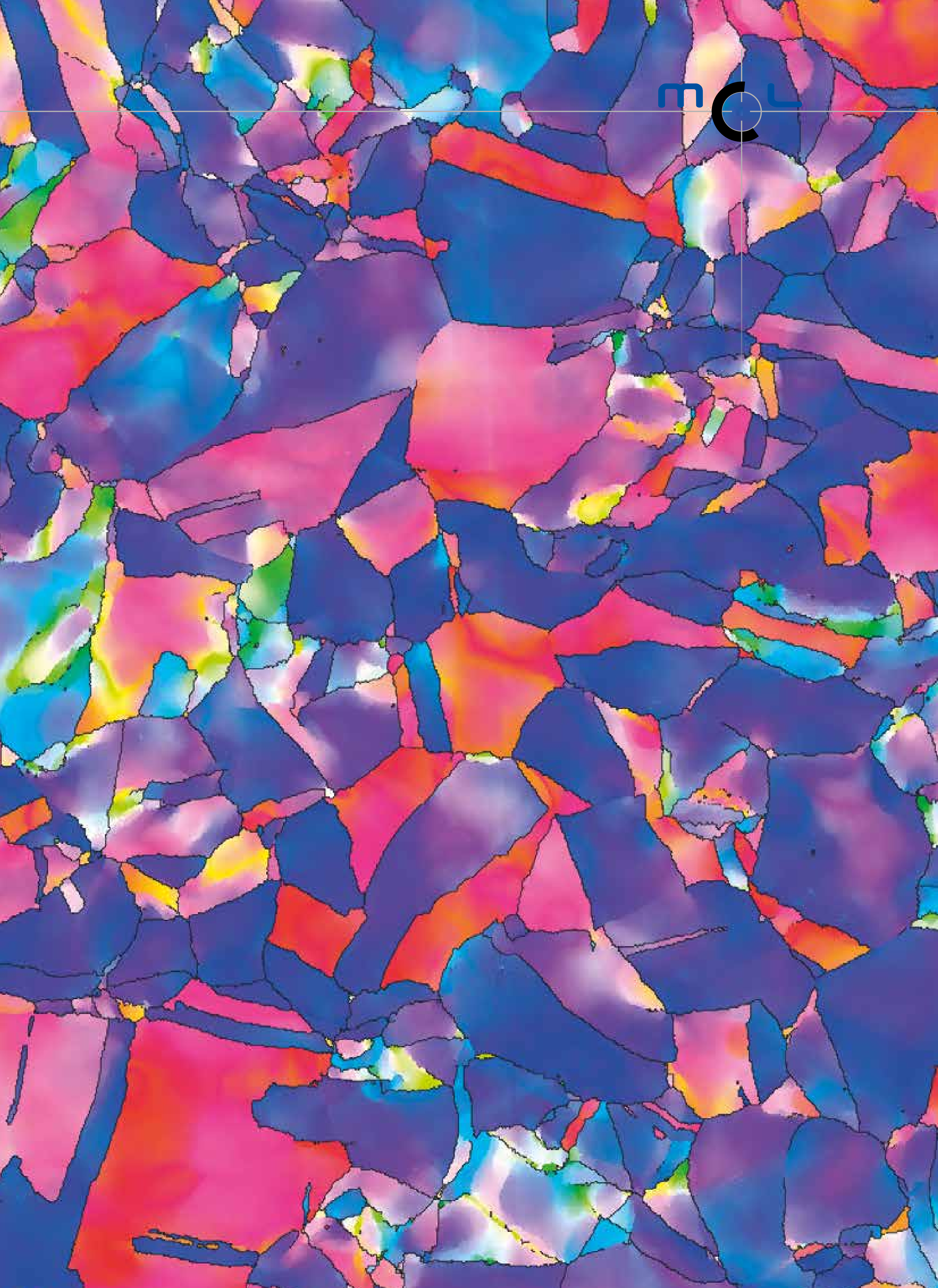

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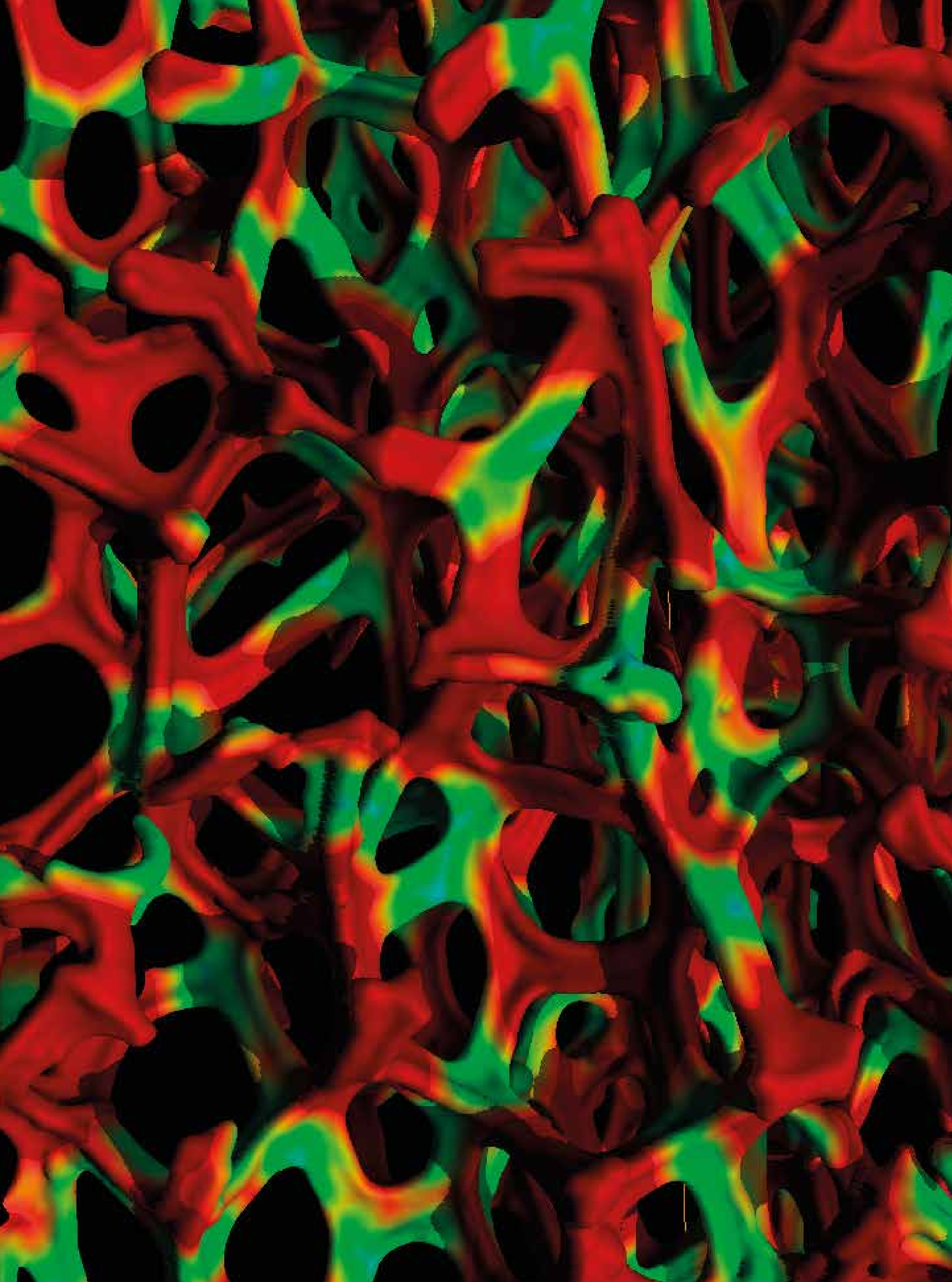

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