MATERIALS CENTER LEOBEN
FORSCHUNG GMBH

ANNUAL**REPORT 2015**

COMET K2 Centre MPPE

Company partners

Scientific partners

Research projects

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„Materials technologies are an indispensable foundation of our modern life.“

Univ.-Prof. Dr. Reinhold Ebner
Managing Director

Management Report 2015

Financial year 2015

The financial year 2015 was year three of the second funding period (2013 to 2017) of the COMET K2 Centre for Integrated Research in Materials, Processing and Product Engineering (MPPE), which is managed and operated by MCL. MCL successfully continued its research activities within the framework of the COMET K2 Programme and substantially increased its participation in national and international research programmes. Numerous project proposals were submitted to various national and international programmes in 2015. A total of eight projects were approved in which MCL acts as the consortium leader or as a project partner.

As in the first two years, the COMET project volume again exceeded the annual average volume of EUR 11.9 million for the current funding period. This results in lower project volumes in the remaining two years of the second COMET funding period. Turnover in the unfunded non-COMET area increased by about 18% compared to the previous year. The project volume in the funded non-COMET area increased by around 42%.

Thematic development

The new MCL strategy drawn up in 2014 was integrated into a concept for the next COMET funding period. The concept developed in 2015 builds on the business plan, which defines the key topics for the next COMET phase. The planned programme for the next COMET funding period was presented at the international MPPE Conference in November 2015. A proposal for establishment of the COMET Centre "Integrated Computational Materials, Process and Product Engineering (IC-MPPE)" will be submitted in 2016.

The new COMET programme plans to continue research into current topics related to the three main areas of

materials, processes and products. The enhanced integration of theoretical fundamentals, sophisticated computational methods and key technologies is designed to promote materials-based innovations and improvements along the entire production chain in different technology sectors. Digitalisation provides the opportunity to develop fast process models for real-time applications which can be used for process monitoring, control and optimisation, a key topic in the context of "Industry 4.0".

MCL is currently working on various projects in the field of "Industry 4.0". One example is the development of a condition monitoring system for the monitoring and lifetime prediction of LEDs. Another project involves work on an intelligent production facility which automatically exchanges its tools to prevent scrap. These and other projects require profound know-how of materials, processes and components in service, which is exactly MCL's field of expertise.

Outlook

The successful establishment of MCL will be driven forward over the next few years. Research at MCL will focus on the integrated computer-based development of materials, including manufacturing and processing, and innovative materials applications. MCL will continue to be a reliable partner with longstanding expertise in materials research, creating the basis for innovations that will secure the future of its partners in the manufacturing industry.

This goal can only be achieved through close and trusting collaboration between the innovation drivers from industry and science, with the support of our shareholders and funding providers, and with highly motivated employees.

„Research brings innovation by people for people“

Mag. Alexandra Purkarthofer, MBA
Managing Director

„MCL is an integral part of the comprehensive and excellent materials expertise based in Leoben.“

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

Shareholder Statement

Orientation towards the future

MCL successfully launched the second COMET funding period in 2013 and 2014 and drew up a business plan in 2014 to define its future strategy and thematic fields. In 2015, MCL started to prepare a concept for the next COMET funding period, which involved coordinating the future topics of MCL with the activities of the partners from industry and research.

MCL plans to participate in the 3rd Call for COMET K2 Centres in 2016. The success of this submission will depend on the quality of the application, the proposed research programme and the results achieved by the Centre so far.

International focus

The steps taken in the previous years to enhance the international position and visibility of MCL and the corresponding staff development measures have started to bear fruit. In 2015, MCL submitted several project applications to internationally funded research programmes as consortium leader or partner. A total of five projects totalling some 2.7 million euros were approved and are scheduled to start in 2016. MCL is also a partner in the VVAC+ consortium, which was admitted as an associate member of the Shift2Rail Joint Undertaking in 2015.

Participation in these projects, many of which involve large consortia and new international partners, allows MCL to expand its international network. MCL will continue its internationalisation efforts in 2016. This will include in particular measures to communicate MCL's fields of expertise, applications for international research projects, further development of the partner network, staff development, participation in international bodies and organisation of international conferences and workshops.

Report from the General Meeting

The Management Board and the Supervisory Board reported at two General Meetings held in 2015. The annual accounts for 2015 were unanimously approved and the Management Board and the Supervisory Board were formally discharged for 2015. The shareholders would like to thank the members of both boards for their excellent work.

The shareholders are very pleased by MCL's positive development and scientific achievements. Its continued trend for growth outside the COMET area is also reflected in the budget allocated for 2016, which provides for further increases.

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

Representatives of company partners:

DI **Josef Hagler**
voestalpine Stahl GmbH

Dr. **Christian Hinteregger**
MAGNA Powertrain AG

Dr. **Harald Leitner**
Böhler Edelstahl GmbH & Co KG

Dr. **Raimund Ratzi**
Miba AG

Dr. **Martin Schrems**
ams AG

Dr. **Manfred Schweinzger**
EPCOS OHG -A Group Company of TDK-EPC Corporation

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

From the COMET K2-Programme Committee

Tasks of the Programme Committee

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

Representatives of scientific partners:

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

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

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

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

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

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

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

New members of the Programme Committee

Dr. Christoph Auer and Univ.-Prof. Dr. Johannes Schenk withdrew from the Programme Committee, which was reappointed in 2015. Univ.-Prof. Dr. Helmut Antrekowitsch and Dr. Manfred Schweinzger were appointed new members of the Programme Committee.

New projects approved by the Programme Committee

In 2015, the Programme Committee approved a total of 7 new projects with a total volume of around EUR 4 million for inclusion in the COMET Programme. Requirements were imposed for some of the projects. The projects continued from COMET Phase I and the projects approved in the second funding period together already account for around 96% of the total project volume for COMET Phase II at the end of 2015.

International Scientific Advisory Board (ISAB)

Tasks of the International Scientific Advisory Board

The International Scientific Advisory Board (ISAB) advises MCL in devising a long-term scientific strategy and proposes measures to enhance its international profile and visibility. The ISAB also supports MCL in its efforts to become involved in international R&D networks.

Members of the ISAB

The ISAB currently comprises 11 members and is scheduled to meet annually.

Name	Institution
Prof. Eduard Arzt (DE)	University of Saarland, INM – Leibniz-Institut für Neue Materialien GmbH
Prof. Michal Basista (PL)	KMM-VIN and Head of Advanced Composite Materials Group, Institute of Fundamental Technological Research, Polish Academy of Sciences
Prof. Wolfgang Bleck (DE)	RWTH Aachen – Department of Ferrous Metallurgy
Prof. Franc Cus (SI)	University of Maribor
Prof. Wilfried Eichlseder (AT)	Montanuniversitaet Leoben
Prof. Peter Fratzl (DE)	Max-Planck Institute of Colloids and Interfaces, Department of Biomaterials
Prof. Fritz Klocke (DE)	Fraunhofer Institute for Production Technology and RWTH Aachen
Prof. Herbert Mang (AT)	Vienna University of Technology, Austrian Academy of Sciences
Prof. Andreas Mortensen (CH)	EPFL Lausanne – Laboratory for Mechanical Metallurgy
DI Reinhard Petschacher (AT)	Formerly Infineon
Prof. Anke Kaysser-Pyzalla (DE)	Ruhr University Bochum, Helmholtz Zentrum Berlin

Second ISAB meeting

The second meeting of the International Scientific Advisory Board took place on 30 June and 1 July 2015 in Leoben. At the meeting, the MCL strategy plan and the focus for participation in the new COMET call were presented and discussed with the international Board members. The ISAB provided valuable feedback to MCL, especially in terms of presenting MCL and its research in the proposal and preparing the presentation for the next COMET application. The next ISAB meeting is scheduled to take place after submission of the COMET application.

The MCL Management wishes to thank the members of the International Scientific Advisory Board for their willingness to join this advisory committee.

RESEARCH PROGRAMME COMET K2 MPPE

Innovation through integrated materials, process and product engineering

Overview of COMET Phase II

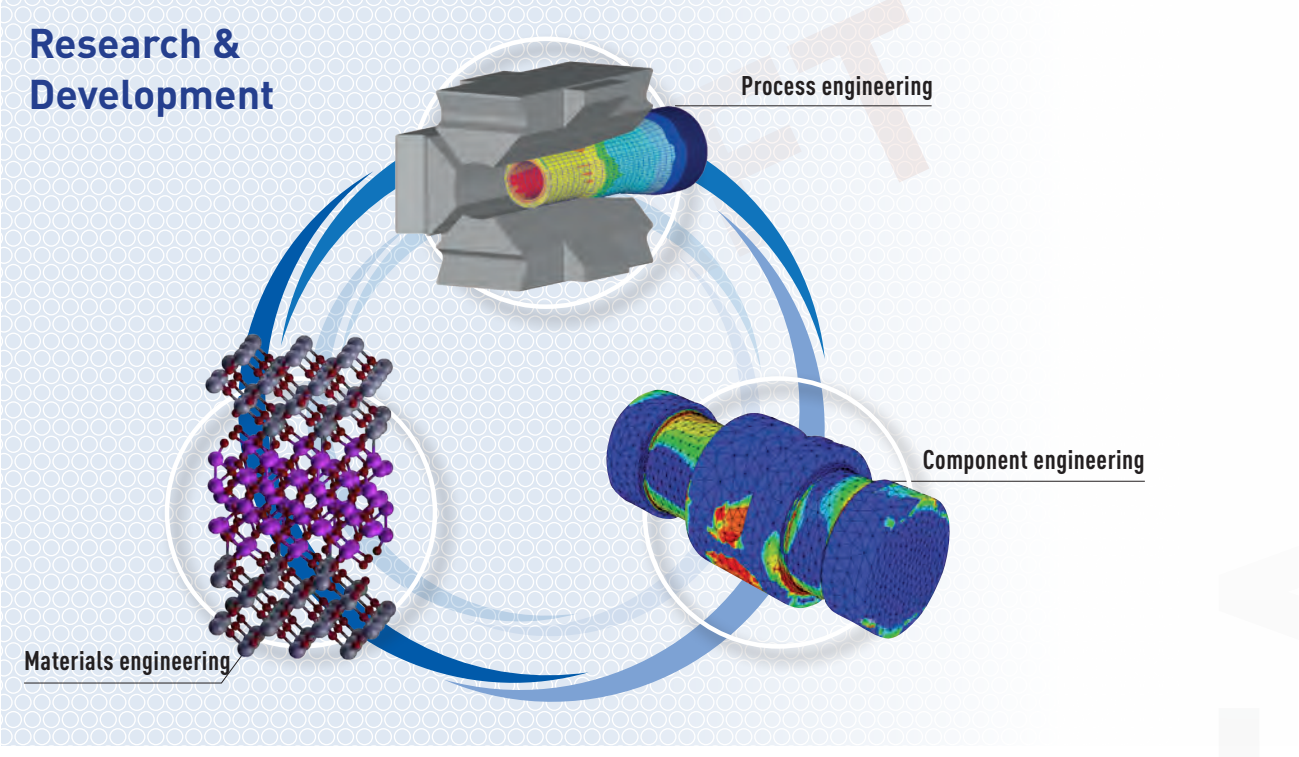
Highlights:

- **Parts for future aircraft**
- **Development of intelligent production facilities**
- **Cutting simulations for better cutting tools**
- **Novel test for characterising interface strengths in printed circuit boards**

Innovation through integrated materials, process and product engineering

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

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



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

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

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

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

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

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

The COMET research activities carried out in long-term projects in 2015 accounted for around 76% of the MCL volume. Some 13% of turnover came from direct research and development contracts or service activities and around 11% of the project volume came from research projects funded under other national and international research programmes.

Overview of COMET Phase II

Project volume and financing of COMET Phase II:

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

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

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

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

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

„Research and innovation are the basis of our prosperity“

Dr. Werner Ecker
Manager Simulation

Project volumes in the years 2013 to 2015:

The COMET volumes achieved in 2013 (€ 13.9 million), 2014 (€ 12.6 million) and 2015 (€ 12.3 million) clearly exceeded the average annual value of € 11.9 million planned for COMET Phase II. This was due to the launch of many new projects resulting from the planning phase for the second funding period and the completion of projects from the first funding period.

Projects and project development in the years 2013 to 2015:

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

11 COMET projects were completed and 7 new projects started in 2015. Thus a total of 45 COMET projects were ongoing at the end of 2015 as part of the COMET programme.

A total of 32 COMET projects were completed in the current funding period.

Projects 2013 to 2015	
completed 2013 to 2015	32
ongoing at the end of 2015	45

Publications and patents:

A total of 309 publications were published in the current funding period, of which 174 appeared in refereed journals. Scientific publications in this period also included 387 other contributions (posters, presentations etc.).

MCL filed two Austrian patents in 2015. A total of 7 patents were filed in the current funding period as part of the COMET Programme.

Publications 2013 to 2015	**309**
of which in refereed journals	174
of which in conference proceedings, journals and books	135
Patents 2013 to 2015	**7**

Degree theses:

A total of 32 doctoral theses and 30 diploma/master's theses were completed in the current funding period of the COMET Programme. Another 58 academic theses (54 doctoral theses and 4 diploma/master's theses) were ongoing at the end of 2015.

Doctoral theses:	**86**
completed 2013 to 2015	32
ongoing at the end of 2015	54
Diploma/Master's these	**34**
completed 2013 to 2015	30
ongoing at the end of 2015	4

COMET partners:

83 company partners and 48 scientific partners have so far been involved in the research programme of COMET Phase II.

Company partners:	**83**
national	44
Europe	36
Overseas	3
Scientific partners:	**48**
national	33
Europe	14
Overseas	1

Research areas:

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

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

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

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

The research activities will be illustrated by some examples.

- Parts for future aircraft
- Development of intelligent production facilities
- Cutting simulations for better cutting tools
- Novel test for characterising interface strengths in printed circuit boards

Parts for future aircraft

Air traffic is rapidly increasing worldwide. This has far-reaching consequences for the environment and the people in urban regions. To address this problem future turbine engines must be quieter, cleaner and more efficient. MCL is working with Böhler Schmiedetechnik and MTU Aero Engines on the development of mathematical models to determine the local material properties of forged turbine components. The aim of the research is to simulate the loads and strength in a turbine disk and thus provide design engineers with a powerful tool for optimising the design of aircraft turbines.

Fig. 1: Open turbine with turbine disk (© MTU Aero Engines)

Modern process technology for quieter ...

According to a forecast of a European aircraft manufacturer 40,000 airplanes will be in the skies by 2035 - twice as many as today. With the current state of technology in the aircraft industry, this would mean twice the air pollution and further acceleration of climate change. With a worldwide increase in passenger traffic, the noise impact on city regions and the global consumption of raw materials will further increase. To counteract this development engine manufacturers need to reduce noise, weight and fuel consumption. Furthermore, the service intervals should be extended. Consistent development efforts are needed to develop the powerful, environmentally friendly and quiet engines of tomorrow.

The Materials Center Leoben has developed a numerical model for the simulation of residual stresses in turbine disks for MTU Aero Engines and BÖHLER Schmiedetechnik GmbH & Co KG. Turbine disks are highly stressed parts of a jet engine containing the turbine blades. The combustion gas causes the turbine to rotate, thus generating thrust. The systematic development of highly loaded turbine components is unthinkable without computer models. In order to improve the properties in the course of the manufacturing process powerful computer models are required to predict the local material structure, material strength and residual stresses.

Fig. 2: Heat treatment measurements after forging with thermocouples in a turbine disk (© Böhler Schmiedetechnik)

... cleaner and more efficient turbines

Strength is the resistance of a material to plastic deformation. It is not a fixed value and can be adjusted by a heat treatment process. For optimum strength, the material needs to be understood on many physical levels, involving thermal, mechanical and chemical processes. After forging, the still hot component is quenched with a variety of liquids or gases. Like a hot glass that shatters when it is filled with cold water, the cooling leads to stresses in the material. These so-called residual stresses have an influence on the lifetime of all engines, because they overlap with the stresses during rotation of the turbine disk, and reduce the service lifetime and efficiency.

Impact and effects

The Materials Center Leoben mathematically describes complex processes and influences on the material properties during heat treatment and develops new computer models. The property distributions in the component are known at the end of a simulation chain and are a powerful tool for engineers involved in aircraft turbine design. It is thus possible to save material in the design phase, while at the same time meeting the stringent safety standards specified by the aircraft industry in terms of service life and load capacity.

Development of intelligent production facilities

Modern production facilities often manufacture large numbers of high-precision components in very complex operations. Due to the complexity and short duration of the individual operations, failures are often not noticed until the end of the production process, i.e. in the finished product. Intelligent production facilities learn to detect failures occurring during individual operations in time to react, e.g. by automatically exchanging a defective tool to prevent scrap.

Fig. 1: Parts that are produced via fine blanking today (© Fritz Schiess AG, CH-9620 Lichtensteig)

Fine blanking - precise and complex production in high quantities

In modern industrial production increasing quantities of identical parts are manufactured at ever higher speeds. Fine blanking is such a production process, where parts with complex geometries (Fig. 1) are cut out of sheet metal with thicknesses of several millimetres using a specific press.

Modern fine blanking presses allow the production of over 500,000 parts per day. As a rule of thumb the blanking forces increase linearly with the thickness and strength of the sheet metal used. The increase in blanking forces leads to an increase in local tool loading, especially for complex part geometries with small radii.

The tool as the "heart" of the cutting process

In fine blanking, the punch that is pressed through the metal sheet is subjected to the highest loads, apart from the matrices.

This punch is installed inside the fine blanking tool and cannot be visually inspected during a production run.

The high loads and abrasion may cause parts of the punch to be chipped off during the cutting process, producing imprints on subsequently produced parts or resulting in incorrect cutting. In the worst case chipped-off parts can even damage the entire cutting tool.

Automated monitoring of tool "health"

The replacement of a specific punch is usually scheduled based on the operator's know-how and depending on the punch geometry, punch material and blank material. However, punches may still break before the end of their service life.

In future, intelligent fine blanking machines should detect an emerging tool failure in time to automatically replace the tool and prevent scrap.

The big challenge is that the readily available global machine data are not sufficient for reliably assessing tool condition. Instead, the information must be obtained directly at the tool and analysed correspondingly.

Scientists at the Materials Center Leoben and the Institute for Automation of the Montanuniversität Leoben have therefore joined forces with the inventors of the fine blanking process, Fritz Schiess AG, in a COMET research project.

Big data and real time: a challenge

The development of future fine blanking machines involves the application of state-of-the-art sensors and the development of new mathematical algorithms. These algorithms enable the interpretation of the large amount of continuous monitoring data collected during production for several months in a fast, yet reliable way.

The speed of the algorithms will then be further optimised to enable real-time data analysis directly at the production site, i.e. on the fine blanking machine. Real time in this context means that data analysis is fast enough to enable an automated intervention between cutting operations.

Cutting simulations for better cutting tools

Increasing productivity is a key factor for successfully coping with international competition in industrial production. This development requires a knowledge-based design of cutting tools based on quantitative information on the tool loads and material reactions involved. To this end, a COMET project has developed a worldwide unique computer simulation model using experimentally determined material data for the hard metal substrate and the hard coatings as input parameters. The predicted location of tensile residual stresses that are detrimental to tool performance was verified using advanced experimental techniques.

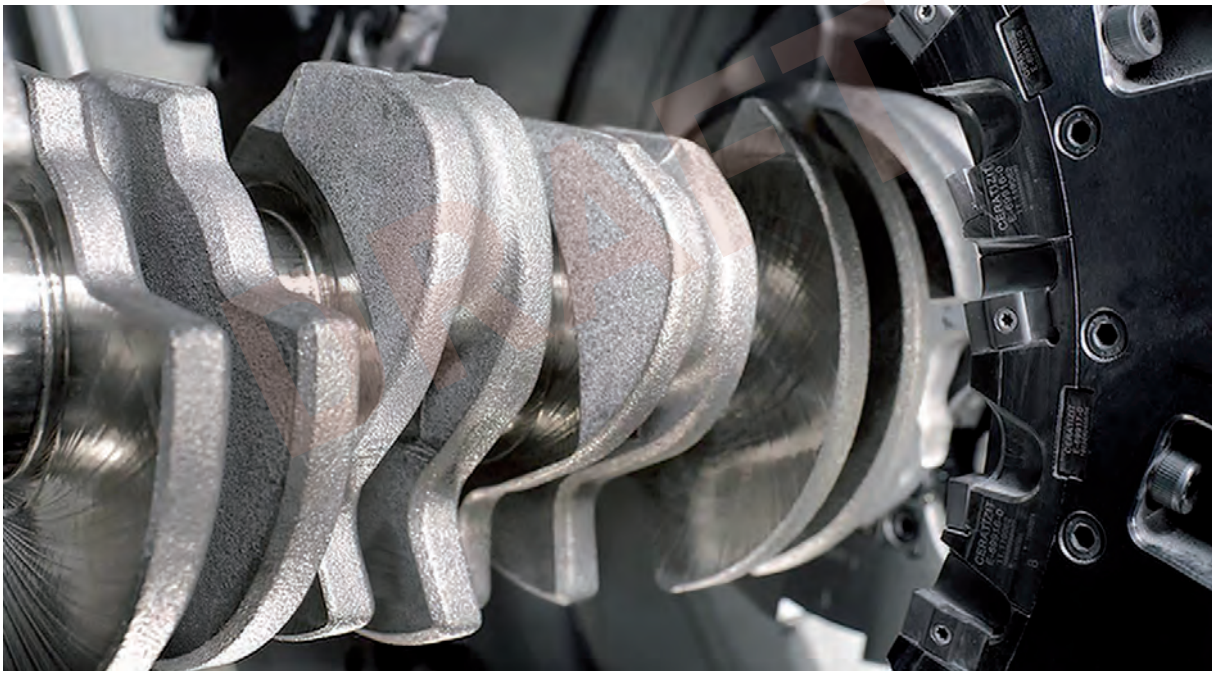


Fig. 1: Ring-shaped cutting tool with indexable inserts for crankshaft production (© Ceratizit Austria)

Increase material strength to decrease part weight

The automotive industry is constantly aiming to reduce the weight of moving parts in cars in order to increase cost and energy efficiency. Materials of higher strength and wear resistance must be used in order to ensure the functionality of these components. These materials put enormous stresses on the cutting tools used for shaping the components.

In machining processes such as milling (Fig.1) and turning, the component is shaped by removing the chips that form at the sharp cutting edges of indexable inserts.

Computer simulation facilitates the design of durable cutting tools

Cutting inserts are tools with a complex architecture. They consist mainly of a thin-film coated high-strength hard metal. The hard metals used are composite materials with a high hard phase content (tungsten carbide) and a metallic binder phase, which is typically cobalt with a volume fraction of 10 %. The wear resistance of cutting inserts is enhanced by the application of a hard coating which is only several micrometers thick. In industrial application the cutting edge is subjected to high loads that trigger wear and fatigue, which subsequently leads to the formation of cracks and tool failure. The efficiency and lifetime of cutting tools strongly depends on the complex interaction of tool load

and the corresponding tool material response.

The main factors influencing tool loads include e.g. material properties of the cut material, cutting edge geometry, depth of cut and cutting speed. The reaction of the tool to this load in turn depends on the properties of the different tool material components.

The development of cutting tools until today has been based mainly on a trial-and-error strategy. A prerequisite for a knowledge-based tool design is an advanced computer simulation model capable of predicting the tool load situation for a certain cutting application. This is achieved by using finite element (FE) simulation, a calculation method that is also applied in other product development processes.

MCL has developed an advanced FE simulation model for cutting tool design in close cooperation with the hard metal and hard coating manufacturers Ceratizit Austria and Ceratizit Luxemburg. The necessary input data for the model such as elastic, plastic and thermal material properties of the hard metal and the hard coating were determined at MCL using advanced experimental methods.

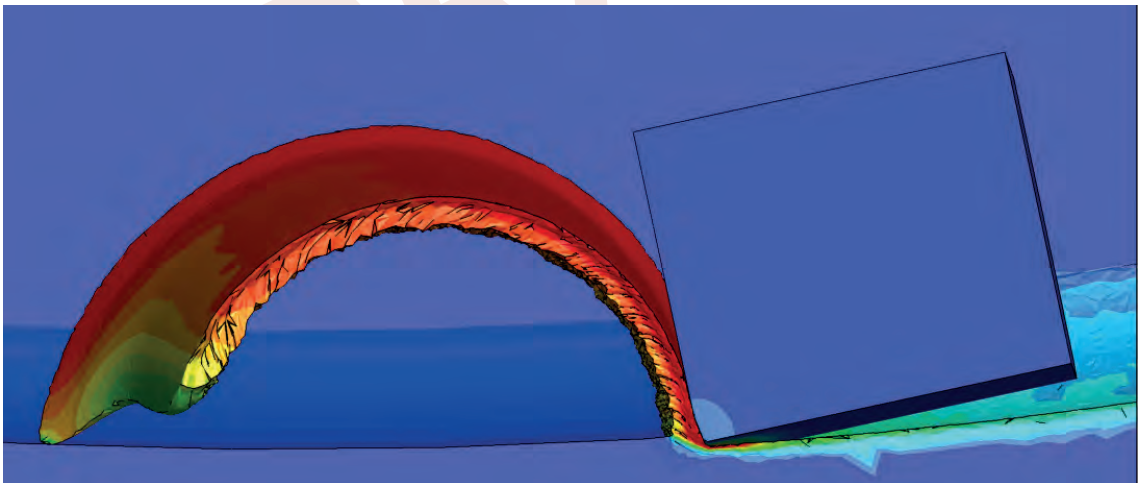


Fig. 2: Three-dimensional finite element simulation of a cutting process (© MCL)

Residual stresses in cutting inserts were measured with the aid of a synchrotron, a high-tech instrument producing high-energy x-ray radiation. Tensile stresses that are detrimental to tool lifetime were measured at exactly the same position in milling inserts as predicted by the simulation model. This successful comparison of theoretical prediction and experimental evidence now enables the knowledge-based virtual evaluation of changes in the tool architecture.

Impact and effects

The validated simulation model helps speed up development processes for hard coated cutting tools for specific cutting applications.

Ceratizit expects a 30 % increase in efficiency of coated hard metal tools as a result of the project. The project is a good example of how the build-up of unique know-how can help to preserve high-tech industrial production and research in Austria.

Novel test for characterising interface strengths in printed circuit boards

Printed circuit boards (PCBs) are the backbone of electronic devices. They are built up of layers of insulating and conductive materials. Delamination between these layers is one of the major reliability issues for PCBs, which makes the precise control of adhesion energy crucial for further improvements. A test setup originally developed for brittle materials was further advanced and applied to PCBs. A simulation software plug-in was programmed and transferred to industry enabling fast and reproducible interface characterisation.

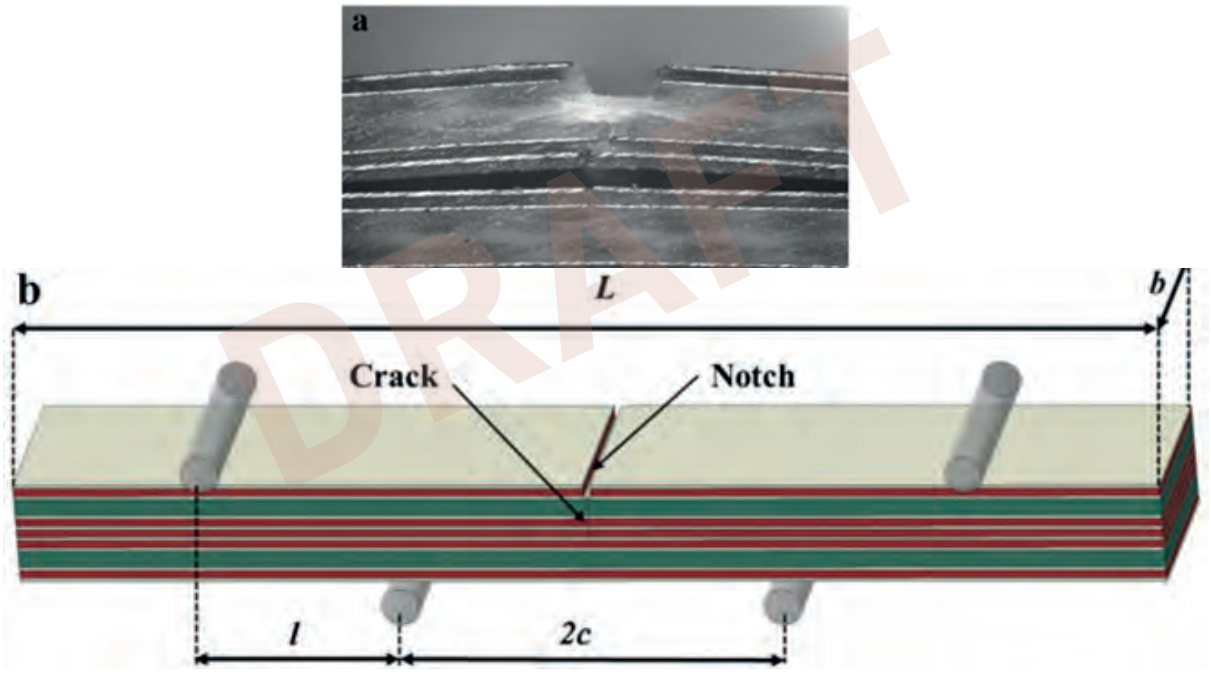


Fig. 1: Fractured interface from 4PB test (a) and layout of samples in the 4PB test (b) (published)

Motivation and Introduction

Printed circuit boards (PCBs) are the backbone of electronic devices; they provide interlayer wiring and mechanical stability. Most PCBs consist of fibre reinforced polymers and copper. The polymer acts as dielectric and mechanical carrier, whereas the copper provides electrical connectivity. Multilayer PCBs are designed to overcome design limitations and to enhance functionality. Such boards contain up to 14 layers of copper and polymer composite laminated together.

This stacking is an intrinsic source of failure because the different types of material differ substantially in their thermal expansion coefficients. This and the polymeric shrinkage during solidification can lead to failures such as cracks in the dielectric material or delamination of copper and polymer layers. The latter is the main cause of failure in PCBs subjected to thermal cyclic loading. Thermal cycling occurs during fabrication of the boards, during component mounting and soldering and during service, for example, when a mobile phone is exposed to the sun. Over the last decades, a lot of effort has been made to overcome these issues, mainly by introducing new composite materials, new processes and improved overall process control.

The recent development of new stacking systems and applications with on-going miniaturisation has reached the limit of existing testing facilities. This impedes knowledge-based design and requires the development of new testing methods.

Innovation and Testing Procedure

The project team took up the challenge to find methods for testing and detailed understanding of high precision engineered interfaces between copper and polymer composites.

The newly developed method consists of a specially designed sample set-up, a so called 4 point bending test, coupled with a finite element (FE) simulation tool for reliable evaluation of the results. The test is sketched in Fig. 1. As shown, the test specimen consists of 8 copper sheets and 7 polymer composite dielectric layers.

In a bending experiment, the force rises constantly until the fracture strength of the sample in the notched area is reached as shown in Fig. 2a. At this point a crack forms at the notch and is deflected at the weakest interface as shown in Fig. 1a, leading to a load plateau in the force-displacement curves. These curves are the basis for the further evaluation and interpretation of interface toughness in PCB materials. The simulation, as shown in Fig. 2, reveals the nonlinear material behaviour and the friction between the sample and the testing device.

The resulting interface energy is calculated considering all mechanical properties of the test species (details are summarised in [1]). The FE code was summarised in the easy-to-use "Bending Test" plug-in, which was made available to company partners for in-house use.

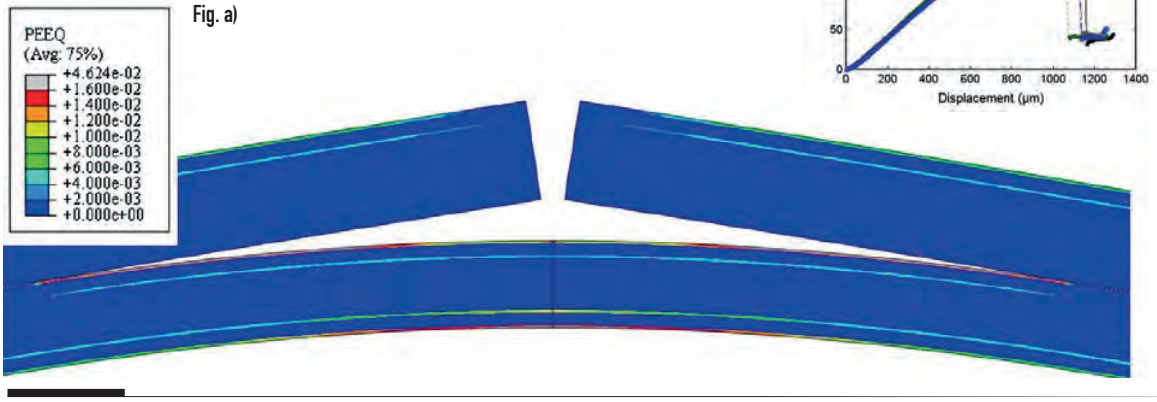
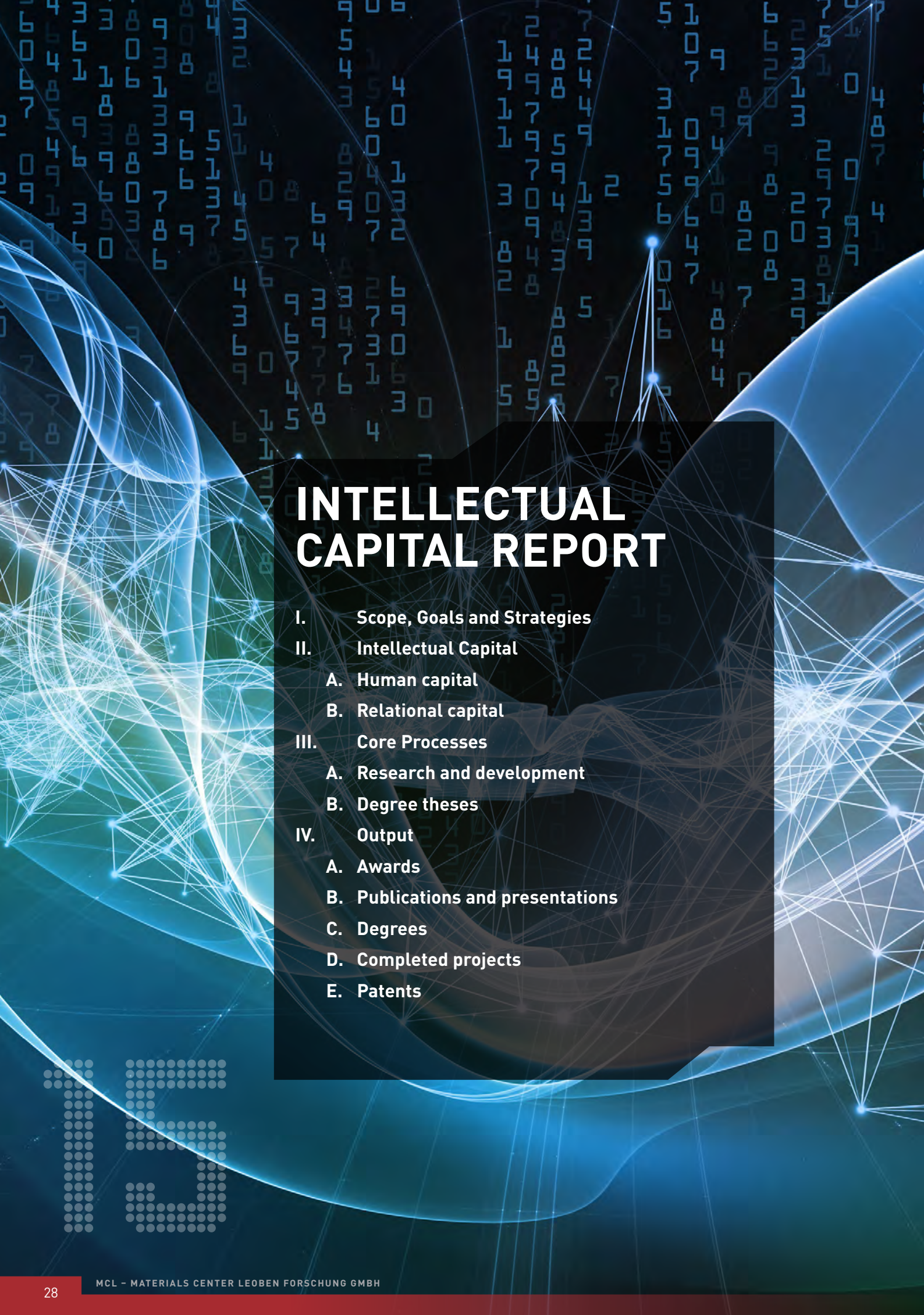


Fig. 2: Force-displacement curves of 4 samples of the same type showing the typical behaviour (a); simulation of the 4 point bending test (b) (published)

Impact and effects

The project provided a deep insight into the main causes of delamination in printed circuit boards via the design of a suitable test method for high quality PCBs. The project generated new knowledge regarding interface strength and developed a new testing method. The former can be directly used by fabrication partners in optimising their manufacturing processes; the latter is now part of the process design and qualification routine at AT&S and Panasonic Austria. It should be a major cornerstone in the development of next generation PCBs for highly loaded applications.

[1] R. Schöngrundner, et al., Adhesion energy of printed circuit board materials using four-point-bending validated with finite element simulations, Microelectronics Reliability (2015)



INTELLECTUAL CAPITAL REPORT

Intellectual Capital Report

I. Scope, Goals and Strategies

Knowledge and expertise are the key factors for the sustainable success of research institutions. The Intellectual Capital Report is designed to provide an overview of MCL's intellectual capital and research outcome. The key indicators in this context are scientific publications, human resources and international networks. Other important factors are output and impact, which are reflected in the number of completed projects or patent applications.

In addition to increasing its scientific excellence and its network, MCL strives to gain better visibility at the international level over the coming years. Various measures have been and will be implemented to achieve this goal:

- MCL defines and launches COMET projects involving new international partners from science and industry.
- Projects with new international partners can be started following successful participation in calls for proposals under international funding programmes.
- Greater cooperation with international scientific partners is being driven forward in order to strengthen the partner network.
- The International Scientific Advisory Board was established to enable renowned international scientists to critically assess the MCL strategy.
- More MCL employees are taking up positions on international committees.
- The drive to employ more international staff is being continued.
- The organisation and hosting of international conferences enables MCL employees to present their own expertise, to enter into contact with excellent international scientists and to discuss opportunities for cooperation.
- MCL employees are being given the support needed to allow them to take part in international conferences and undertake research abroad.
- Greater attention is being paid to how MCL publications are perceived externally.

II. I. Intellectual Capital

A. Humankapital

Development

MCL had 146 employees at the end of 2014. Unfortunately, staff numbers decreased in the course of the financial year and reached 133 at the end of 2015. This decrease resulted almost exclusively from a reduction in the number of Junior Scientists. Most Junior Scientists left MCL after completing their diploma/master's or doctoral theses, while doctoral students recruited for new projects in the COMET area were increasingly employed by the scientific partners.

By the end of 2015, MCL employed 27 international staff members from 14 different countries. This represents some 20% of the workforce. Our international employees bring significant benefits to MCL, and their collective experience adds greatly to MCL's range of expertise.

Over 400 additional employees of our company and scientific partners are working on projects in the COMET Programme. With a total of around 550 staff, the COMET Programme thus offers enormous potential for taking on highly complex scientific challenges.

Personnel at MCL/MPPE 2015

as of: 31/12/2015	Employees male	female	total
Research	**84**	**26**	**110**
Scientific management	1	0	1
Key scientists	14	1	15
Senior scientist	19	7	26
Junior scientist	50	18	68
Administration	**0**	**11**	**11**
Technicians / Skilled staff	**9**	**3**	**12**
Total MCL	**93**	**40**	**133**

Personnel at COMET Partners 2015

Company partners	200	16	216
Scientific partners	172	35	207
Gesamt	**372**	**51**	**423**

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

Gender Mainstreaming

The proportion of female employees at MCL increased further in 2015. As of 31 December 2015, women accounted for 30% of the total workforce and around 24% of scientific employees. The proportion of women working in the Microelectronics division was significantly higher and reached 50%, taking into account technicians and students.

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

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

Qualification measures and personell development

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

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

MCL also helps employees organise their professional environment so that they can complete post-doctoral qualifications.

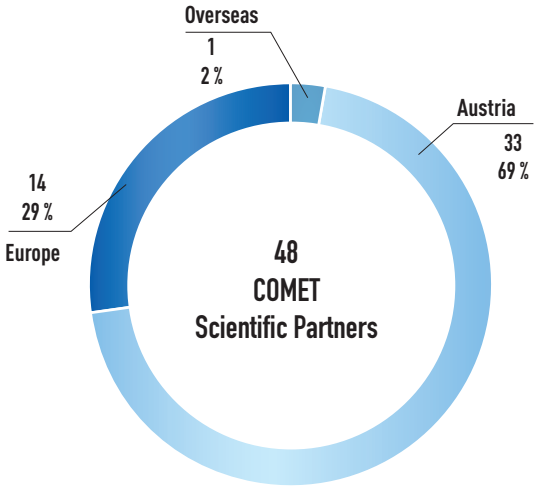
B. Relational capital

COMET – Scientific Partners

A large number of scientific partners have joined the COMET Programme over the past few years to work jointly on the solution of complex research problems. A total of 48 scientific partners from 24 research institutions and universities were involved in COMET Phase II until 2015:

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

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



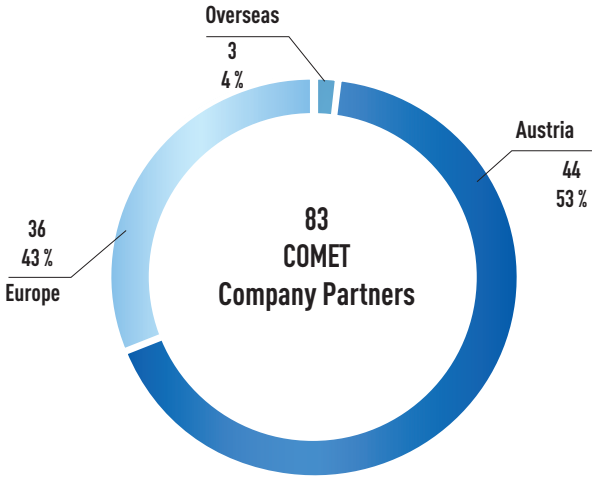
Number and origin of scientific partners

COMET – Company Partners

The majority of the company partners from COMET Phase I also participate in the second funding period. 4 new company partners joined the COMET Programme in 2015. A total of 83 national and international companies were involved in COMET Phase II until 2015:

Agie Charmilles SA
Almatis GmbH
Alstom Transport Deutschland GmbH
AMAG Casting GmbH
AMAG Rolling GmbH
ams AG
AMSC Austria GmbH
Andritz AG
Andritz Hydro GmbH
AT&S AG
AVL List GmbH
Bochumer Verein Verkehrstechnik GmbH
Böhler Edelstahl GmbH & Co KG
Böhler Schmiedetechnik GmbH & Co KG
Böhler Schweißtechnik Austria GmbH
Böhler Schweißtechnik Deutschland GmbH
BOLIDEN Commercial AB
Bruker AXS Analytical X-Ray Systems GmbH
Buderus Edelstahl GmbH
Calderys France SA
Ceratizit Austria Gesellschaft mbH
Ceratizit Deutschland GmbH
Ceratizit Luxembourg S.a.r.l.
Continental Automotive GmbH
Deutsche Edelstahlwerke Gmbh
Eisenwerk Sulzau-Werfen R. & E. Weinberger AG
Epcos OHG
Europipe GmbH
Faively Transport Witten GmbH
Federation for International Refractory Research and Education
Fritz Schiess AG
Georg Fischer Automotive AG
Gutehoffnungshütte Radsatz GmbH
Hegenscheidt MFD GmbH & Co KG
Infineum International Limited
Kerneos SA
Komptech Umwelttechnik GmbH
Konrad Forsttechnik GmbH
Krenhof Aktiengesellschaft
LINMAG GmbH
Linsinger Maschinenbau GmbH
LUK GmbH &CoKG
MAGMA Gießereitechnologie GmbH
MIBA Gleitlager GmbH
MIBA Sinter Austria GmbH
MTU Aero Engines GmbH
Nemak Linz GmbH
Nicolis Technology AG
ÖBB Infrastruktur AG
OMV Exploration & Production GmbH
Panasonic Industrial Devices Materials Europe GmbH
Pewag Austria GmbH

Plansee SE
Platit AG
Primetals Technologies Austria GmbH.
Pyrotek High-Temperature Industrial Products Inc.
RAG - Rohöl-Aufsuchungs AG
RHI AG
Rio Tinto Alcan
Robert Bosch GmbH
Sandvik Mining and Construction GmbH
Schoeller-Bleckmann Edelstahlrohr GmbH
Siemens Aktiengesellschaft Österreich
SKF Österreich AG
Stadler Pankow GmbH
Stahl Judenburg GmbH
Sucotec AG
TAG s.r.l.
Tata Steel Ijmuiden B.V.
Thales Corporate Services
ThyssenKrupp Presta AG
TIWAG Tiroler Wasserkraft AG
Vallourec Group
voestalpine Edelstahl GmbH (former: Böhler Uddeholm AG)
voestalpine Grobblech GmbH
voestalpine Schienen GmbH
voestalpine Stahl Donawitz GmbH & Co KG
voestalpine Stahl GmbH
voestalpine Tubulars GmbH & Co KG
voestalpine VAE GmbH
Voith Turbo GmbH & Co.KG
Welser Profile Austria GmbH
W. Blösch AG



Number of company partners by origin

Non-COMET partners

Nationally funded programmes

In addition to ongoing projects, MCL launched two new nationally funded projects under the "Production of the Future" programme ("FlipTheLED" and "HiTec") in 2015. MCL coordinates the "FlipTheLED" project and also the "Smart Forge" project, which started in 2015 as part of the TAKE OFF funding programme. Another project under the FFG General Programme was started in cooperation with an Austrian company partner.

MCL cooperated with a range of partners in a total of 13 projects funded under various national programmes (e.g. "Intelligent Production", "Production of the Future, "FWF", etc.) in 2015. A wide variety of national funding programmes are available for different target groups, so that MCL's industrial partners in this area range from medium-sized to large enterprises.

Programmes with international funding

In 2015, MCL was involved in the two ENIAC projects "POLIS" and "eRamp", which had been launched in the previous year. These projects include 23 and 28 national and international project partners from industry (e.g. STMicroelectronics, EVG Group, Infineon Technologies, etc.) and science (e.g. CEA-Leti, University of Edinburgh, IMEC, etc.), offering MCL the opportunity to increase its expertise and international visibility and further expand its partner network.

In 2015, MCL also coordinated the project "MSP - Multi Sensor Platform for Smart Building Management", which started in 2013 and includes 17 partners from industry, universities and research institutions in 6 European countries, e.g. AMS AG, EV Group, Siemens AG, Samsung R&D Institute UK, Fraunhofer, the University of Cambridge and the University of Oxford.

The project "EasyForm", which was carried out together with 5 project partners from industry and non-university research was completed successfully in 2015.

Another 5 internationally funded projects, some of which involve large international consortia, were approved in 2015 and are scheduled to start in 2016.

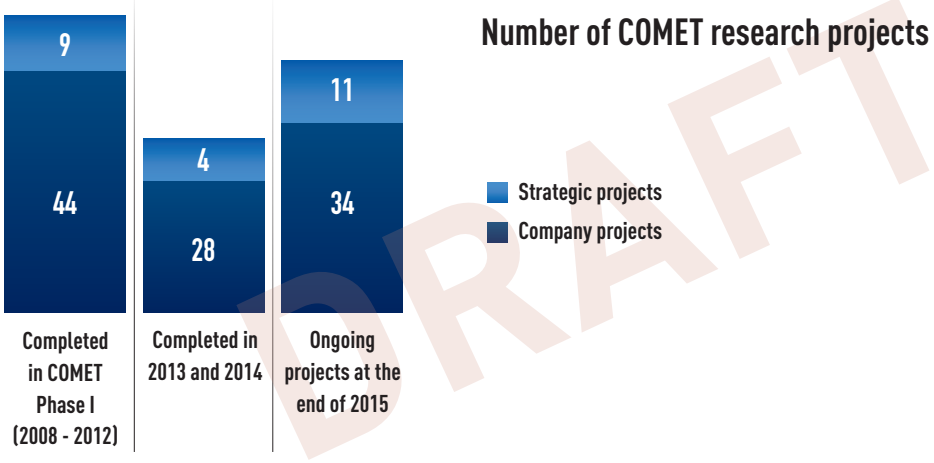
Unfunded non-COMET projects

In 2015, MCL again succeeded in winning many new customers and establishing regular customers. New customers were involved in both smaller contracts as also larger projects. While the list of regular customers is dominated by large enterprises, the smaller contracts come from many smaller and medium-sized businesses. All in all, MCL has a broad customer base of some 160 company partners in the unfunded sector.

III. Core Processes

A. Research and development

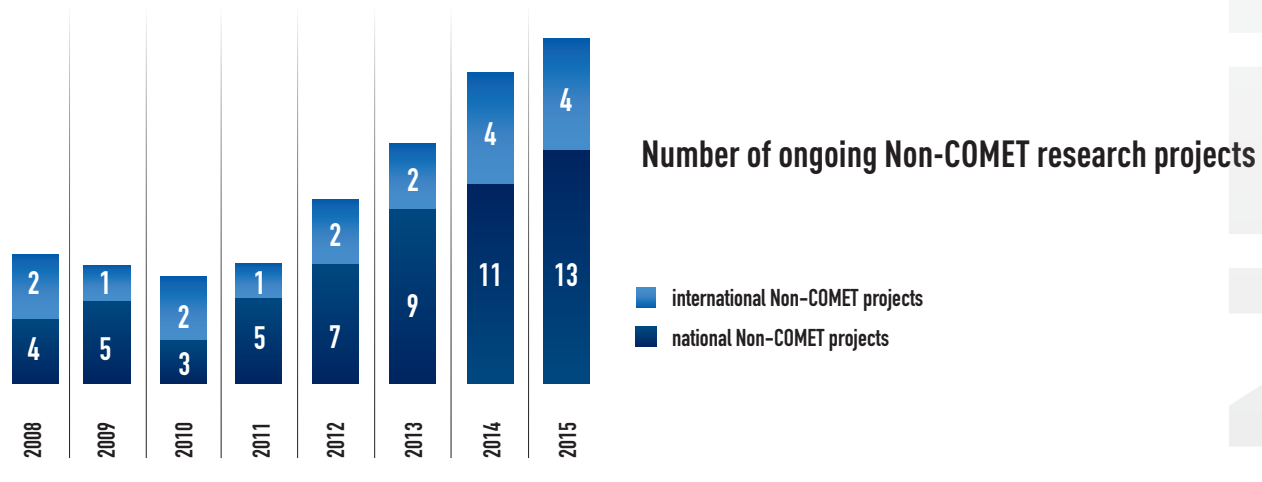
In 2015, MCL started 7 new **COMET projects** in collaboration with company partners. 9 company projects and 2 strategic projects were successfully completed in 2015. A total of 45 COMET projects were ongoing at the end of 2015, creating a sound basis for the coming years.



In the **non-COMET area**, MCL worked on a total of 13 nationally funded and 4 internationally funded projects in 2015. MCL was also extremely successful in both national and international project applications.

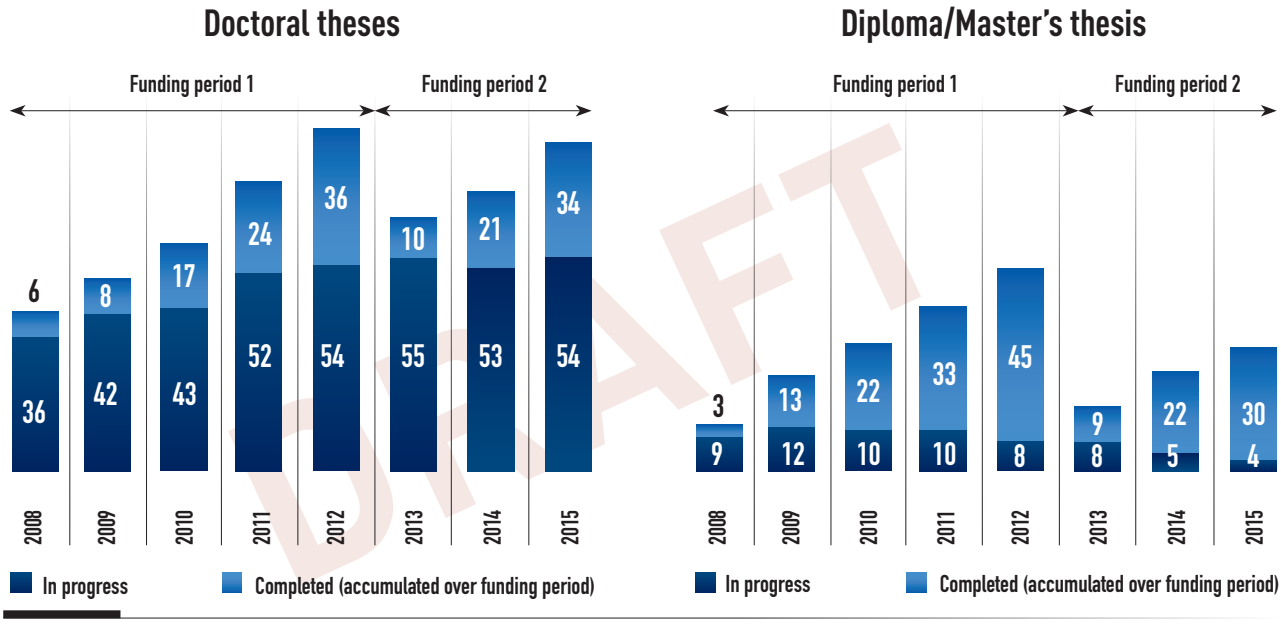
A total of eight projects were approved in which MCL acts as the consortium leader or as a partner: two projects in the national "Production of the Future" programme, one project in the Austrian aviation programme TAKE OFF, two HORIZON 2020 proposals, two ECSEL projects and one project in the Clean Sky 2 Joint Undertaking.

MCL also became a member of the Shift2Rail Joint Undertaking as part of the VVAC+ consortium and will participate in the relevant calls in 2016.



B. Degree theses

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



Doctoral theses as part of COMET projects:

During 2015, a total of 11 doctoral theses were successfully completed as part of COMET projects carried out at MCL. 54 doctoral theses were in progress by the end of 2015. A total of 32 doctoral theses were successfully completed in the current funding period by the end of 2015. In comparison, 17 doctoral theses were successfully completed during the first three years of the first funding period, and 36 over the entire first COMET funding period.

Diploma/Master's theses as part of COMET projects:

A total of 30 diploma/master's theses in the COMET area were successfully completed in the current funding period by the end of 2015. Another 4 theses were in progress at the end of 2015. In comparison, 22 diploma/master's theses were successfully completed during the same period in the first funding period and 45 theses in the entire first funding period.

Doctoral, Diploma/Master's theses as part of non-COMET projects:

The increase in the number of funded non-COMET projects carried out at MCL has also led to a corresponding increase in the number of degree theses in this area. One doctoral thesis and 6 diploma/master's theses were successfully completed outside the COMET area in 2015. Another 7 doctoral theses and 2 diploma/master's theses were in progress in the non-COMET area by the end of 2015.

IV. Output

A. Awards

Award for Dr. Marco Deluca as most cited author in 2014

The 3rd General Assembly of the Austrian Ceramic Society (AuCerS) took place at TU Wien on 10 February 2015 and was attended by 23 scientists.

The event also included a presentation competition and Dr. Marco Deluca received the prize as the most cited author in 2014.

Most cited publications by Dr. Deluca (acc. to ISI Web of Knowledge):

- Lone-Pair-Induced Covalency as the Cause of Temperature- and Field-Induced Instabilities in Bismuth Sodium Titanate, by D. Schütz, M. Deluca, W. Krauss, A. Feteira, et al., Adv. Funct. Mater. 22[11], 2285-2294 (2012) – 43 citations.
- Structure and Properties of Fe-modified Na0.5Bi0.5TiO3 at Ambient and Elevated Temperature, by E. Aksel, J. S. Forrester, B. Kowalski, M. Deluca, et al., Phys. Rev. B 85[2], 024121 (2012) – 37 citations.
- Raman Spectroscopic Study of Phase Transitions in Undoped Morphotropic PbZr1-xTixO3, by M. Deluca, H. Fukumura, N. Tonari, C. Capiani, et al., J. Raman Spectrosc. 42[3], 488-495 (2011) – 20 citations.

MCL congratulates Marco Deluca on winning this prize.

Dr. Vsevolod Razumovskiy is Recognised Reviewer for the Journal of Alloys and Compounds

Dr. Razumovskiy, who has worked for MCL since 2012, was awarded Recognised Reviewer status for the Journal of Alloys and Compounds from Elsevier publishers.

The Journal of Alloys and Compounds is intended to serve as an international medium for the publication of work on solid materials comprising compounds as well as alloys. Its great strength lies in the diversity of disciplines which it encompasses, drawing together results from materials science, solid-state chemistry and physics.

In much of the work published in the journal, synthetic and structural studies are combined with investigations of chemical and physical properties of alloys and compounds, contributing to the development of areas of current scientific interest. Papers submitted for publication should contain new experimental or theoretical results.

For more information go to:
http://www.journals.elsevier.com/journal-of-alloys-and-compounds

Our congratulations on receiving this award!

Franz Leitner Award for Dr. Martin Leitner

The Franz Leitner Award in recognition of excellent achievements in the field of welding technology was presented at this year's ASMET Forum on 19 May 2015.

Dr. Ronald Schnitzer (Head of Research and Development, voestalpine Böhler Welding Austria GmbH) Dr. Martin Leitner (Montanuniversitaet Leoben, Chair of Mechanical Engineering) DI Martin Reicher (COO, voestalpine Böhler Welding Austria GmbH)

The award is presented every two years in memory of the achievements of Bergrat h.c. Professor Dr.mont. Dr.techn. Franz Leitner and is sponsored jointly by the board of the Austrian Society for Metallurgy and Materials (ASMET) and the management of Böhler Welding Technology Austria GmbH.

The first prize this year went to the doctoral thesis of DI Dr.mont. Martin Leitner from the Chair of Mechanical Engineering.

The doctoral thesis was completed as part of the COMET K2 project "Method development for characterising the fatigue assessment of high-strength steel weld ends".

Our congratulations on receiving this award!

Josef Krainer Sponsorship Award 2015 for Dr. Paul Kainzinger

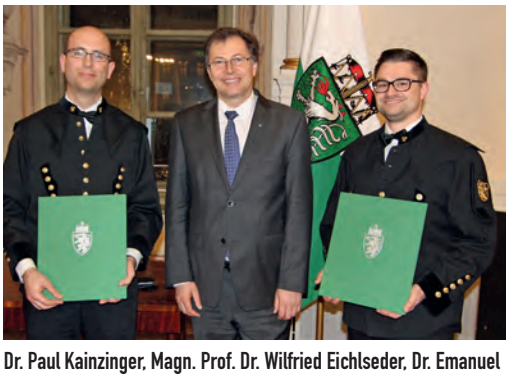
Each year since 1993, the Gedenkwerk organisation founded in 1973 has presented Josef Krainer Awards in three categories in remembrance of the great Styrian Governor. The Josef Krainer Sponsorship Award is presented to young scientists in recognition of their achievements and aims to encourage them to continue to engage in scientific work.

DI Dr.mont. Paul Kainzinger from the Chair of Mechanical Engineering received the Josef Krainer Sponsorship Award for his doctoral thesis at the prize-giving ceremony on 16 March 2015.

Dr. Kainzinger wrote his doctoral theses on "Influence of defects on fatigue resistance of ductile iron" at the Chair of Mechanical Engineering. The thesis develops material models for predicting local cyclic material strength, thus allowing optimal exploitation of the material's potential.

The doctoral thesis was completed as part of a COMET K2 project of the MPPE Competence Centre for Integrated Research in Materials, Processing and Product Engineering.

Our congratulations on receiving this award!



Dr. Paul Kainzinger, Magn. Prof. Dr. Wilfried Eichlseder, Dr. Emanuel Schwaighofer

Hans List Fonds scholarship for DI Florian Summer

The Hans List Fonds was launched in memory of Prof. Dr. Dr. h.c. Hans List, founder of AVL List GmbH. Its aim is to grant scholarships for innovative and outstanding Master's and doctoral theses in the fields of internal combustion engine development, drive technology and related fields. A total amount of € 26,000 was disbursed to students of Styrian universities in 2015.

DI Florian Summer, doctoral student at the Chair of Mechanical Engineering, Montanuniversitaet Leoben, received a scholarship for his doctoral thesis entitled "Tribometric assessment towards functionality of current and future journal bearing systems".

The research originates from several funded projects such as the COMET K2 project A6.21 of the Competence Centre for Integrated Research in Materials, Processing and Product Engineering and a project carried out under the Austrian aviation programme TAKE OFF.

We congratulate Florian Summer on winning this scholarship!

Hans Theisbacher Award for DI Stefan Schachner

This award has been established in memory of Hans Theisbacher (his widow, Friedl Theisbacher, is an honorary citizen of Montanuniversitaet Leoben), former CEO and representative of Radex Austria in Australia. It is awarded for excellent Diploma and Master's theses relating to refractories by graduates who have completed their studies at Montanuniversitaet Leoben with distinction. The prize is awarded by a Board of Trustees and has been presented since the academic year 1992/93.

DI Stefan Schachner received the award for his Master's thesis entitled "Investigation of the dissolution kinetics of ZrO2 and Al2O3 in mold powders with a confocal laser scanning microscope at high temperature". The Master's thesis was written as part of a COMET K2 project.

Our congratulations on receiving this award!

Magn. Prof. Dr. W. Eichlseder, Xiao Yang, DI Stefan Schachner, Bergrat h.c. Honorary Senator DI Dr.mont. H. Longin

Best Poster Award for DI Manuel Schemmel at Heat Treat 2015

The American Society of Metals (ASM) organised the 28th ASM Heat Treating Society Conference and Exposition ("Heat Treat 2015") in Detroit, Michigan, USA, from 20 to 22 October 2015.

An expert jury awarded first prize to the poster "Modeling the Quenching and Annealing Process of Massive Hot-Work Tool Steel Components" presented by DI Manuel Schemmel.

Heat treatment is one of the most decisive processes in the production chain for steel components. Rapid quenching from temperatures over 1000°C and repeated annealing at approx. 600°C make it possible to tailor the hardness and fracture toughness of the steel to the specific application requirements.

High-pressure gas quenching is the technology of choice for massive die-casting dies with a typical unit weight of 2 to 3 t. Compared to liquid quenching media, this technology enables the production of dies with clean surfaces, homogeneous hardness distributions, reduced distortion and low residual stresses.

The research is aimed at increasing the service life of dies while also reducing the risk of quench cracks occurring during the heat treatment process. The simulation methods and models presented enable the prediction of residual stress development, hardness and fracture toughness taking into account the phase conversions occurring during quenching. The results were validated using x-ray residual stress measurements of laboratory specimens (160 kg) and real-size dies (3 t)

We congratulate Manual Schemmel on this success!

Richard Marek Award for Dr. Martin Leitner

Ass.Prof. Dr. Martin Leitner from the Chair of Mechanical Engineering, Montanuniversitaet Leoben, received the Richard Marek Award for his paper "The potential of welded high strength steel structures for lightweight design". The prize was presented on 30 September 2015 in Linz during the trade show SCHWEISSEN 2015 and the accompanying workshop organised by the Austrian Welding Society (ÖGS).

The prize is presented to the most innovative welding solution submitted. The assessment criteria include clear presentation of the problem to be solved, the level of innovation, the metallurgical and technological approach chosen and the industrial implementation taking economic aspects into account.

The findings presented in the paper largely originate from the COMET K2 project "Fatigue assessment of high strength steel welded joints emphasizing finishes of complete welds" of the MPPE Competence Centre for Integrated Research in Materials, Processing and Product Engineering.

Ass.Prof. Dr. Martin Leitner (Montanuniversitaet Leoben, AMB) and Dr. Gerhard Posch (Chairman of the OGS Executive Board)

Award for DI Clemens Krautgasser at the AuCerS Student Speech Contest

The 3rd Meeting of the Austrian Ceramic Society (AuCerS) was held at TU Wien on 10 February 2015. 23 scientists participated in this meeting.

The event included a poster competition, in which DI Krautgasser took second place with his presentation "Ceramic Based Printed Circuit Boards - Influence of Temperature and Humidity on the Substrate Strength":


Urkunde

Anlässlich des Präsentationswettbewerbs der Österreichischen Keramischen Gesellschaft

wird Herrn Clemens Krautgasser

für die Präsentation

Ceramic Based Printed Circuit Boards – Influence of Temperature and Humidity on the Substrate Strength

der 2. Preis zuerkannt

Wien, am 10. Februar 2015

Der Vorsitzende der Österreichischen Keramischen Gesellschaft

Prof. Dr. Robert Danzer

Most modern electronic components are mounted on circuit boards. Low Temperature Co-fired Ceramic technology (LTCC) provides components with improved electrical, thermal and geometrical behaviour (e.g. a low dielectric loss factor) compared to the widely used polymer laminate based printed circuit board (PCB) technology. The mechanical stability of the device and thus its functionality, depends on the strength of the board substrate material.

Due to the glass content in LTCC materials their strength is strongly affected by the environment. Strength degradation is related to subcritical crack growth mechanisms acting at the crack tip during mechanical loading. In this work the effect of humidity and temperature on the strength of a commercial Low Temperature Co-fired Ceramic was investigated using a biaxial testing procedure. Experiments were performed in argon and in air at different stress rates between 25°C and 125°C. The effect of humidity on strength was assessed at room temperature by varying only the relative humidity. The sole effect of temperature was evaluated in argon at high stress rates. The combined effect of humidity and temperature was determined in air by testing at different temperatures. The results showed the existence of an inert strength of the material at room temperature. Measurements in ambient air showed a counterbalance effect of temperature and humidity yielding an almost constant strength for this material in the typical application range.

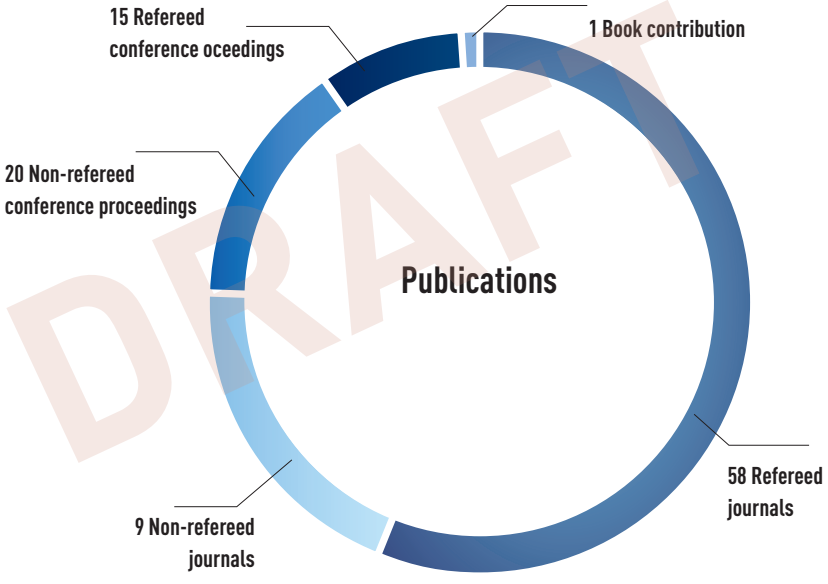
Congratulations on winning this award!

„Collaboration in research – the key to success“

Dr. Stefan Marsoner
Manager Materials Technology and Internal & External Services

B. Publications and presentations

The majority of scientific papers from the COMET Center were published in refereed journals. The Center's results were also communicated at numerous national and international conferences, workshops and specialist events in the form of oral and poster presentations. The scientists presented their project results at relevant European events, as also at conferences in the USA, Canada, Australia, Central America and the Middle East.



During 2015 the COMET Center used various channels to present its research output:

- papers in specialist journals (of which 58 in refereed journals)
- 86 international conferences, workshops and specialist events
  - 35 papers in conference proceedings (of which 15 in refereed proceedings)
  - 115 oral/poster presentations
  - 1 book (Characterization of fatigue crack growth with the configurational force concept, Fortschritt-Berichte VDI, Reihe 18 Mechanik/Bruchmechanik)

The growing number of projects outside COMET have enabled MCL to increase its publication output in this area. Research carried out as part of non-COMET projects led to 17 articles (of which 16 refereed), two conference papers (of which 1 refereed) and two presentations in 2015.

Over the past years greater attention has been paid to the external perception of MCL publications. Therefore in 2012 a database was set up to record and access citations of publications relating to MCL projects. The database is used to calculate and track the number of cited publications, the total number of citations, and the h-index of MCL team members. The development of these indicators over the years show a very positive trend, providing evidence of the scientific productivity and the increased impact and visibility of MCL in the scientific community.

C. Degrees

The following doctoral and diploma theses were completed in 2015.

Dissertationen:

Magnien Julien
Investigation of Mechanical Behavior and Failure Mechanisms in Miniaturized Solder Interconnects

Macurova Katerina
Simulation of the packing process of embedded components in printed circuit boards

Shengli Jin
Investigation of compressive refractory creep

Ochensberger Walter
Characterization of fatigue crack growth with the configurational force concept

Krautgasser Clemens
Mechanical characterization of low temperature co-fired ceramics for microelectronic applications

Kracalik Michal
Influence of the vehicle-track parameters on the crack growth in rails

Tkadletz Michael
Advanced characterization techniques for the knowledge-based design of hard coatings

Triebl Christoph
Numerische Simulation des gesamten Vorwärmprozesses zur Behandlung von Stahlbändern am Beispiel der Feuerverzinkungslinie der voestalpine

Zhou Xiang
Rissfortschritt in duktilen Stählen unter zyklischer Belastung: Einfluss des Herstllungsverfharens und der Lastgeschichte

Mühlbacher Marlene
Interdiffusion with model TiN/Cu and TiTaN/Cu systems synthesized by combinatorial thin film deposition

Fasching Christoph
Mikromechanische Simulation der Gefügeausbildung und der Eigenschaften einer Magnesia-Spinell Keramik

Öksüz Kerem Ilyas
Thermodynamic and thermokinetic quantitative prediction about precipitation of dispersoids containing Fe, CR and/or Mn in 6xxx series aluminium alloys

Diploma / Master's theses:

Brandl Dominik
Optimierung eines Glühprozesses zur Perlitisierung von Stahlstäben aus dem Einsatzstahl 18CrNiMo7-6 in großen Dimensionen

Doppler Markus
Entwicklung einer Umlaufbiegeprüfmaschine zur Bewertung des Größeneffekts zyklisch beanspruchter Kompontenten

Faheem Shah
Crack propagation analysis of welded joints by numerical and experimental investigations

Kaufmann Petra
Bestimmung der Domänentextur in piezoelektrischen Aktoren mittels polarisierter Raman-Spektroskopie

Koczwara Christian
Elektro-thermische Charakterisierung von MultiLayer-Varistoren

Mitterhuber Lisa Maria
Structure function based evaluation of the thermal behavior of an LED (TUG)

Pöttinger Maximilian
Characterization of the Zirconium and Chromium dispersoid in 7xxx aluminium alloys during the homogenization process

Reinhart Ricardo
Verzug von diamantbeschichtetem Hartmetallwerkzeug

Reisinger Stephan
Mikrostruktureller Aufbau eines Karbid aushärtbaren Stahls im bainitischen Zustand

Schachner Stefan
Untersuchung der Auflösungskinetik von ZrO2 und Al2O3 in Gießschlacken mit einem konfokalen Laser-Scanning-Mikroskop bei hoher Temperatur

Stoxreiter Thomas
Durchführung und numerische Simulation des Keilspalttests an Gesteinsproben

Thöni Nicle Maria
UV-Photodetection with ZnO nanowire arrays and SnO2 Thin Films on Silicon Chips (Leopold Franzens Uni Innsbruck)

Travieso Bernat Zaragoza
Real Time Embedded Wind Turbine Emulator with Fault Injection Capabilities (FH Joanneum)

Wilhelm Kubin
Voraussage von wachstumsfähigen Squats ausgehend von einer Fehlstelle im Randbreich der Fahrspur einer Schiene

„Creativity, commitment and diligence are essential for turning plans into reality“

Dr. Günther Maier
Manager Materials for Microelectronics

D. Completed projects

A total of 11 COMET projects were successfully completed in 2015:

A1.9 The impact of atomic trapping on diffusion and phase transformation kinetics

Technische Universität Wien, Montanuniversitaet Leoben, Technische Universität Graz, Academy of Sciences of the Czech Republic, Materials Center Leoben Forschung GmbH

A1.10 Modelling of the micro-structure evolution during cold rolling and continuous solution annealing of aluminium alloys

AMAG rolling GmbH, Technische Universität Graz, Technische Universität Wien, LKR Leichtmetallkompetenzzentrum Ranshofen GmbH, Materials Center Leoben Forschung GmbH

A2.17 Advanced techniques for characterizing structure and residual stresses in multilayered thin films and engineering components

Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A3.18 Simulation of the packaging process of embedded components in printed circuit boards (PCBs)

AT&S AG, Thales Global Services, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A4.16 Creep of refractories under tensile loads

RHI AG, voestalpine Stahl GmbH, Montanuniversitaet Leoben, Group d'Étude des Matériaux Hétérogènes, Ecole Nationale Supérieure de Céramique Industrielle, Materials Center Leoben Forschung GmbH

A5.13 Low expansion alloys for industrial application

Böhler Edelstahl GmbH & Co KG, Karl-Franzens-Universität Graz, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A5.16 Knowledge-based design of coated hard metal cutting tools

CERATIZIT Austria GmbH, CERATIZIT Luxembourg S.à.r.l., Sucotec AG, Montanuniversitaet Leoben, Austrian Academy of Science, Materials Center Leoben Forschung GmbH

A6.18 Gebrauchseignungskonzept für Großgeneratoren

Andritz Hydro GmbH, Montanuniversitaet Leoben, Österreichische Akademie der Wissenschaften, Materials Center Leoben Forschung GmbH

A6.19 Fatigue assessment of high strength steel welded joints emphasizing finishes of complete welds

Siemens Aktiengesellschaft Österreich, Komptech Umwelttechnik GmbH, Konrad Forsttechnik GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH

A7.11 Life time of functional multilayer ceramic systems

EPCOS OHG, Continental Automotive GmbH, Montanuniversitaet Leoben, Universität Wien, Materials Center Leoben Forschung GmbH

A7.14 Interface Properties between Pre-preg and Conductive Layers

AT&S Aktiengesellschaft, Panasonic Industrial Divices Materials Europe GmbH, Montanuniversitaet Leoben, Materials Center Leoben Forschung GmbH Forschung GmbH

4 projects were successfully completed in the non-COMET area in 2015:

High TEMP-CFK **Development of cost efficient CFK compound materials with thermal protection and reflective coatings**
Programme line: FFG - Intelligent Production
Partners: 3

SolDot **Sol based doping of ceramics**
Programme line: FFG - Bridge
Partners: 2

Rail Systems **RCF – influence of vehicle/track parameters**
Programme line: COMET (ViF)
Partners: 7

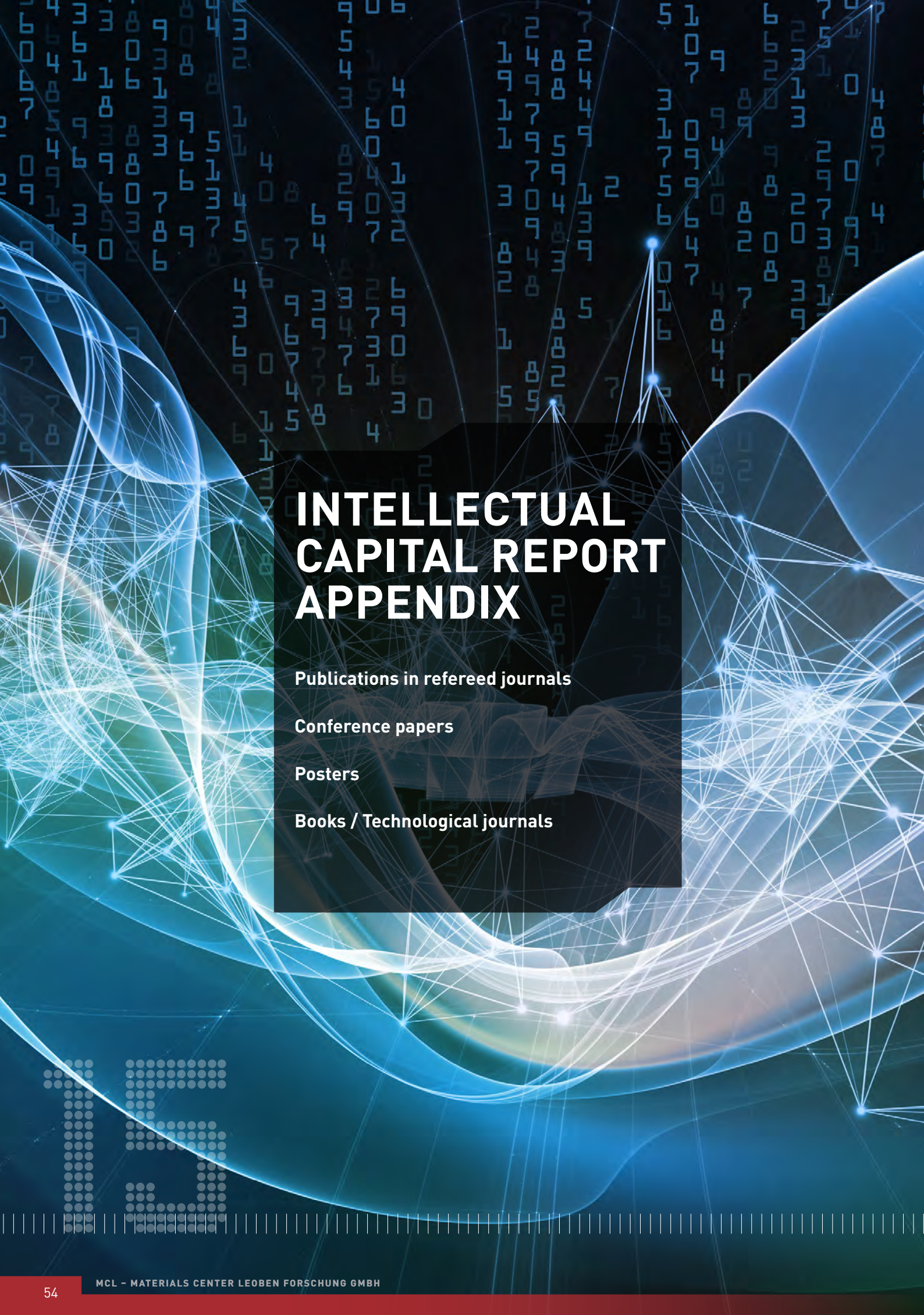
EasyForm **Laser assisted metal spinning for an efficient and flexible processing of nickel and titanium alloys**
Programme line: EU/FP7
Partners: 5

E. Patents

Patents are key indicators of the innovative strength of a competence centre. MCL and COMET researchers were involved in the following patent applications filed in 2015:

- "Verfahren und Vorrichtung zur Überwachung eines Halbleitermoduls" ("Method and device for monitoring a semiconductor module"); Austrian patent application; Applicant: Materials Center Leoben Forschung GmbH.
- "Verfahren und Vorrichtung zum Trennen eines Werkstückes" ("Device and method for separating a workpiece"); Austrian patent application; Applicant: Materials Center Leoben Forschung GmbH.

MCL is working to build an IPR portfolio in the fields of materials, processes and test methods, as also condition monitoring, which is the subject of the two patent applications filed in 2015. This topic has been established as a new innovative research field at MCL. MCL intends to use its expertise in the simulation of component behaviour for the analysis and interpretation of operating data. Another patent application in this area is planned for 2016.



INTELLECTUAL CAPITAL REPORT APPENDIX

Publications in refereed journals

Conference papers

Posters

Books / Technological journals

Appendix

A) Publications in refereed journals

Author Co-Author	Title	Journal	Edition/ Year
Acosta, M.; Liu, N.; Deluca, M.; Heidt, S.; Ringl, I.; Dietz, C.; Stark, R.W. & Jo, W.	**Tailoring ergodicity through selective A-site doping in the $Bi_{1/2}Na_{1/2}TiO_3$–$Bi_{1/2}K_{1/2}TiO_3$ system**	Journal of Applied Physics	117 (2015) 134106 (1-8)
Acosta, M.; Schmitt, L. A.; Molina-Luna, L.; Scherrer, M.C.; Brilz, M.; Webber, K.G.; Deluca, M.; Kleebe, H.J.; Rödel, J. & Donner, W.	**Core-shell lead-free piezoelectric ceramics: Current status and advanced characterization of the $Bi_{1/2}Na_{1/2}TiO_3$-$SrTiO_3$ system**	Journal of the American Ceramic Society	98 (2015) 3405-3422
Baraki, R.; Novak, N.; Hofstätter, M.; Supancic, P.; Rödel, J. & Frömling, T.	**Varistor piezotronics: Mechanically tuned conductivity in varistors**	Journal of Applied Physics	118 (2015) 85703
Bohacek, J.; Kharicha, A.; Ludwig, A. & Wu, M.	**An approximate Riemann solver for shallow water equations and heat advection in horizontal centrifugal casting**	Applied Mathematics and Computation	267 (2015) 179-194
Daniel, R.; Zeilinger, A.; Schöberl, T.; Sartory, B.; Mitterer, C. & Keckes, J.	**Microstructure-controlled depth gradients of mechanical properties in thin nanocrystalline films: Towards structure-property gradient functionalization**	Journal of Applied Physics	117 (2015) 235301
Deluca, M.; Picht, G.; Hoffmann, M.J.; Rechtenbach, A.; Töpfer, J.; Schader, F.H. & Webber, K.G.	**Chemical and structural effects on the high-temperature mechanical behavior of (1-x)(Na1/2$Bi_{1/2}$)TiO_3-x$BaTiO_3$ ceramics**	Journal of Applied Physics	117 (2015) 134110 (1-11)
Eck, S.; Gänser, H.P.; Marsoner, S. & Ecker, W.	**Error analysis for finite element simulation of orthogonal cutting and its validation via quick stop experiments**	Machining Science and Technology: An International Journal	19 (2015) 460-478
Fasching, C.; Gruber, D. & Harmuth, H.	**Simulation of micro-crack formation in a magnesia spinel refractory during the production process**	Journal of the European Ceramic Society	35 (2015) 4593-4601
Fischer, F.D. & Svoboda, J.	**Stress,deformation and diffusion interactions in solids – A simulation study**	Journal of the Mechanics and Physics of Solids	78 (2015) 427-442

Author Co-Author	Title	Journal	Edition/ Year
Fischer, F.D.; Svoboda, J.; Antretter, T. & Kozeschnik, E.	**Relaxation of a precipitate misfit stress state by creep in the matrix**	International Journal of Plasticity	64 (2015) 164-176
Gamsjäger, E. & Rettenmayr, M.	**The kinetics of diffusive phase transformations in the light of trans-interface diffusion**	Philosophical Magazine	95 (2015) 2851-2865
Gamsjäger, E.; Wiessner, M.; Schider, S.; Chen, H. & van der Zwaag, S.	**Analysis of the mobility of migrating austenite-ferrite interfaces**	Philosophical Magazine	95 (2015) 2899-2917
Gänser, H.P.; Maierhofer, J. & Christiner, T.	**Statistical correction for reinserted runouts in fatigue testing**	International Journal of Fatigue	80 (2015) 76-80
Gänser, H.P.; Maierhofer, J.; Tichy, R.; Zivkovic, I.; Pippan, R.; Luke, M. & Varfolomeev, I.	**Damage tolerance of railway axles - The issue of transferability revisited**	International Journal of Fatigue	published online (2015)
Gollner, C.; Ziegler, J.; Protesescu, L.; Dirin, D.N.; Lechner, R.T.; Fritz-Popovski, G.; Sytnyk, M.; Yakunin, S.; Rotter, S.; Amin, A.A.Y.; Vidal, C.; Hrelescu, C.; Klar, T.A.; Kovalenko, M.V. & Heiss, W.	**Random lasing with systematic threshold behavior in films of CdSe/CdS core/thick-shell colloidal quantum dots**	ACS Nano	9 (2015) 9792-9801
Gorbatov, O.I; Gornastyrev, Y.N.; Korzhavyi, P.A. & Ruban, A.V.	**Effect of Ni and Mn on the formation of Cu precipitates in α-Fe**	Scripta Materialia	102 (2015) 41944

Author Co-Author	Title	Journal	Edition/ Year
Gruber, M.; Ploberger, S.; Ressel, G.; Wiessner, M.; Hausbauer, M.; Marsoner, S. & Ebner, R.	**Effects of the comined heat and cryogenic treatment on the stability of austenite in a high Co-Ni steel**	Archives of Metallurgy and Materials	60 (2015) 2131-2137
Gruber, M.; Ploberger, S.; Wiessner, M.; Marsoner, S. & Ebner, R.	**Influence of heat treatment on the microstructure of a high Co-Ni secondary hardening steel**	Materials Today: Proceedings	2 (2015) 949-952
Grünwald, E.; Nuster, R.; Treml, R.; Kiener, D.; Paltauf, G. & Brunner, R.	**Young's modulus and Poisson's ratio characterization of tungsten thin films via laser ultrasound**	Materials Today: Proceedings	2 (2015) 4289-4294
Hofstätter, M.; Raidl, N.; Sartory, B. & Supancic, P.	**Nonlinear lock-in infrared microscopy: A complementary investigation technique for the analysis of functional electroceramic components**	Microscopy and Microanalysis	21 (2015) 1145-1152
Kaiser, R.; Stefenelli, M.; Hatzenbichler, T.; Antretter, T.; Hofmann, M.; Keckes, J. & Buchmayr, B.	**Experimental characterization and modelling of triaxial residual stresses in straightened railway rails**	The Journal of Strain Analysis for Engineering Design	50 (2015) 190-198
Kharicha, A.; Bohacek, J.; Ludwig, A. & Wu, M.	**Modified shallow water equations with application for horizontal centrifugal casting of rolls**	Journal of Fluids Engineering: ASME DC	137 (2015) FE-14-1091
Kolb, F.; Deluca, M. & Maier, G. A.	**The quality of prepared specimens of Si-wafers for raman spectroscopy**	Practical Metallography	52 (2015) 355-373
Kolb, F.; Pichler, A.; Mali, H. & Schenk, J.	**Standardized iron ore characterization methodology for metallurgy**	Practical Metallography	52 (2015) 43952

Author Co-Author	Title	Journal	Edition/ Year
Krautgasser, C.; Danzer, R.; Supancic, P. & Bermejo, R.	**Influence of temperature and humidity on the strength of low temperature co-fired ceramics**	Journal of the European Ceramic Society	35 (2015) 1823-1830
Kurz, S.J.B.; Meka, S.R.; Schell, N.; Ecker, W.; Keckes, J. & Mittermeijer, E.J.	**Residual stress and microstructure depth gradients in nitrided iron-based alloys revealed by dynamical cross-sectional transmission X-ray microdiffraction**	Acta Materialia	87 (2015) 100-110
Lederer, M.; Magnien, J.; Khatibi, G. & Weiss, B.	**FEM simulation of the size- and constraining effect in lead-free solder joints with the theory of strain gradient elasticity**	Journal of Physics: Conference Series	602 (2015) 12020
Leitner, M.; Gerstbrein, S.; Ottersböck, M. J. & Stoschka, M.	**Fatigue strength of HFMI-treated high-strength steel joints under constant and variable amplitude block loading**	Procedia Engineering	101 (2015) 251-258
Li, J.; Hage, F.; Wiessner, M.; Romaner, L.; Scheiber, D.; Sartory, B.; Ramasse, Q. & Schumacher, P.	**The roles of Eu during the growth of eutectic Si in Al-Si alloys**	Scientific Reports	5 (2015) 13802
Li, J.H.; Wiessner, M.; Albu, M.; Wurster, S.; Sartory, B.; Hofer, F. & Schumacher, P.	**Correlative characterization of primary Al_3(Sc,Zr) phase in an Al-Zn-Mg based alloy**	Materials Characterization	102 (2015) 62-70
Maciol, P.; Bureau, R.; Poletti, C.; Sommitsch, C.; Warczok, P. & Kozeschnik, E.	**Agile multiscale modelling of the thermo-mechanical processing of an aluminium alloy**	Key Engineering Materials	651-653 (2015) 1319-1324

Author Co-Author	Title	Journal	Edition/ Year
Macurova, K.; Angerer, P.; Bermejo, R.; Pletz, M.; Schöngrundner, R.; Antretter, T.; Krivec, T.; Morianz, M.; Brizoux, M. & Lecavelier, A.	**Stress and deflection development during die embedding into printed circuit boards**	Materials Today: Proceedings	2 (2015) 4196-4205
Macurova, K.; Bermejo, R.; Pletz, M.; Schöngrundner, R.; Antretter, T.; Krivec, T.; Morianz, M.; Brizoux, M. & Lecavelier, A.	**Comparison of different methods for stress and deflection analysis in embedded die packages during the assembly process**	Journal of Microelectronics and Electronic Packaging	12 (2015) 80-85
Maier, V.; Leitner, A.; Pippan, R. & Kiener, D.	**Thermally activated deformation behavior of ufg-Au: Environmental issues during long-term and high-temperature nanoindentation testing**	JOM	67 (2015) 2934-2944
Maierhofer, J.; Gänser, H.P. & Pippan, R.	**Modified Kitagawa-Takahashi diagram accounting for finite notch depths**	International Journal of Fatigue	70 (2015) 503-509
Michelic, S.; Goriupp, J.; Feichtinger, S.; Kang, Y.; Bernhard, C. & Schenk, J.	**Study on oxide inclusion dissolution in secondary steelmaking slags using high temperature confocal scanning laser microscopy**	Steel Research International	86 (2015) PaperNo. 9999
Mikl-Resch, M.J.; Antretter, T.; Gimpel, M.; Kargl, H.; Pittino, G.; Tichy, R.; Ecker, W. & Galler, R.	**Numerical calibration of a yield limit function for rock materials by means of the Brazilian test and the uniaxial compression test**	International Journal of Rock Mechanics and Mining Sciences	74 (2015) 24-29

Author Co-Author	Title	Journal	Edition/ Year
Mühlbacher, M.; Bochkarev, A.S.; Mendez Martin, F.; Sartory, B.; Chitu, L.; Popov, M. N.; Puschnig, P.; Spitaler, J.; Ding, H.; Schalk, N.; Lu, J.; Hultman, L. & Mitterer, C.	**Cu diffusion in single-crystal and polycrystalline TiN barrier layers: A high-resolution experimental study supported by first-principles calculations**	Journal of Applied Physics	118 (2015) 85307
Mühlbacher, M.; Mendez-Martin, F.; Sartory, B.; Schalk, N.; Keckes, J.; Lu, J.; Hultman, L. & Mitterer, C.	**Copper diffusion into single-crystalline TiN studied by transmission electron microscopy and atom probe tomography**	Thin Solid Films	574 (2015) 103-109
Philippot, G.; Albino, M.; Epherre, R.; Chevallier, G.; Beynet, Y.; Maniere, C.; Weibel, A.; Peigney, A.; Deluca, M.; Elissalde, C.; Maglione, M.; Aymonier, C. & Estournes, C.	**Local distortions in nanostructured ferroelectric ceramics through strain tuning**	Advanced Electronic Materials	1 (2015) 1500190 (1-8)
Prehal, C.; Weingarth, D.; Perre, E.; Lechner, R.T.; Amenitsch, H.; Paris, O. & Presser, V.	**Tracking the structural arrangement of ions in carbon supercapacitor nanopores using in situ small-angle X-ray scattering**	Energy & Environmental Science	8 (2015) 1725-1735
Pritz, L.; Marsoner, S.; Ebner, R.; Fluch, R.; Tatschl, A. & Münzer, R.	**Investigation into microstructural changes due to the rolling contact fatigue of the AISI M50 bearing steel**	WIT Transactions on Engineering Sciences	91 (2015) 35-45

Author Co-Author	Title	Journal	Edition/ Year
Raidl, N.; Supancic, P.; Danzer, R. & Hofstätter, M.	**Piezotronically modifed double schottky barriers in ZnO varistors**	Advanced Materials	27 (2015) 2031-2035
Razumovskiy, V. I. & Ghosh, G.	**A first-principles study of cementite (Fe_3C) and its alloyed counterparts: Structural properties, stability, and electronic structure**	Computational Materials Science	110 (2015) 169-181
Razumovskiy, V. I.; Lozovoi, A.Y. & Razumovskii, I.M.	**First-principles-aided design of a new Ni-base superalloy: Influence of transition metal alloying elements on grain boundary and bulk cohesion**	Acta Materialia	82 (2015) 369-377
Razumovskiy, V. I.; Popov, M. N.; Ding, H. & Odqvist, J.	**Formation and interaction of point defects in group IVb transition metal carbides and nitrides**	Computational Materials Science	104 (2015) 147-154
Rebelo de Figueiredo, M.; Abad, M.D.; Harris, A.J.; Czettl, C.; Mitterer, C. & Hosemann, P.	**Nanoindentation of chemical-vapor deposited Al_2O_3 hard coatings at elevated temperatures**	Thin Solid Films	578 (2015) 20-24
Röhrig, S.; Krautgasser, C.; Bermejo, R.; Jones, J.L.; Supancic, P. & Deluca, M.	**Quantification of crystalline texture in ferroelectric materials by polarized Raman spectroscopy using Reverse Monte Carlo modelling**	Journal of the European Ceramic Society	35 (2015) 4321-4325
Röhrig, S.; Petschenig, I.; Bermejo, R.; Hofstätter, M.; Aldrian, F.; Danzer, R. & Supancic, P.	**Thermography and complementary measurements as tools to detect micro-irregularities in electronic components**	Journal of Ceramic Science and Technology	6 (2015) 255-260
Saringer, C.; Tkadletz, M. & Mitterer, C.	**Restrictions of stress measurements using the curvature method by thermally induced plastic deformation of silicon substrates**	Surface and Coatings Technology	274 (2015) 68-75
Sax, C.R.; Schönfeld, B. & Ruban, A.V.	**Effect of magnetism and atomic order on static atomic displacements in the Invar alloy Fe-27 at.% Pt**	Physical Review B	92 (2015) 54205

Author Co-Author	Title	Journal	Edition/ Year
Scheiber, D.; Razumovskiy, V. I.; Puschnig, P.; Pippan, R. & Romaner, L.	**Ab initio description of segregation and cohesion of grain boundaries in W-25 at.% Re alloys**	Acta Materialia	88 (2015) 180-189
Schemmel, M.; Prevedel, P.; Schöngrundner, R.; Ecker, W. & Antretter, T.	**Size effects in residual stress formation during quenching of cylinders made of hot-work tool steel**	Advances in Materials Science and Engineering	(2015) 678056 (7pp)
Schöngrundner, R.; Cordill, M. J.; Maier, G. A. & Gänser, H.P.	**Adhesion energy of printed circuit board materials using four-point-bending validated with finite element simulations**	Microelectronics Reliability	55 (2015) 2382-2390
Schuller, E.; Galler, R.; Barwart, S. & Wenighofer, R.	**The transparent face - Development work to solve problems in mechanized hard rock tunnelling**	Geomechanics and Tunnelling	8 (2015) 200-210
Simunek, D.; Leitner, M.; Maierhofer, J. & Gänser, H.P.	**Fatigue crack growth under constant and variable amplitude loading at semi-elliptical and V-notched steel specimens**	Procedia Engineering	133 (2015) 348-361
Stechauner, G. & Kozeschnik, E.	**Thermo-kinetic modeling of Cu precipitation in α-Fe**	Acta Materialia	100 (2015) 135-146
Stefenelli, M.; Daniel, R.; Ecker, W.; Kiener, D.; Todt, J.; Zeilinger, A.; Mitterer, C.; Burghammer, M. & Keckes, J.	**X-ray nanodiffraction reveals stress distribution across an indented multilayered CrN-Cr thin film**	Acta Materialia	85 (2015) 24-31
Steinhauer, S.; Singh, V.; Cassidy, C.; Gspan, C.; Grogger, W.; Sowwan, M. & Köck, A.	**Single CuO nanowires decorated with sizeselected Pd nanoparticles for CO sensing in humid atmosphere**	Nanotechnology	26 (2015) 175502 (6pp)
Svoboda, J.; Shan, Y.V. & Fischer, F.D.	**A new self-consistent model for thermodynamics of binary solutions**	Scripta Materialia	108 (2015) 27-30

Author Co-Author	Title	Journal	Edition/ Year
Svoboda, J.; Zickler, G.A.; Kozeschnik, E. & Fischer, F.D.	**Kinetics of interstitials segregation in cottrell atmospheres and grain boundaries**	Philosophical Magazine Letters	95 (2015) 458-465
Teppernegg, T.; Angerer, P.; Klünsner, T.; Tritremmel, C. & Czettl, C.	**Evolution of residual stress in Ti–Al–Ta–N coatings on hard metal milling inserts**	International Journal of Refractory Metals and Hard Materials	52 (2015) 171-175
Tkadletz, M.; Keckes, J.; Schalk, N.; Krajinovic, I.; Burghammer, M.; Czettl, C. & Mitterer, C.	**Residual stress gradients in α-Al_2O_3 hard coatings determined by pencil-beam X-ray nanodiffraction: The influence of blasting media**	Surface and Coatings Technology	262 (2015) 134-140
Ursic, H.; Bencan, A.; Drazic, G.; Esteves, G.; Jones, J.L.; Usher, T.M.; Rojac, T.; Drnovsek, S.; Deluca, M.; Jouin, J.; Bobnar, V.; Trefalt, G.; Holc, J. & Malic, B.	**Unusual structural-disorder stability of mechanochemically derived-$Pb(Sc_{0.5}Nb0._5)O_3$**	Journal of Materials Chemistry C	3 (2015) 10309-10315
Weisz, T.; Warczok, P.; Ebner, T.; Falahati, A. & Kozeschnik, E.	**Simulation of natural aging in Al-Mg-Si alloys**	Materials Science Forum	828-829 (2015) 468-473
Wurster, S.; Treml, R.; Fritz, R.; Kapp, M.W.; Langs, E.M.; Alfreider, M.; Ruhs, C.; Imrich, P. J.; Felber, G. & Kiener, D.	**Novel methods for the site specific preparation of micromechanical structures**	Practical Metallography	52 (2015) 131-146

Author Co-Author	Title	Journal	Edition/ Year
Yadav, S.D.; Sonderegger, B.; Sartory, B.; Sommitsch, C. & Poletti, C.	**Characterisation and quantification of cavities in 9Cr martensitic steel for power plants**	Materials Science and Technology	31 (2015) 554-564
Yoneda, J.; Otsuka, T.; Takakura, T.; Pioro-Ladriere, M.; Brunner, R.; Lu, H.; Nakajima, T.; Obata, T.; Noiri, A.; Palmstrom, C.; Gossard, A.C. & Tarucha, S.	**Robust micromagnet design for fast electrical manipulations of single spins in quantum dots**	Applied Physics Express	8 (2015) 084401 (4pp)
Zeilinger, A.; Daniel, R.; Schöberl, T.; Stefenelli, M.; Sartory, B.; Keckes, J. & Mitterer, C.	**Resolving depth evolution of microstructure and hardness in sputtered CrN film**	Thin Solid Films	581 (2015) 75-79
Zeilinger, A.; Daniel, R.; Stefenelli, M.; Sartory, B.; Chitu, L.; Burghammer, M.; Schöberl, T.; Kolednik, O.; Keckes, J. & Mitterer, C.	**Mechanical property enhancement in laminates through control of morphology and crystal orientation**	Journal of Physics D: Applied Physics	48 (2015) 295303
Zenisek, J.; Kozeschnik, E.; Svoboda, J. & Fischer, F.D.	**Modelling the role of compositional fluctuations in nucleation kinetics**	Acta Materialia	91 (2015) 365-376
Zhou, X.; Hohenwarter, A.; Leitner, T.; Gänser, H.P. & Pippan, R.	**Load history effects on fatigue crack propagation: Its effect on the R-curve for threshold**	Frattura ed Integrità Strutturale	33 (2015) 209-214

Author Co-Author	Title	Journal	Edition/ Year
Zhuang, C. I.; Liu, J. Bernhard, C. & Presoly, P.	**Analysis of Solidification of High Manganese Steels Using Improved Differential Thermal Analysis Method**	Journal of iron and steel research international	22(8) (2015) 709-714

B) Conference papers

Author Co-Author	Title	Conference title	Conference
Sistaninia, M. & Kolednik, O.	**Design of fracture resistant composites by utilizing spatial material property variations**	20th International Conference on Composite Materials	20th International Conference on Composite Materials (ICCM20)
Grün, F.; Godor, I.; Summer, F.; Bergmann, P. & Moder, J.	**Tribological in-situ evaluation of lubricated contacts of real-life engineering materials**	3rd OilDoc Conference and Exhibition	3rd OilDoc Conference and Exhibition
Garb, C.; Tauscher, M. & Kainzinger, P.	**Quantifizierung der ermüdungsrelevanten Mikroporengrößen mittels CT-Analyse an Aluminium Gussbauteilen**	42. Tagung des DVM-Arbeitskreises Betriebsfestigkeit	42. Tagung des DVM-Arbeitskreises Betriebsfestigkeit
Bergmann, P.; Grün, F.; Godor, I. & Hager, G.	**Simulative Investigations of a Close-to-Component Journal Bearing System and Comparison with Test Data**	Ecotrib 2015	5th European Conference on Tribology (ECOTRIB 2015)
Summer, F.; Grün, F.; Godor, I.; Offenbecher, M. & Laine, E.	**Tribometric assessment of start stop journal bearing wear with the aid of a component close test methodology**	European Conference on Tribology – Book of abstracts	5th European Conference on Tribology (ECOTRIB 2015)
Ochensberger, W. & Kolednik, O.	**Physically correct assessment of fatigue crack growth in elastic–plastic materials with the J-integral**	Extended Abstract at the 15th International ASTM/ESIS Symposium on Fatigue and Fracture Mechanics	15th International ASTM/ESIS Symposium on Fatigue and Fracture Mechanics (40th ASTM National Symposium on Fatigue and Fracture Mechanics)
Presoly, P. & Bernhard, C.	**On the importance of thermodynamic investigations for the re-assessment of selected ternary Fe-base systems**	Liquid Metal Processing and Casting Conference (LMPC) 2015	Liquid Metal Processing and Casting Conference (LMPC) 2015
Kircher, V.; Kölbl, N.; Marschall, I. & Harmuth, H.	**High temperature microscopic investigation in the field of ceramics - an overview**	Mitt. Österreichische Mineralische Gesellschaft	Fundametal Research and Applications in Mineralogy and Petrology (MinPet 2015)

Author Co-Author	Title	Conference title	Conference
Horn, A.; Tichy, R.; Gänser, H.P.; Schnitzer, R.; Egger, R.; Hammer, A. & Ebner, R.	**Experimental and numerical investigations on the fracture behavior of an API 5L X100M base material and weldings**	Proceedings of 10th Pipeline Technology Conference 2015	10th Pipeline Technology Conference 2015
Kozic, D.; Treml, R.; Schöngrundner, R.; Brunner, R.; Kiener, D.; Zechner, J.; Antretter, T. & Gänser, H.P.	**Fracture mechanics of thin film systems on the sub-micron scale**	Proceedings of EuroSimE 2015	16th International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE 2015)
Daves, W.; Kracalik, M. & Scheriau, S.	**Crack growth rate and direction under wheel/rail rolling sliding contact using elastic/plastic material description**	Proceedings of the 10th International Conference on Contact Mechanics	10th International Conference on Contact Mechanics
Daves, W.; Kracalik, M. & Scheriau, S.	**Crack Growth Rate and Direction of Surface Cracks in Rails Depending on Contact Load, Slip and Plasticity**	Proceedings of the 10th International Conference on Contact Mechanics	10th International Conference on Contact Mechanics
Daves, W.; Kubin, W.; Scheriau, S. & Pletz, M.	**A finite element model to simulate the physical mechanisms of wear and crack initiation in wheel/rail contacts**	Proceedings of the 10th International Conference on Contact Mechanics	10th International Conference on Contact Mechanics
Michelic, S.; Dieguez Salgado, U. & Bernhard, C.	**In-situ observation of the behavior of non-metallic inclusions at different interfaces in the system steel-slag-refractory**	Proceedings of the 2015 International Symposium on Liquid Metal Processing and Casting	Liquid Metal Processing and Casting Conference (LMPC) 2015
Pletz, M.; Ossberger, U.; Ossberger, H. & Daves, W.	**Dynamic finite element crossing model - Loading of wing rail and crossing nose**	Proceedings of the 24th International Symposium on Dynamics of Vehicles on Roads and Tracks	24th International Symposium on Dynamics of Vehicles on Roads and Tracks

Author Co-Author	Title	Conference title	Conference
Gamsjäger, E.; Wiessner, M.; Gruber, M. & Zwaag, S.	**Evolution of reverted austenite and martensite during thermal processing of chromium stainless steels**	Proceedings of the International Conference on Solid-Solid Phase Transformations in Inorganic Materials 2015	International Conference on Solid-Solid Phase Transformations in Inorganic Materials (PTM 2015)
Gruber, M.; Ploberger, S.; Wiessner, M.; Marsoner, S. & Ebner, R.	**Influence of heat treatment on the stability of austenite in a high Co-Ni secondary hardening steel**	Proceedings of the International Conference on Solid-Solid Phase Transformations in Inorganic Materials 2015	International Conference on Solid-Solid Phase Transformations in Inorganic Materials (PTM 2015)
Keplinger, A.; Wiessner, M.; Marsoner, S. & Ebner, R.	**Tempering behaviour in a Mo-W-Ni Steel investigated by in-situ high temperature XRD, dilatometry, and TEM**	Proceedings of the International Conference on Solid-Solid Phase Transformations in Inorganic Materials 2015	International Conference on Solid-Solid Phase Transformations in Inorganic Materials (PTM 2015)
Daves, W.; Kubin, W.; Kracalik, M. & Scheriau, S.	**Mechanismen des Risswachstums und Rissinitiierung im Rad/Schiene Kontakt**	Proceedings oft the 11. Tagung Gefüge und Bruch	Gefüge und Bruch 2015
Sidi Mammar, A.; Jin, S.; Harmuth, H. & Gruber, D.	**Tensile and compressive creep testing of refractories at service related loads**	UNITECR 2015 - Unified International Technical Conference on Refractories	UNITECR 2015 - Unified International Technical Conference on Refractories
Kasberger, R.; Buchmayr, B. & Kolednik, O.	**Massgeschneiderte Mehrschichtverbunde mit hoher Schadenstoleranz**	XXXIV. Colloquium on metal forming, Tagungsband	XXXIV Verformungs-kundliches Kolloquium
Weber, A. & Buchmayr, B.	**Gefügeeigenschaften niedriglegierter Kohlenstoffstähle hinsichtlich Sauergasbeständigkeit**	XXXIV. Colloquium on metal forming, Tagungsband	XXXIV Verformungs-kundliches Kolloquium

Author Co-Author	Title	Conference title	Conference
Presoly, P.; Six, J. & Bernhard, C.	**Thermodynamic optimization of individual steel databases by means of systematic DSC measurement**	1st International Conference on Materials, Processing and Product Engineering (MPPE 2015)	1st International Conference on Materials, Processing and Product Engineering (MPPE 2015)
Kharicha, A.; Pfeiler, C.; Bohacek, J.; Ludwig, A.; Wu, M.; Mogeritsch, J.; Angeli, G. & Riener, C.	**A shallow layer model predicting the zinc film thickness during the continuous hot-dip galvanizing process**	8th International Conference on Thermal Engineering: Theory and Applications	8th International Conference on Thermal Engineering: Theory and Applications (ICTEA)
Pfeiler, C.; Mataln, M.; Kharicha, A.; Riener, C.K. & Angeli, G.	**Importance of the zinc film modeling for gas jet wiping simulations**	AIST Galvatech Proceedings	10th International Conference on Zinc and Zinc Alloy Coated Steel Sheet (AIST Galvatech 2015)
Pittino, G.; Galler, R.; Antretter, T.; Mikl-Resch, M.; Tichy, R.; Ecker, W.; Gimpel, M. & Kargl, H.	**Numerical analysis of the rock cutting process based on a two-parameter description of tensile strenght using the weibull theory**	ISRM Congress 2015 Proceedings	The 13th International ISRM Congress 2015
Petersmann, M.; Antretter, T. & Waitz, T.	**Special cases of martensite compatibility: A near single-variant habit-plane and the martensite of nanocrystalline NiTi**	MATEC Web of Conferences	10th European Symposium on Martensitic Transformations (ESOMAT) 2015
Triebl, C.; Spijker, C.; Raupenstrauch, H.; Jarosik, A. & Angeli, G.	**Modeling of the annealing furnace in a hot dip galvanizing line**	Proceedings of the 10th European Conference on Industrial Furnaces and Boilers	10th European Conference on Industrial Furnaces and Boilers
Mataln, M.; Pfeiler, C.; Strutzenberger, J. & Angeli, G.	**Simulation of physical phenomena inside a molten zinc bath by using computational fluid dynamics method**	Proceedings of the 10th International Conference on Zinc and Zinc Alloy Coated Steel Sheet	10th International Conference on Zinc and Zinc Alloy Coated Steel Sheet (AIST Galvatech 2015)

Author Co-Author	Title	Conference title	Conference
Macurova, K.; Gruber, M.; Pletz, M.; Supancic, P.; Danzer, R.; Aldrian, F. & Bermejo, R.	**Mechanical testing and fracture analyses of miniaturized ZnO-based multilayer components**	Proceedings of the 48th Annual International Symposium on Microelectronics	48th Annual International Symposium on Microelectronics (IMAPS)
Gamsjäger, E.; Wiessner, M. & Angerer, P.	**Characterization of stainless steels by means of in-situ high temperature X-ray diffraction**	Proceedings of the 8th European Stainless Steel and Duples Stainless Steel Conference 2015	8th European Stainless Steel and Duples Stainless Steel Conference 2015
Drexler, A.; Maderbacher, H.; Povoden-Karadeniz, E.; Gänser, H.P.; Ecker, W.; Oberwinkler, B. & Fischersworring-Bunk, A.	**Yield stress evolution in Inconel 718 samples under standard heat treatment process conditions of turbine disks**	Proceedings of the European Conference on Heat Treatment 2015	European Conference on Heat Treatment 2015 and 22nd IFHTSE Congress Heat Treatment and Surface Engineering
Razumovskiy, V. I.; Reyes-Huamantinco, A. & Ruban, A.V.	**Spin wave method for the total energy of the paramagnetic state: Practical applications**	Proceedings of the International Conference on Solid-Solid Phase Transformations in Inorganic Materials 2015	International Conference on Solid-Solid Phase Transformations in Inorganic Materials (PTM 2015)
Waitz, T.; Matsuda, M.; Kerber, M. & Panigrahi, A.	**High temperature TiPd shape memory alloys subjected to severe plastic deformation**	Proceedings of the International Conference on Solid-Solid Phase Transformations in Inorganic Materials 2015	International Conference on Solid-Solid Phase Transformations in Inorganic Materials (PTM 2015)
Ossberger, U.; Eck, S. & Stocker, E.	**Performance of different materials in a frog of a turnout**	Proceedings of the International Heavy Haul Association Conference	International Heavy Haul Association Conference 2015 (IHHA)
Bermejo, R.; Krautgasser, C.; Deluca, M.; Pletz, M.; Supancic, P.; Aldrian, F. & Danzer, R.	**Mechanical characterisation of miniaturized functional substrates and componets in different environments**	Proceedings: IMAPS/ACerS	11th International CICMT Conference and Exhibition (IMAPS ACerS)

Author Co-Author	Title	Conference title	Conference
Röhrig, S.; Petschenig, I.; Bermejo, R.; Hofstätter, M.; Aldrian, F.; Danzer, R. & Supancic, P.	**Heat development at the microscale in ceramic components - thermography and complementary tools**	Proceedings: IMAPS/ACerS	11th International CICMT Conference and Exhibition (IMAPS ACerS)
Mutianti, G.C.; Brunet, E.; Yurchenko, O.; Laubender, E.; Urban, G.; Köck, A.; Steinhauer, S.; Siegert, J.; Rohracher, K.; Schrank, F. & Schrems, M.	**Bimetallic nanoparticles for optimizing CMOS integrated SnO_2 gas sensor devices**	Solid State Device Research Conference (ESSDERC)	Solid State Device Research Conference (ESSDERC)

C) Posters

Author Co-Author	Title	Conference
Bochkarev, A.; Popov, M.; Spitaler, J. & Puschnig, P.	**Ab initio modeling of copper impurity diffusion in TiN**	11th International Conference on Diffusion in Solids and Liquids (DSL2015)
Bochkarev, A.; Popov, M.; Spitaler, J. & Puschnig, P.	**First-principles modeling of copper impurity diffusion in TiN**	PSI-K Conference 2015
Defregger, S.; Kraker, E.; Grbic, M. & Mitterhuber, L.	**Thermal management of LED-Systems using thermal impedance measurements**	ME2C Clustermeeting
Dengg, T.; Romaner, L.; Razumovskiy, V. I.; Puschnig, P. & Spitaler, J.	**Ab-initio investigation on the interplay of elasticity and temperature**	PSI-K Conference 2015
Fritz-Popovski, G.; Morak, R.; Sharifi, P. & Paris, O.	**Deformation of microporous films during adsorption and desorption of water**	16. International Conference on Small-Angle Scattering (SAS 2015)
Garb, C.; Kainzinger, P. & Grün, F.	**Fatigue relevant pore size detection of casted aluminum components using CT-analysis**	FEFMAT User Meeting 2015
Jonke, M.; Klünsner, T.; Supancic, P.; Harrer, W.; Glätzle, J.; Barbist, R. & Ebner, R.	**Untersuchung der Bruchfestigkeitsverteilung von WC-Co Hartmetall unter uni- und biaxialer Belastung**	Gefüge und BruchGefüge und Bruch 2015
Kargl, H.; Gimpel, M.; Antretter, T.; Galler, R.; Pittino, G.; Ecker, W.; Tichy, R. & Mikl-Resch, M.	**Numerical analysis of the rock cutting process and the loading of cutting tools**	The 13th International ISRM Congress 2015

Author Co-Author	Title	Conference
Keplinger, A.; Gelder, S.; Leitner, H.; Marsoner, S. & Ebner, R.	**Auswirkungen einer martensitischen und bainitischen Matrix auf das Sprödbruchverhalten**	Gefüge und BruchGefüge und Bruch 2015
Morak, R.; Putz, F.; Elsaeser, M.; Popovski, G.; Balzer, C.; Hüsing, N.; Reichenauer, G. & Paris, O.	**Structural characterisation and sorption induced deformation of hierarchicall silica monoliths with anisotropic porosity**	16. International Conference on Small-Angle Scattering (SAS 2015)
Popov, M.; Razumovskiy, V. I.; Ding, H. & Odqvist, J.	**Formation and interaction of point defects in group IVb transition metal carbides and nitrides**	PSI-K Conference 2015
Povoden-Karadeniz, E.; Mayer, W. & Kozeschnik, E.	**Thermodynamic modeling of carbon clusters in martensite**	International Conference on Computer Coupling of Phase Diagrams and Thermochemistry (CALPHAD XLIV)
Pritz, L.; Marsoner, S.; Ebner, R.; Fluch, R.; Tatschl, A. & Münzer, R.	**Schädigungsuntersuchung nach Überrollermüdung am Lagerwerkstoff AISI M50 für Flugtriebwerke**	Gefüge und Bruch 2015
Rafiezadeh, S.; Falahati, A. & Kozeschnik, E.	**Simulation of microstructure evolution during homogenization of electromagnetic cast ingots of 7050 aluminum alloys**	Euromat 2015
Raidl, N.; Hofstätter, M. & Supancic, P.	**Piezotronically modified I-V characteristics of ZnO varistor ceramics**	14th International Conference of the European Ceramic Society (ECERS)
Raidl, N.; Hofstätter, M. & Supancic, P.	**Impact of the piezotronic effect on Metal-Oxide Varistor properties**	MS&T Materials Science and Technology
Raidl, N.; Hofstätter, M. & Supancic, P.	**Modelling the piezotronically modified I-V characteristics of ZnO varistor ceramics**	14th International Conference of the European Ceramic Society (ECERS)
Rath, M.; Povoden-Karadeniz, E. & Kozeschnik, E.	**A thermodynamic description for the new n-phase Ni_6AlNb**	Euromat 2015

Author Co-Author	Title	Conference
Razumovskiy, V. I.; Popov, M.; Ding, H. & Odqvist, J.	**Point defect formation and interaction in group IVB transition metal carbides and nitrides**	PSI-K Conference 2015
Reyes-Huamantinco, A.; Knebl, D.; Puschnig, P.; Gholizadeh, H. & Wiessner, M.	**The SFE-TOOL: Automatized DFT-based calculation of the temperature-dependent stacking-fault energy in steels**	PSI-K Conference 2015
Reyes-Huamantinco, A.; Knebl, D. & Wiessner, M.	**Longitudinal spin-fluctuations in paramagnetic FeMnCr and FeMnSiAl random alloys**	SPICE-Workshop on Computational Quantum Magnetism
Schemmel, M.; Prevedel, P.; Schöngrundner, R.; Wlanis, T.; Ecker, W. & Antretter, T.	**Modeling the quenching and annealing process of massive hot-work tool steel components**	28th ASM Heat Treating Society Conference and Exhibition (HeatTreat2015)
Stix, G.; Weber, A. & Buchmayr, B.	**Influence of weld length on behavior of tubular K-joints under load**	68th IIW Annual Assembly and International Conference
Triebl, C.; Spijker, C.; Raupenstrauch, H.; Jarosik, A. & Angeli, G.	**Modeling of the annealing furnace in a hot dip galvanizing line**	10th European Conference on Industrial Furnaces and Boilers
Tulic, S.; Matsuda, M.; Kerber, M.; Panigrahi, A.; James, R.D. & Waitz, T.	**Ti-Ni-Pd shape memory alloys processed by severe plastic deformation**	10th European Symposium on Martensitic Transformations (ESOMAT) 2015
Umgeher, A.; Kreuzer, H.; Hebesberger, T. & Kolednik, O.	**Effect of strain rate on cleavage fracture in Fe-Si-Al alloys**	22th SMM Soft Magnetic Materials Conference
Waitz, T.; Matsuda, M.; Kerber, M. & Panigrahi, A.	**High temperature TiPd shape memory alloys subjected to severe plastic deformation**	International Conference on High-Temperature Shape Memory Alloys-From Basics to Applications
Waitz, T.; Matsuda, M.; Kerber, M. & Panigrahi, A.	**High temperature TiPd shape memory alloys subjected to severe plastic deformation**	International Conference on Solid-Solid Phase Transformations in Inorganic Materials (PTM 2015)
Weber, A. & Buchmayr, B.	**Einfluss von Silizium auf bainitische Gefüge und deren Eigenschaften**	Gefüge und BruchGefüge und Bruch 2015

D) Books / Technological journals

Author Co-Author	Title, Book	Technological journals	Edition/ Year
Ochensberger, W.	**Characterization of fatigue crack growth with the configurational force concept**	Fortschritt-Berichte VDI, Reihe 18 Mechanik/ Bruchmechanik	
Ecker, W.	**Simulatonsmodell der Wärmebehandlung**	HTM	2015
Fuchs, N.; Krajewski, P. & Bernhard, C.	**In-situ observation of austenite grain growth in plain carbon steels by means of high-temperature laser scanning confocal microscopy**	BHM	2015
Gehwolf, P. & Galler, R.	**Numerical modelling of the small scale rock cutting test**	BHM	2015
Krajewski, P.; Krobath, R.; Bernhard, C.; Miettinen, J.; Louhenkilpi, S.; Ilie, S & Schaden, T.	**A novel approach for the simulation of surface crack formation in continuous casting**	BHM	2015
Leitner, M.; Stoschka, M.; Ottersböck, M. & Simunek, D.	**Ermüdungsfestigkeit hochfester Stahlschweißverbindungen**	BHM	2015
Mitterer, C.; Jörg, T.; Franz, R.; Mühlbacher, M.; Sartory, B.; Mendez Martin, F. & Schalk, N.	**Functional thin films for display and microelectronics applications**	BHM	2015
Presoly, P. & Bernhard, C.	**Untersuchung der Wirkung von Legierungselementen auf die peritektische Phasenumwandlung in Stählen**	BHM	2015
Stoschka, M.; Leitner, M. & Ottersböck, M.	**Application of local approaches, to assess the fatigue crack**	IIW-Document	2015
Stoxreiter, T. & Galler, R.	**Laborversuch und numerische Simulation des Keilspalttests an Sandstein- und Granitproben**	BHM	2015
Yildirim, H.; Leitner, M.; Marquis, G.; Stoschka, M. & Barsoum, Z.	**Application studies for the fatigue strength improvement of welded structures by high-frequency mechanical impact (HFMI) treatment**	IIW	2015

BUSINESS FIGURES 2015

Business development

Profit and loss account

Balance sheet

Business development

Business volume

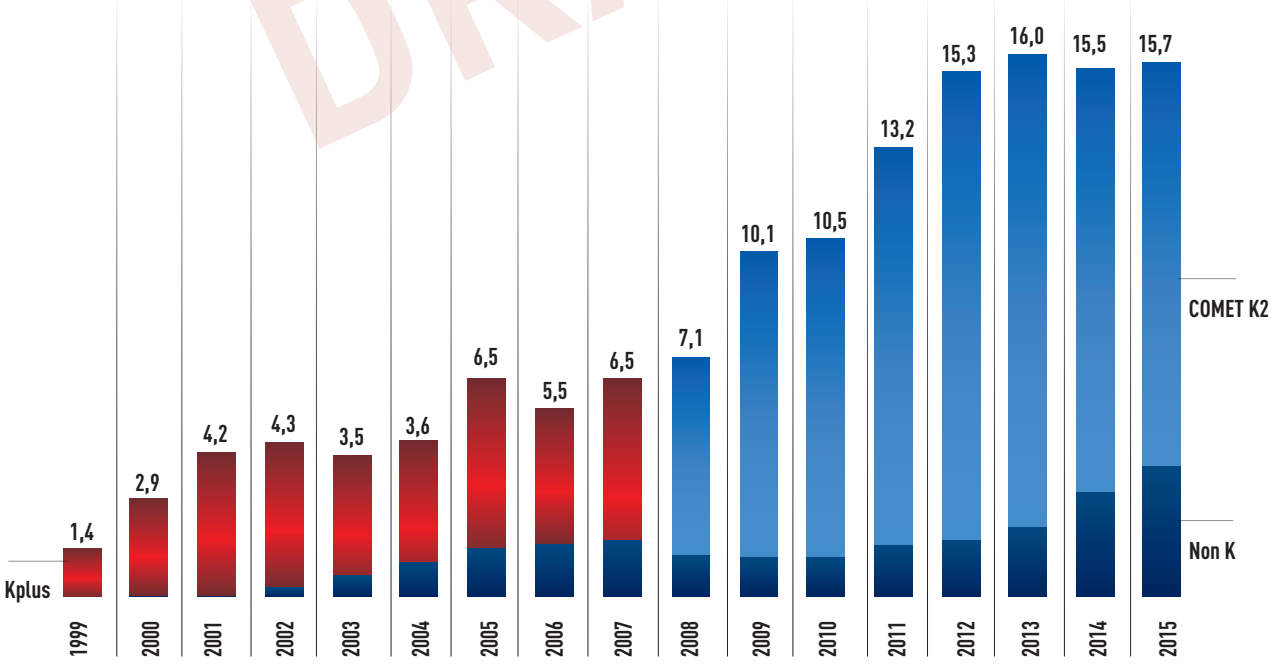
The 2015 financial year was the third year of the second funding period (1/1/2013 to 31/12/2017) of the COMET K2 Centre for Integrated Research in Materials, Processing and Product Engineering (MPPE).

A project volume of € 59,500,000 was approved for COMET Phase II, resulting in an annual average of € 11,900,000. As in the two previous years, this level was significantly exceeded in 2015, with the costs in the COMET area amounting to € 12,266,192 (previous year (PY): k€ 12,568).

The volume of funded non-COMET projects was € 1,983,730 (PY: k€ 1,399), which is again a substantial increase compared to the previous year.

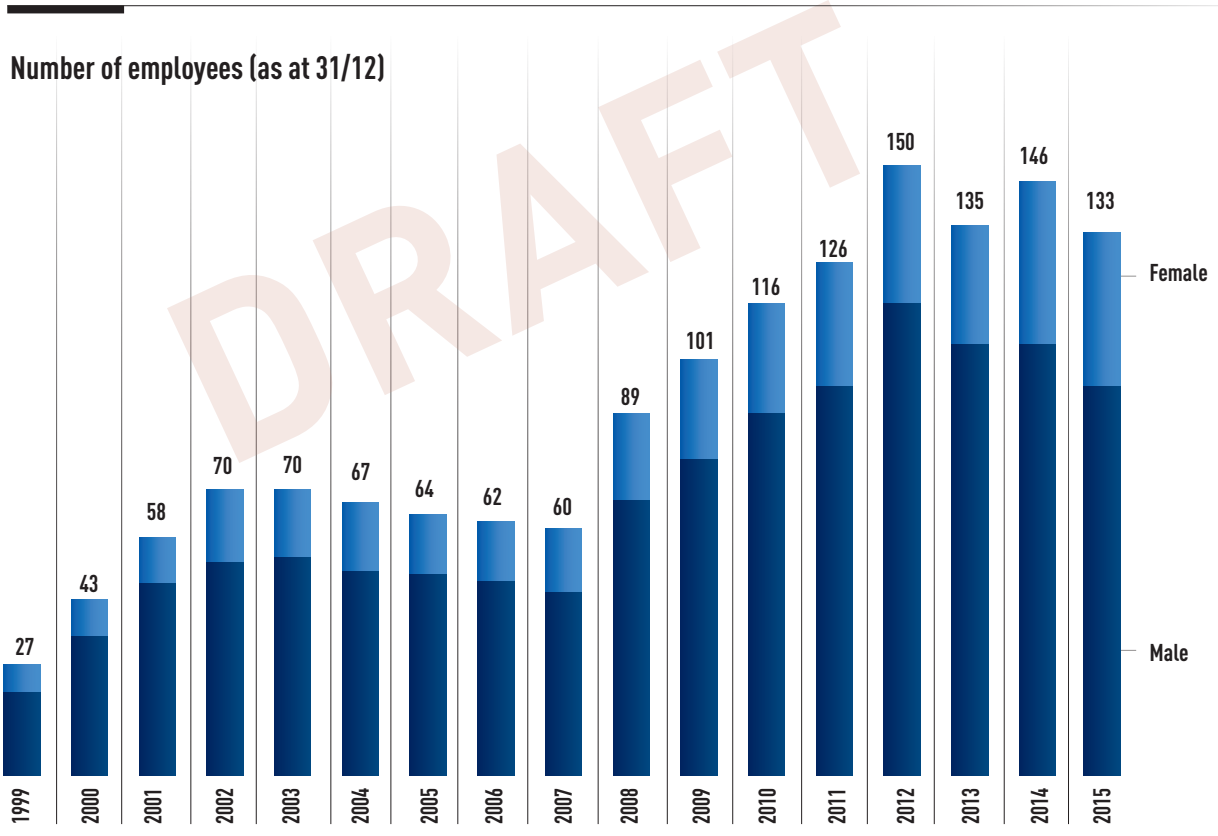
A turnover of € 2,038,629 was generated in the non-funded area (PY: k€ 1,729), representing an 18% increase over the previous year.

Turnover development (in million euros)



Staff development

The number of employees did not increase as planned. The company had 133 employees / full-time equivalents: 103.28 (PY: 146 / FTE 112.7) as at 31/12/2015. The largest decrease in the number of employees in 2015 was observed in the group of Junior Scientists.
Total staff consisted of 110 (FTE: 83.78) scientific staff (including students), 12 (FTE: 10.88) technical staff (technicians) and 11 (FTE: 8.63) administrative staff.
The proportion of female employees was 30.1% (headcount), or 26.4% (FTE), as at 31/12/2015.



Financial and earnings position

Earnings position

Materials Center Leoben Forschung GmbH reported an operating result of € 16,658.32 (PY: k€ 457) in the 2015 financial year. Income from financial assets amounted to € 27,418.52 (PY: k€ 34) and taxes on income were € 7,019 (PY: k€ 1). This resulted in a profit for the year and balance sheet profit of € 37,057.84 for the 2015 financial year.

An amount of € 437,439.40 (PY: k€ 713) was allocated to unappropriated revenue reserves in the 2015 financial year.

Turnover mainly includes (cash and in-kind) contributions of € 6,265,116.19 (PY: k€ 6,889) from the COMET partners and non-COMET project revenue of € 2,403,820.90 (PY: k€ 1,787). Work in progress amounted to € 95,770.40 (PY: k€ 206) in 2015. COMET and non-COMET funding together amounted to € 6,967,207.81 (PY: k€ 6,613). Other operating income, including the release of investment allowances and provisions, income from the disposal of fixed assets and the research bonus amounted to € 781,322.97 (PY: k€ 1,090). Overall revenue including other operating income and changes in work in progress (items 1 to 5 of the profit and loss account) amounted to € 16,513,238.27 (PY: k€ 16,586) in the 2015 financial year.

Raw material expenses and expenditure for services received amounted to € 7,566,585.39 (PY: k€ 7,392), and staff expenses amounted to € 6,260,728.03 (PY: k€ 6,364).

Depreciation and amortisation in the 2015 financial year amounted to € 1,075,397.16 (PY: k€ 987), and other operating expenses to € 1,593,869.37 (PY: k€ 1,385).

Asset position

The book value of fixed assets rose to € 3,116,766.05 (PY: k€ 2,747) in the 2015 financial year. This increase is mainly due to investments in the research areas "Materials Engineering" and "Materials for Microelectronics".

In 2015, the balance sheet profit of € 437,439.40 for 2014 was allocated to unappropriated reserves according to the resolution on the appropriation of net income (allocation PY: k€ 713). These reserves totalled € 4,605,199.97 (PY: k€ 4,168) as at 31/12/2015 and serve to ensure liquidity for the transition to the next COMET funding period and secure the development of research projects and activities in the future. The balance sheet profit of € 37,057.84 for 2015 will be allocated to unappropriated reserves in 2016.

Capital and reserves increased to € 4,934,257.81 (PY: k€ 4,897) in the 2015 financial year. The company has an equity ratio of 35.5% (PY: 32.4%) as at 31/12/2015, determined in accordance with Sec. 23 of the Austrian Company Reorganisation Act (URG).

Financial position

Net cash flow from ordinary activities was k€ 1,632 (PY: k€ 1,262), net cash flow from investment activities was k€ -1,468 (PY: k€ -1,288), and net cash flow from financing activities was k€ -0 (PY: k€ -6). Changes in cash and equivalents totalled k€ 164 (PY: k€ -32) in the 2015 financial year, bringing the value of cash and equivalents as at 31/12/2015 to k€ 7,807 (PY: k€ 7,643).

Outlook for 2016

The annual average volume for the second COMET funding period (2013 – 2017) was exceeded in the first three years of the funding period. A reduction in the COMET volume is therefore planned for 2016. A substantially higher volume is planned for the non-COMET area, which should be achieved mainly by an increase in nationally and internationally funded projects.

MCL plans to increase its number of employees in 2016 in order to be able to implement these and future projects.

Profit and Loss Account

		€	2015 €	2014 T €
1.	**Turnover**		**2,403,820.90**	**1,787**
2.	**Services not yet billable**		**95,770.40**	**206**
3.	**Income from cash and in-kind contributions by partners COMET K2**		**6,265,116.19**	**6,889**
4.	**Public funding and allowances**			
	a) income funding and allowances COMET K2	5,671,022.53		5,603
	b) income funding and allowances Non Comet K2	1,296,185.28		1,010
			6,967,207.81	**6,613**
5.	**Other operating income**			
	a) release of investment allowances	114.14		6
	b) income from disposal of fixed assets	500.00		0
	c) income from the reversal of accruals	39,424.26		36
	d) other	741,284.57		1,048
			781,322.97	**1,090**
6.	**Material expense and expenditure for services received**			
	a) material expense	1,019,921.24		859
	b) expenditure for services received	6,546,664.15		6,533
			7,566,585.39	**7,392**
7.	**Staff expenses**			
	a) Wages	23,871.15		21
	b) Salaries	4,801,410.34		4,886
	c) Employee income provision fund	70,963.36		71
	d) Expenses for social security payment prescribed by law as well as taxes and mandatory contributions dependent on compensation	1,305,884.22		1,338
	e) Expenses for other employee benefits	58,598.96		47
			6,260,728.03	**6,364**
8.	**Amortization**			
	a) of fixed assets		**1,075,397.16**	**987**
9.	**Other operating expenses**			
	a) taxes, in so far as they are not on income or on revenue	16,188.94		16
	b) other	1,577,680.43		1,369
			1,593,869.37	**1,385**
10.	**Operating result**		**16,658.32**	**457**
11.	Other interest income and similar income		27,496.46	34
12.	Interest and similar expenses		77.94	0
13.	**Financial result**		**27,418.52**	**34**
14.	**Profit from operating activities**		**44,076.84**	**491**
15.	Taxes on income and revenue		7,019.00	1
16.	**Net income**		**37,057.84**	**490**
17.	Allocation to profit reserves			
	a) other reserves (free reserves))		0	277
18.	**Profit for the year**		**37,057.84**	**212**
19.	Profit carried forward from the previous years		0	225
20,	**Balance sheet profit**		**37,057.84**	**437**

Balance Sheet

as at 31/12	€	2015 €	2014 T €
Assets			
A. Fixed Assets			
I. Intangible Assets			
1. Licences and software		64,356.72	79
II. Tangible Assets			
1. Equipment	2,748,914.31		2,146
2. Tools, fixtures and fittings	278,445.02		325
3. Payments made on account	25,050.00		196
		3,052,409.33	2,667
		3,116,766.05	**2,747**
B, Current Assets			
I. Inventories			
1. Services not yet billable	382,190.96		286
2. Payments made on account	80,000.00		60
		462,190.96	346
II. Receivables and other Assets			
1. Receivables arising from deliveries and services	447,982.27		413
2. Receivables of cash and in-kind contributions from partner companies	695,113.71		1,164
3. Receivables from subsidies und project subsidies	232,267.11		102
4. Other receivables and assets	925,610.62		1,745
		2,300,973.71	3,423
III. Cash on hand and bank deposits		7,807,139.71	7,643
		10,570,304.24	**11,413**
C. Trust assets		**0**	**716**
D. Prepaid expenses, deferred charges		**214,130.13**	**245**
Total Assets		**13,901,200.42**	**15,121**

as at 31/12	€	2015 €	2014 T €
Liabilities and Shareholders' Equity			
A. Capital and Reserves			
I. Share capital		292,000.00	292
II. Revenue reserves			
1. Other reserves (free reserves)		4,605,199.97	4,168
III. Balance sheet profit		37,057.84	437
thereof profit carried forward from the previous years		0	225
		4,934,257.81	**4,897**
B. Investment Allowances		151.07	6
C. Accruals			
1. Tax accruals	1,386,100.18		1,013
		1,386,100.18	**1,013**
D. Liabilities			
1. Liabilities arising from deliveries and services	2,657,916.70		3,091
2. Other liabilities	1,154,791.03		517
thereof taxes	104,475.40		11
thereof social security	128,736.23		132
		3,812,707.73	**3,608**
E. Trust assets		**0**	**716**
F. Prepaid expenses, deferred charges		**3,768,097.77**	**4,886**
Total Liabilities and Shareholders' Equity		**13,901,200.42**	**15,121**
Contingent Liability		**5,744.00**	**6**

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