Evaluation of the Research and Professional Activity of the Institutes of the Czech Academy of Sciences (CAS) for the period 2010–2014

Final Report on the Evaluation of the Institute

Name of the Institute: Institute of Physics of Materials of the CAS, v. v. i.

Fields, in which the Institute registered its teams:

Materials engineering, materials science and nanotechnology

Observer representing the Academy Council of the CAS: Jiří Chýla
Observer representing the Institute: Jaroslav Polák, substitute observer Milan Svoboda

Commission No. 8: Engineering and technology
Chair: em Prof.DI.Dr.Dr.hc. Hans Peter Nachtnebel

Date(s) of the visit of the Institute: October 12 - October 21, 2015
Programme of the visit of the Institute: see attached Minutes from the visit

Evaluated research teams:
No. 1 - Advanced High-temperature Materials Group; No. 2 - Brittle Fracture Group; No. 3 - Creep of Metallic Materials Group; No. 4 - High Cycle Fatigue Group; No. 5 - Low Cycle Fatigue Group; No. 6 - Electrical and Magnetic Properties Group; No. 7 - Structure of Phases and Thermodynamics Group

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM) of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM is sited in Brno, Zizkova 22, in the centre of the city. Here are placed both the Director and the Economic and operational Department as well as the three Research Departments (Dept. of Mechanical Properties, Dept. of Structure of Materials and Dept. CEITEC IPM) with their laboratories, experimental devices and the numerical facilities. Each Department is divided in Groups with well-defined expertise and fields of interest:

1. Dept. Mechanical Properties:
- Creep of Metallic Materials
- Advanced High Temperature Materials
- High Cycle Fatigue
- Low Cycle Fatigue
- Brittle Fracture

2. Dept. of Structure of Materials[1]
- Structure of Phases and Thermodynamics
- Electrical and Magnetic Properties

3. CEITEC IPM
- Multiscale Modelling and Measurements of Physical Properties
- Advanced Metallic Materials and Composites

As regards the Economic and Opearational Department, four different groups are identified: Information Technology, Technical-Operational, Accounting and Workshop.

[1] Department CEITEC IPM is an organizational unit of the Central European Institute of Technology. All members of this Department are simultaneously members of Dept. of Mechanical Properties and Dept. of Structure of Materials and they are evaluated within these units according to the Basic Principles of the Evaluation of the Research and Professional Activities of the Institutes of the Czech Academy of Sciences for 2010–2014, Article 3, 3f. The creation of Department CEITEC IPM was a strict requirement of the MEYSof the Czech Republic.

1.2 Brief history of the institute

The Institute was created from the Laboratory for the Study of the Properties of Metals of the Czechoslovak Academy of Sciences, which was founded in 1955 and changed to the Institute of the Properties of Metals in 1963. In 1969, the name was changed to the Institute of Physical Metallurgy. The current name was adopted in 1994. From its foundation the IPM has gained an increasing recognition in the international material science environment with different steering researchers in the subjects dealt with by the Institute.

1.3 Mission and research topics

The main mission of the Institute lies in getting new basic knowledge on metal based materials, ceramics and composites to elucidate the relation between the behaviour and properties of materials and their structural and microstructural characteristics which will help to maintain the sustainable growth. The position of the institute in this rather broad scientific field lies prevailingly in the research of metallic materials. There are two main research areas:

(i) physical nature of processes taking place in metallic materials during creep, fatigue, creep/fatigue and under other types of mechanical loading
(ii) structure of materials and selected thermodynamic, diffusion and magnetic properties.

Research covers broad interdisciplinary field of Engineering and technology and Physical sciences and there is traditionally broad co- operation with industry and university sector.

1.4 Staff size and full time equivalents age distribution

At present the Institute has altogether more than one hundred and forty employees. One half of them are scientific workers and co-workers (i.e. Ph.D. or equivalent degree) and second half is supporting staff and administration, technicians and workshop included. In terms of Full Staff Equivalent (**FTE**) stated at December, 2014 the Institute can count on **29.49 technical workers and 33.97 administrative workers**. In Fig. 1 the age structure of the Institute at the end of 2014 is shown.

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members	6	20	20	19	16	8	9	17	20	14	8

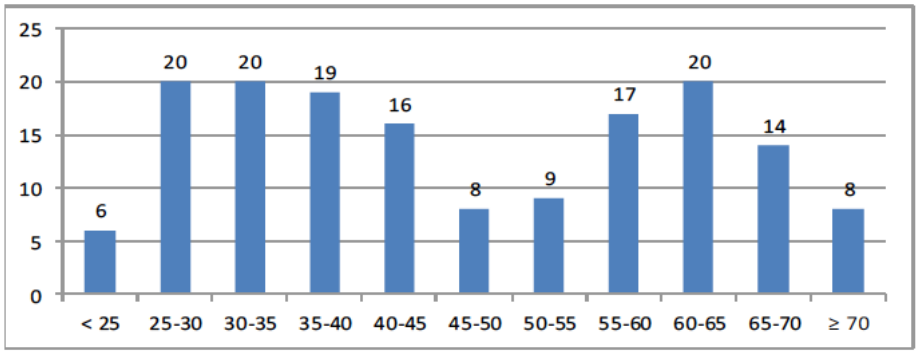

Figure - 1 Age structure of the institute (Dec. 2014)

At present the Institute believes that the age structure in the interval 25 to 45 year is optimal as regards the Institute's size and structure. The minimum on the age structure diagram, which at present corresponds to the age of 50 is an inheritance of the nineties of the last century. The peak on the diagram, which corresponds to the age 60 to 65, counts also relatively old employees on positions of porters and charwoman are included. In terms of FTE, IPM can count on 29.49 technical workers and 33.97 administrative workers.

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

While the research topics as they appear in the title are at a first glance consolidated and incremental more than strongly innovative, the way the research is oriented at the Institute is related to an innovative vision of research and society, and the research lines are oriented toward subjects strongly influential for the next generation way of life. That is to say that the research is oriented to a deep understanding of damage mechanisms and makes use of the most recent experimental devices with resolutions once not possible and toward topical subjects for the development of the next generation systems: development of basic and deep knowledge of the damage mechanisms (mainly fatigue and creep) of new materials with superior properties obtained by new technology processes aimed at ultra fine grain materials, development of new composite materials for applications in extreme environments, lifetime prediction of polymer structures, environmentally friendly lead free soldering.
On the base these comments, the timeliness of the overall research activity is considered **very good.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

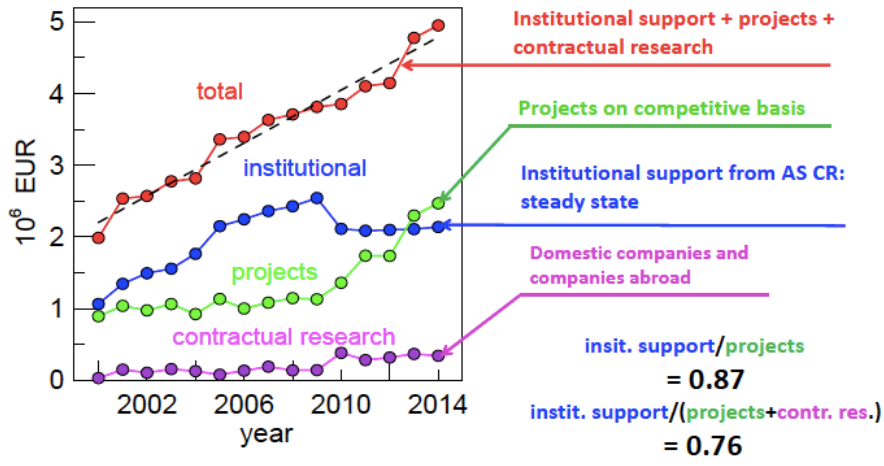

Figure 2 – Trend of the budget (evaluated period 2010-2014).

In Fig. 2 the trend of funding during the evaluated period is shown. It can be noted that the total trend is always increasing and that while the institutional grants are stable, the funds coming from competitive calls (grants) are increasing and in 2014 are more that the institutional incomes. A minor and stable but negligible budget contribution coms form contractual research: this is also remarkable if the mission of the IPM (mainly focussed on basic research) is considered.
In numbers in the period 2010-2014 106 projects were assigned to IPM prevalently by the Czech Science Foundation, the Ministry of Education and Sport and Ministry of Industry and Trade. The European projects are increasing (GlaCERCo (Marie Curie Action), Rolicer (FP7), Z- Ultra (FP7), CoACH (Marie Curie Action, H2020), EFDA (Euroatom) Projects).
The assessment is **very good.**

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

The dimension of the Groups in each Department is limited while the number of research subjects and their experimental complexity is great. This is made possible by a strong integration and cooperation of the different Groups, both as regards the experimental facilities and the elaboration of the results. The Institute is able to attract a good number of international researchers and PhD students.

The cooperation with the other Institutes of CAS is not remarkable due to complementary character of the different Institutes, the cooperation with national university is well developed, in particular with the Brno Technical University and Masarik University, Charles Univerisity in Prague (other major cooperation with: Technical University of Ostrava). The cooperation is active as regards the pedagogical activities (many researchers at IPM teach at ne university) and also s concern the research activity. The close co-operation with universities is reflected in courses, joint PhDs, common grants. The benefit is in the effective utilization of the experimental facilities. An example of excellent co-operation with universities is the project CEITEC, which is a consortium whose partners include the most prominent universities and research institutes in Brno. Participation in this consortium provides an access to a number of unique experimental facilities and significantly expands the interdisciplinary cooperation in the field of materials engineering and life sciences.

The cooperation is also active with the main companies active on the national territory: ABB, GE Aviation, Honeywell, Bonatrans Group, ČEZ, Siemens, První brněnská strojírna Velká Bíteš, Voest-Alpine are some of the main names of companies the IPM cooperates with for applied research subjects. About 100 research reports for industries were written in the evaluation period.

The international involvement is consolidated due the traditional relevance of the Institute in many fields. A strong link with University of Zilina and Ruhr University, Bochum, Germany (RU) is established with regular lectures given by IPM professors and associate professors. Scientists attached to the Institute regularly lectures at these universities or are supervisors of bachelor, master and doctoral studies or are supervisors of postdoctoral researchers.

Totally 9 professors and 6 associate professors regularly lectures at these universities or are supervisors of bachelor, master and doctoral studies or are supervisors of postdoctoral researchers. Other cooperation that is worth citing are with : Material Science Vienna University of Technology, Montanuniversität Leoben, Polytechnic University of Turin, École Nationale Supérieure de Mécanique et D'Aérotechnique Poitiers, Polytechnic University of Milan.

Also from a scientific point of view the IPM can count on well-established international cooperation with almost the same universities.

Finaly, the intensity of the collaborations of the Institute is **defined very good**

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2.4 Position of the institute within the Czech scientific community and its international position

The reputation of the Institute in the Czech Scientific community is **quite high** and derives both from the results achieved in the past and from present activities. This is documented also by the number of papers and by the successful scientific events organized by the institute.

Also in the international contest the Institute can count on a solid reputation that has been increased in the evaluation period also by the participation in EU funded projects (FP7, Marie-Curie Action, Euratom), all on subjects strategic for the IPM.

2.5 The overall capacity of staff

The overall capacity of the staff is qualitatively adequate for the activities of the Institute. From a quantitative point of view, the recent introduction of more young people as well as an increasing has enforced the operative capability of the Institute. The distribution of the staff among the different group is not homogeneous and somehow reflects the scientific activity intensity.

2.6 Reasonability of the structure of the institute and the departments

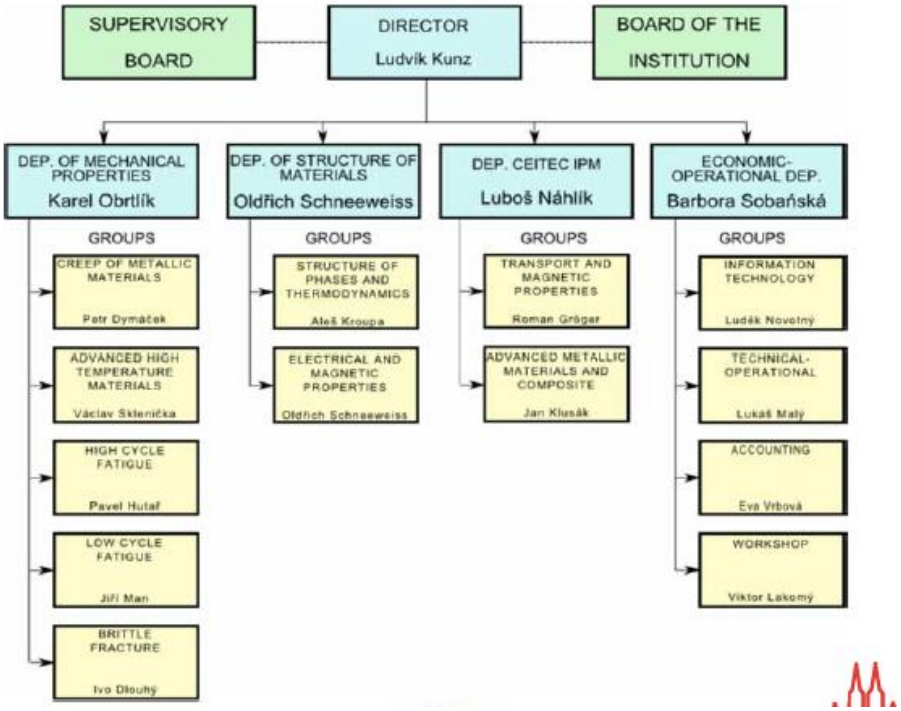

Figure 3 – Organization of institute IPM

The management structure of the Institute is shown in Fig. 3. It is a well-consolidated scheme among the institute of the CAS and is reasonable for an adequate management of the Institute. As regards the structure of the different groups, due to the limited number of researchers in each group it is substantially based on a Responsible with some researchers/post-doc/PhD students that follow the different running activities.
The Board is formed by six internal members (among them the Chair and the Vice-chair) plus 3 external members and one secretary. The Board is holding approx. 6 attendance meetings and 12 per rollam meetings per year: this is assessed enough for the steering action of the Board. The duties of the Board are given by Statutes of the the Czech Academy of Sciences, Art. 11-1. In particular The Institute Board is approving the Institute budget and its amendments, the Institute internal regulations and their amendments, the Annual Report of the Institute.

The Institute Board is discussing and evaluating drafts and proposals of research objectives and research projects, drafts of agreements on international cooperation of the Institute and of agreements on its collaboration with domestic institutions, plans for purchases of new large equipment (over~10000 Euro).

The structure of the Institute is aligned with the ones of the other Institutes of CAS. **Very good.**

2.7 Comments on the age structure

The age of the structure was fond to be one main weak point in the previous CAS evaluation.

In 2010-2014 the management of the Institute dida great effort to improve the structure of the age and with the benefit of benefits **Operational Programme** Research and Development for Innovations and the Programme for Educational Co-operations (MEYS) and **Pedagogical activities** of our researchers at Brno universities was able to attract more young researchers that improved the present situation to much better framework, especially as regards the researchers. There are still margins of improvements.

2.8 Frequency and quality of publications

In Fig. 4 the total outputs in the evaluation period by the Institute are shown.

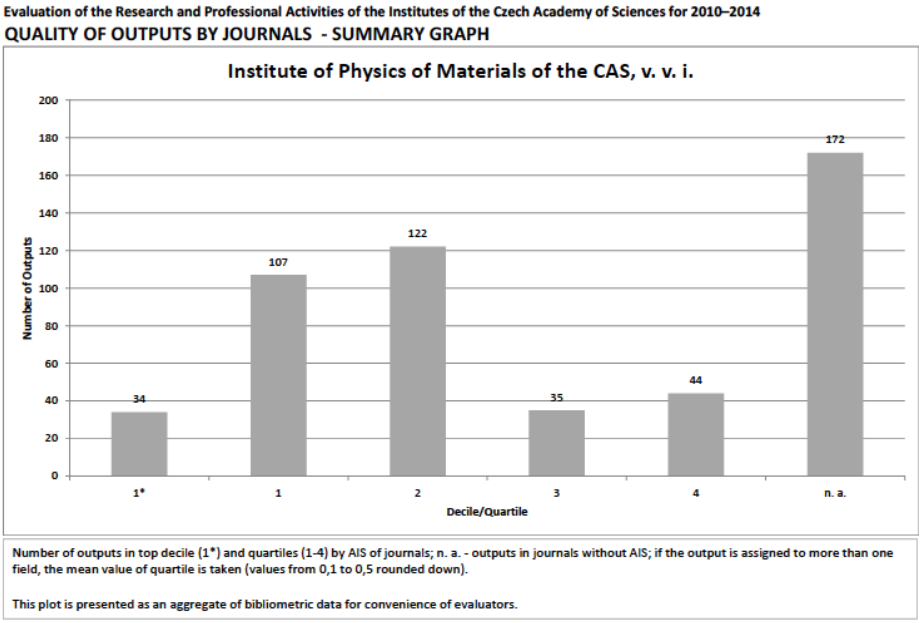

Figure 4 – Quality of the outputs of IMP by journals

It is possible to note that both the number (and, thus, the frequency) and the quality of the journals can be defined more than adequate.

This is confirmed by looking at the output as Ranked in Phase I: 90 papers were considered and, among them, in 6 (15) were ranked 1 (world-leading in terms of originality, significance and rigour) 39 (43%) were ranked 2 (internationally excellent) 40 (48%) were ranked 3 (recognized internationally) and 5 (12%) were ranked 4 (recognized nationally). No papers were ranked 5 (below the standards). It is interesting to note also that the results were achieved with an excellent ratio Institutional Subsidy/n. papers.

In Fig. 5 it is shown a graph showing this data in comparison with the other institutes: it is noted that IPM is the lowest one.

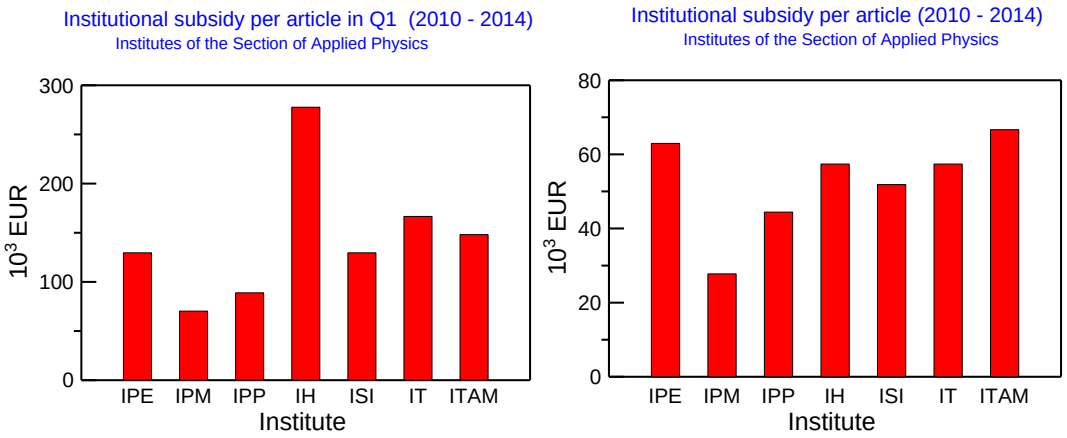

Figure 5 – Institutional subsidy per article – Institutes of the Section Applied Physics: Q1 and total number of papers.

Finally, the quality of the output can be defined **very good**.

2.9 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming form contractual research is stable and limited for IPM.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The budget structure is characterized by a stable amount of institutional support by CAS. The ratio of the institutional and competitive financing is steadily decreasing.

There is a low institutional support for investments (150 kEUR/year) and no support at all of investments from domestic Grant agencies.
This is an index of the quality of the results the IPM has got but can be a weakness point in the mid-term.

In fact, the structure of funding can be a mid-term problem since it is more and more based on competitive grants (average duration 3-4 years): this cannot allow long-term plans for investments and limits the research view to somehow more immediate results.

And competitive grants risk fragmentising the investigation, making more difficult the management and increasing the bureaucracy. Number of necessary project managers is steadily increasing in proportion to the complexity of project applications and reporting of monitoring indicators.

3.2 Comments on the age structure

The age structure can be further improved.

3.3 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Departments and the Groups are well structured and basically balanced but Creep of Metallic Materials and Advanced High Temperature Materials could be better integrated by removing overlaps or can merged in one more structured and massive Group.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

Internal awards related to papers in very high ranked journals (in the materials category) can improve the competition of the different groups and, somehow, improve the collaboration among the different groups.

4.3 Identification of new research topics

While the experimental facilities are now up-to-date and are no more an urgent issue to be faced, margins of improvement are noticed as regards the numerical simulation and the recent methods and techniques developed for multi-scale simulation, from macro to atomistic, of materials. This could be an added value to the achievements obtained by the experimental work with a deeper understanding of the experimental evidence. Investments in this kind of software are suggested.

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The main orientation of the research activities considers both “basic” research (i.e. research resulting in new knowledge suitable for publication in scientific periodicals) and “applied” research (i.e.contractual and collaborative research for industry), with a special view on basic research and basic damage mechanisms. The main research activities are strictly related to the structure of the Institutes and the Groups it is formed of.

Basically the Institute covers this two main research areas: (i) physical nature of processes taking place in materials during combined loading (creep, fatigue, creep/fatigue, brittle fracture) and (ii) structure of materials and thermodynamic, diffusion and magnetic properties.

Particular emphasis is placed upon the research into advanced metallic materials and composites with a metal base and ceramics in relation to their microstructure and production.

The research activity is generally based on experimental activity, with a complete set of facilities and devices allowing to cover the broad spectrum of requirements related to the subjects just mentioned. The laboratories were completed, during the evaluation period, with new machines: this gives the perspective to remain competitive in the next years and able to face the new challenges in the field of materials.

In spite of the strong experimental effort, the theoretical and numerical area is well equipped in terms of hardware, software and expertise of the researchers. In particular, the Group of Electrical and Magnetic Properties is strongly involved in theoretical and numerical analysis for multiscale model development.

Relevance in the national and international context

The relevance of the research activity of the Institute is high. In the national context the Institute has unique expertise, not only within the institutes of the CAS, that makes possible to maintain the leader position in the framework of the research in the filed of basic research in mechanics of materials and development of damage mechanisms.

The relevance of the Institute in the international context is excellent in many of the areas of activity and appears nowadays aligned with the traditional leading role had in the past with achievements of high international value. .The overall relevance is considered **quite high**.

Overall quality of publications

The publications of the Institute are generally of high quality: 34 papers are in the top decile, 107 in the first quartile and 122 in the second quartiles, while a minority of papers is the the 3rd and 4th quartile (35 and 42, respectively). The 122 papers in journals without AIS reflects the involvement of the institute in other than scientific activity (science popularization,…) and publications at national level as well as books and book chapters not ranked in usual databases (ISI, Scopus,…).

Specification of the main achievements

The main scientific achievements can be summarized as follows: (i) new piece of knowledge on the physical nature of processes which occur in advanced metallic materials during creep, fatigue, creep/fatigue interaction, brittle fracture and their combinations in the relation to the evolution of microstructure and in getting, (ii) new findings concerning the relations of material microstructure and thermodynamic, diffusion and magnetic properties of prospective materials and in theory-guided materials design and ab initio calculations. Structure of materials is understood in a very broad sense, ranging from atomic bonds, through crystal lattice and its imperfection, the size of crystallites in materials, to the macroscopic dimensions of loaded bodies.

In particular the main results were in the field of creep processes and fatigue behavior of ultrafine-grained metallic materials, the effect of Zr addition on creep of Fe-30 at.% Al alloys, fibre reinforced composite on ceramic basis, initiation of fatigue cracks, lifetime prediction of polymer structures, lead free soldering, computational studies of atomic configurations of defects are the main research subjects dealt with in the evaluation period.

All these achievements have important reflects on societal issues and present technological challenges. This is believed one of the key factors that make the Institute to get an increasing number of grants assigned on competitive (peer review) base.

Specification of the contributions of the team to publications

The previously mentioned achievements have a multidisciplinary character and show a strong interlinking of the different groups and requires very expensive experimental equipment used in close combination with high-level theoretical, computational and modelling knowledge.

This can somehow compensate the general low dimension f each group, as stated during the in-situ visit. And this is believed a key factor for maintain the leadership position in the present research panorama.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The IPM has 4 joined accreditations for the Ph.D. studies with Brno Technical University and 1 with Masarik University in the areas of interest for the interest (*Advanced Nanotechnologies and Microtechnologies, Advanced Materials, Applied Mechanics, Physical and Materials Engineering, Physics of Condensed Matter, Mechanical properties of solid state).* From the students supervised by the professors of the IPM 11 BSc, 32 MSc and 15 PhD thesis defended their theses successfully in the evaluation period.

Table 1 Supervision of students

Type of study	No. of supervisors (theses, dissertations)	No. of consultants or co-supervisors	Theses defended in 2010-2014
Bachelor	10	3	11
Master	21	8	32
Doctoral	25	15	15

Thanks to the EU project GlaCERCo and operational projects of MEYs 6 talented PhD students or post-doc were hired from abroad while 9 PhD internships were activated with students coming from other countries of the EU, China and Japan.

Particular contributions of students to research

The students are actively involved in the research activities and are among the authors of the papers published by the IPM.

Number of defended PhD students in relation to students involved (success rate)

The total number of theses defended in the evaluation period is 11 (BSc), 32 (MSc) and 15 (PhD) with a very good rate of success with respect of the supervised number of theses, equal to, respectively, 10, 21 and 25.

Employment of former PhD students (career options)

At present the Institute is employing few of the former PhD students but a definitive number was not found. The main problem is to find an adequate budget.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

Even if mainly related to basic research, the results of the scientific activities are in topical subjects for the economy and the society. Their impact on the economy in the mid-term is high.

In fact, most of the subjects are related to the present major challenges for a better understanding of the behaviour of materials, thus enabling the use in more and more severe conditions thus increasing their efficiency and exploitation in many of the fields now of critical interest as energy, transport and modern technologies for manufacturing.

The educational activities go in this direction with students in the same area that will be employed in those fields and will introduce new views in the companies. The other activities, pedagogical, research popularization and editorial go in the same direction.

Impacts of the results and other activities on education

The involvement of the IPM in education through supervised students is high. The strict cooperation with different universities and the coursed hold by IPM researchers/professors indifferent universities increases the impact to a very good level and high reflects on the education activities both at the host universities and at the Institute itself.

Impacts of the results and other activities on culture

Further to the scientific papers, as regards the impact of the Institute results and other activities on culture, it is to be underlined the active role of the IPM in organizing conferences and publishing and editing books. In the evaluation period the IPM organized 9 successful International Conferences and edited their proceedings, even with well known and international recognized Publishers.

The IPM publishes since 1963 the Journal Kovove Materialy/Metallic Materials (with IF, 0.546) in co-opeartion with the Institute of Materials and Machine Mechanics, Slovak Academy of Sciences.
Dr. A. Kroupa was the editor of the book published by COST office in the scope of the international COST MP0602 project "Advanced Solder Materials for High Temperature Application (HISOLD)" which he led in years 2007-2011. The results of the project were published in the form of 3-volume publication "Handbook of High-Temperature Lead-Free Solders" (ISBN 978-80-905363-0-2). A. Kroupa was the editor of the volume 3 (ISBN 978-80-905363-3-3). The whole 3-volume publication was met with high interest in the scientific and industrial community, according to the COST office; the number of requests for sending the publication highly exceeded usual demand. The impact of these activities on culture is high.

Services for research (libraries, data bases, collections,..)

Library of the Institute is a library with specialized fond from the area of material sciences. It provides librarian and information services in the sphere of science and research within workplaces of the Academy of Sciences and also to other users. 10 206 librarian units are available for borrowing services, of which 5 411 are books and 4 795 magazine volumes. 25 671 loans were granted in the years 2010-2014. The library of the Institute also provides interlibrary loan services, which were for this period 920, of which 71 were international library loans. 41 institutions provided 695 loans to the IPM and we provided 154 loans from our own fond to 31 institutions. The library is quite good.

Popularisation and similar activities

The IPM participated to FameLab® and J. Kluusak won the national science-popuparization competition. The IPM is also parecipating to Science Poluparization lectures for high school students and general public and is involved in Open Days with lectures, excursions to the labs and amazing thetre of Physics. IPM is the co-producer and the main author of the episode of Mystery Hunters series broadcasted in Czech Television.
Another project is the Science Academy Project supporting science popularization activities at the institute.

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The position of IPM in the international context is traditionally of primary importance and impact. In particular it is worth reminding the leading contribution of the IPM in the field of high and low cycle fatigue and the publication of book that are still a reference for researchers and engineers active in this field. The present activity of the Institute is well aligned with the tradition: the IPM is still a leading research institute in its field of activity with a high number of papers published in high ranked journals (1st decile and 1st quartile), especially if the number of researchers in the institute is considered. Since important results in the fields of interest for the Institute today can be achieved only if new and powerful facilities are available, this can be considered an index of the ability of the institute to keep up to date the experimental and numerical devices.

The comparison with international leading teams is highly positive especially if the ratio between the scientific output and the amount of incomes (institutional, competitive grants and contractual research) are considered: this is also an index of the ability to correctly steer the activities in the correct directions.

Role and position in international collaboration

IPM has a wide number of international cooperation, especially but not only with neighborough countries. The cooperation is enforced by the personal relations of many of the researchers of the IPM and by the European Projects the Institute is involved in.
The position of the Institute is generally leading.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
The world leading teams active in the same field are generally larger than IPM and with a greater number of researchers. The ability of the Institute to remain competitive is justified by the strong interaction among the different groups and by a correct address of the investments and expenses.

Ability to attract foreign researchers at different levels

In the present framework, the ability of Czech Institute to attract foreign researchers is somehow limited by the average level of salary, lower than in other well developed countries of Europe. Just with EU funds this gap can be filled.
In spite of this objective problem, the IPM attractiveness from of scientific point of view is good at the different levels. Thanks also to the EU funds and projects the Institute is able to attract an increasing number of PhD students and post-doc. Also the PhD internships and the researchers coming from abroad are worth mentioning and increasing.
17 prestigious international scientists spent a period at the institute in the framework of running cooperation.

Possible missing research directions

The research areas in the field of Physics of Materials are well represented but a specific address on surface engineering is not expressed while could complete the plan of the Institute.

Position of the team in the national context

The IPM is the national leader institute.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The composition of the staff was one of the weak points during the last evaluation procedure. Now the structure is improved and the average age of the staff is 43 years.

About 25% of the staff is female. The qualification of the staff is high and the researchers are PhD and have a recognized experience abroad.

Attraction of research programmes for young people

The substantial improvement of the structure age in the last five years is related to the improved ability of the institute to attract young people and talents.

This is due both the pedagogical activities able to attract young people and by the strong effort to obtain projects funded by the Operational Programmes Research and Development for Innovations and Programme for Educational Co-operations.

Also the Further, the subsidy from the start-up project of CEITEC IPM substantially helped improving the attractiveness toward young talents.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding structure is evolving toward a system with substantially stable institutional grants while increasing of competitive grants based on peer review procedure. The contractual research is not negligible even if not quantitatively important as the other two types of funds.
The output of the IPM are relevant compared with the total outputs, thus showing a good efficiency in managing the available resources, in spite of the expensive experimental facilities needed to develop the work of the institute.

Effectiveness of research (based on comparing size of groups, funding and output)

The effectiveness of research is high if the funding total incomes and the scientific outputs are considered. The relatively small dimensions of is groups can be a limiting factor but the strong interaction among them limits the possible overlapping and not optimal use of the available resources.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

The structure of the Institute has a director on top, scientific responsible of the Departments and of single research groups. A board formed by 9 people (6 internal plus 3 external) meets 6 times a year with the task of evaluating the research objectives, discussing the proposals, plans for new equipment (>10k€), agreements on international cooperation. The Board organizes also workshops where group leaders present the achievements and plans for future scientific activities. Future plans are in such way then discussed at the Institute level. This strongly supports scientific collaboration among researchers and groups of the Institute.The Board discuss research incentives and programs for publishing and identifies new research directions, based on proposals by the Groups and researchers.

The evaluation of the researchers at the Institute is performed on account of his/her scientific production and on general contribution to the basic and applied research outputs. The same procedure is applied for evaluation of research groups. Individual researchers are evaluated from two angles:

a) from the point of view of the researcher's professional career,
b) from the point of view of the contribution for the Institution as a whole - who is interested in how to best achieve mission of the Institute.

For the evaluation two steps are used:

a) mandantory: defined by the legal requirements and standards of the Czech Academy of Sciences at the regular sessions of the Attestation Commission of the Institute.
b) defined by institutional statutes and rules. Particularly, the basis for the evaluation is the Annual report on publication activity of individual researchers, grants, contributions to the contractual research, organization of seminars and pedagogical activity.

Since the year 2013, according to decree of the director of the Institute, the best publishing young and senior researches get a financial reward. The reward goes to junior scientists who published - as the first author - two or more papers in journals with impact factor. Similar approach is valid for senior researchers but at least three papers are required.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The declared strategy of the IPM is based on a continuous improvements and new achievements in the present research fields, following the on-going needs and new trends in the different areas of interest. The research will be continuously kept on international levels.

IPM is strongly involved in the Strategy AV21 program and is the coordinator of one of the 14 Research Programmes (New Materials Based on Metals, Ceramics and Composites) with the aim of developing new metal-, ceramics-, and composite-based materials, deepening the understanding of properties of materials in relation to their microstructure and engineering applications and increasing the effectiveness of utilization of the existing and newly built research infrastructures. The Institute is also involved in other programs of pertinence.

Adequacy of available means and human resources to achieve these plans

The financial structure of the Institute can raise some problems for the sustainability of the strategy for the next years since it is more and more based on competitive than institutional grants. This prevents long-term investments. The experimental facilities are expensive and cannot be used for small contractual research: this could limit the applied-research activities preventing possible interesting developments.
The human resources are adequate.

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

Team 1: Advanced High-Temperature Materials Group(AHTM)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-Advanced High-Temperature Materials (AHTM) Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-AHTM Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Brief history of the institute

1.3 Mission and research topics

Mission: Understanding the underlying creep deformation, damage and fracture processes to provide insight to facilitate further development and applications of improved advanced high temperature materials.

The selected research fields of the group in the last five years:

- High temperature creep deformation and damage processes in ZrNb alloys
- Creep behaviour of ultrafine-grained materials processed by SPD
- Creep strength and microstructure of advanced martensitic 9-12%Cr steels and new-generation of ODS alloys and ODS composites
- Microstructure, properties and application of gamma-TiAl intermetallics
- Creep deformation and damage in MMCs and in-situ composites
- Creep damage assessment and lifetime prediction methods
- Modelling of thermodynamics processes in advanced materials
- Microstructure and functional characteristics of NiTi shape memory alloys

Goals:

- Maximizing efficiency and reduction emission of ultra supercritical power plants involves operation at the highest possible temperatures and pressures need to develop new generation of advanced creep-resistant materials
- The deep knowledge of creep behaviour and properties of high temperature materials play vital role in improving the safety criteria of high temperature components in nuclear power plants.

- New high-strength materials for lightweight construction in transportation industry are strongly needed

1.4 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members		2	1	2	1		1	2		2	1

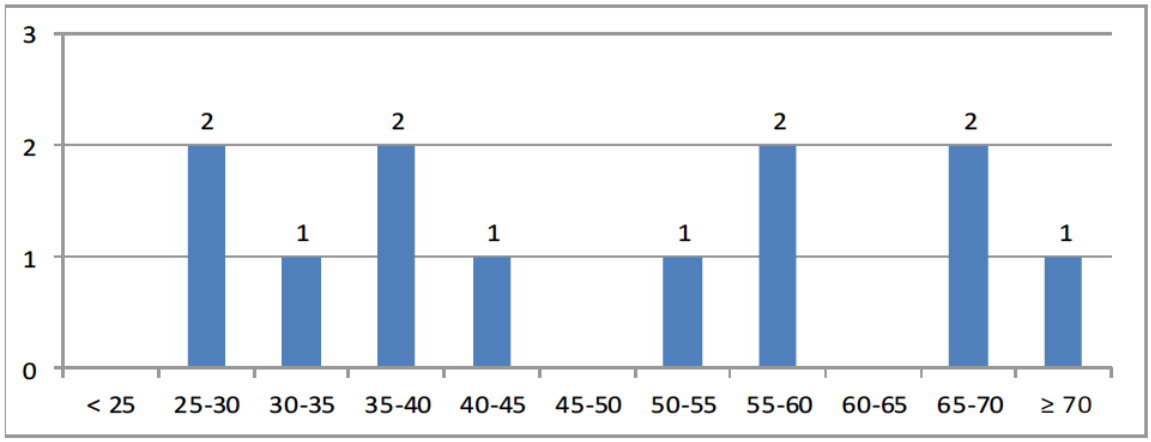

Figure 6: Age Distribution of group AHTM

4 senior researchers (V. Sklenička, A. Dlouhý, K. Kuchařová, J. Svoboda)
5 junior researchers (J. Dvořák, M. Kvapilová, P. Král, M. Kuběnová, T. Záležák)
3 technicians
1 PhD student

In terms of full tine equivalent age distribution, the Group is formed by 7.44 FTE researchers and 3.06 FTE other workers (at 31.12.2014).

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research subjects of the AHTM groups are aligned with some of the most urgent societal needs and face the following urgent needs: maximizing efficiency and reduction emission of ultra supercritical power plants (this involves operation at the highest possible temperatures and pressures need to develop new generation of advanced creep-resistant materials), development of safety criteria of high temperature components in nuclear power plants, development of new high-strength materials for lightweight construction in transportation industry are strongly needed. On the base these comments, the timeliness of the overall research activity is considered **very good.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The AHTM group has several close links with the commercial sector and raised about 583 k€ in the evaluation period from contractual research.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:

- intradepartmental (Department of Mechanical Properties):
  Creep of Metallic Materials Group
  (creep testing at extremally low applied stresses, Zr-Nb alloys, 9-12%Cr steels),
  High Cycle Fatigue Group (interaction of creep –fatigue, Ni-base superalloys)

- interdepartment (Department od Structure of Materials)
  Structure of Phases and Thermodynamics (microstructural analysis, thermodynamics modelling of multicomponent systems, diffusion processes, microstructure UFG matls)
  Department CEITEC IPM
  Advanced metallic materials and composites (creep-resistant steels, MMCs)

In the National environment (national cooperation):

Faculty of Nuclear Sciences and Physical Engng., Czech Technical University in Prague (advanced creep-resistant steels, Zr alloys, fractography)
Faculty of Mathematics and Physics, Charles University in Prague (magnesium alloys and composites, stereology of secondary phases)
Faculty of Metallurgy and Materials Engng., VSB-University of Technology in Ostrava (ultrafine-grained metallic materials)

In the International environment (International cooperation)

The researchers of the Group can count on many cooperation with professors from USA (University of Southern California, creep of UFG materials, Ohio State University (advanced TEM, SMAs), Oak Ridge National Laboratory (intermetallics, DS eutectics)) South Korea (Hanyang University Seoul (processing of UFG materials)), Argentina (Centro Atomic Bariloche (shape memory alloys – SMAs)), India (Indian Institute of Science, (composites)), Japan (National Institute of Materials Science (NIMS) (creep resistant steels), Kyushu University (processing and properties of UFG materials)), Germany (Fraunhofer Institute, Freiburg (thermodynamic modelling), Max Planck Institute, Düsseldorf (ab-initio modelling), Ruhr University, Bochum (intermetallics), University of Erlangen-Nürnberg (creep mechanisms), Clausthal University of Technology (magnesium alloys and composites)), Austria (Materials Centrer Leoben (thermodynamic modelling, development of Fe-Al-O ODS steels)), Montan Universität Leoben (thermodynamic modelling), Technical University of Vienna (thermodynamic modelling), University of Vienna (defects in UFG materials), Russia (Ioffe Physical-Technical Institute, RAS (creep damage), Baikov Institute Materials Science, RAS (UFG materials), Belgorod State University (Ti alloys)), Slovakia (Inst. Materials and Machine Mechanics, SAS (UFG materials), Welding Research Inst. Bratislava (creep resistant steels)), Italy (Centro Sviluppi Materiali S.p.A. (creep-resistant steels, MACPLUS))

In the period 2010-2014 the team has participated in 2 international EC FP7 projects and 6 bilateral international projects.

More than 45 joint publications with foreign partners were published in the evaluation period.
The intensity of cooperation of the Group is rated as **very good.**

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2.4 Position of the institute within the Czech scientific community and its international position

The reputation of the Group in the Czech Scientific community is high. This is documented also by the number of papers (74) and book chapters (3) published in the evaluation period.

Also in the international contest the Group can count on a solid reputation that has been increased in the evaluation period also by the participation in EU funded projects (FP7, Marie-Curie Action, Euratom), all on subjects strategic for the the Group.

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 6. From a quantitative point of view, the recent introduction of more young people as well as an increasing as enforced the operative capability of the Institute. The capacity of the staff **is good.**

2.6 Comments on the age structure

After the last evaluation more young scientists were introduced in the staff. During the period 2010-2014 all younger scientists have been much more involved in the research of the team. They have been the investigators and/or coinvestigators of 4 research projects, members of the research teams in other 6 grant projects and they were involved as authors and/or co-authors in the most publications of the group. In this year all of them applied for the new grant projects for the Czech Science Foundation. Thanks to the new young researchers the research field of the team has been expanded into both new types of materials investigated (e.g. zirconium and titanium alloys, discontinuously reinforced metal matrix composites, ODS alloys, nickel-based superalloys, new types of intermetallics) and the creep response of those materials. The age structure is now adequate enven if there are still margins for improvements.

2.7 Frequency and quality of publications

The total outputs of the group is 124. In Fig. 7 it is shown the quality of the outputs by journal ranking.

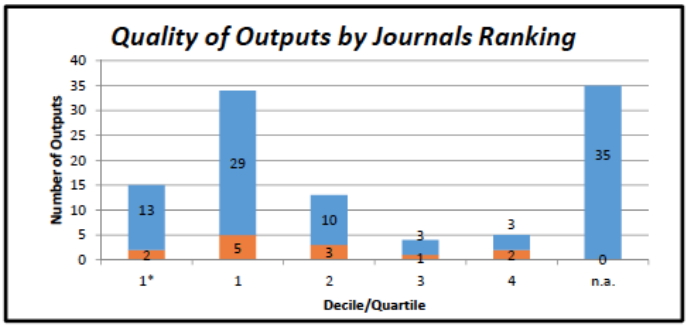

Figure 7: Quality of outputs of AHTM by Journal Ranking

While the journals of publications are generally adequate, the number of citations is somehow lower than expected.

If we refer to the output as Ranked in Phase I: 13 papers were considered and, among them, 1 (15) was ranked 1 (world-leading in terms of originality, significance and rigour) 4 (43%) were ranked 2 (internationally excellent) 6 (48%) were ranked 3 (recognized internationally) and 2 (12%) were ranked 4 (recognized nationally). No papers were ranked 5 (below the standards).

Finally, the quality of the output can be defined **good/very good**.

2.8 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is not mentioned.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

Since the experimental facilities are quite expensive and bearing in mind the structure of the budget of the institute, it is expected that the ratio of the institutional budget could be a critical factor.

3.2 The overall capacity of staff

The quality of the staff is adequate, the number of members should be improved.

3.3 Comments on the age structure

The age structure can be further improved attracting more PhD students and young researchers.

3.4 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

Based on the strengths, opportunities, weaknesses and threats some recommendations can be elaborated. Sub-sections (topics) may refer to:

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Groups Creep of Metallic Materials and Advanced High Temperature Materials could be better integrated by removing overlaps or can merged in one more structured and massive Group.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

The AHTM Group could be joined to the Creep of Metallic Materials Group.

4.3 Identification of new research topics

The action of the Group for the introduction of new research lines is adequate.

5. DETAILED EVALUATION

According to the guidelines the following sub-sections should be included:

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The experimental research activities are concentrated in the creep area and they were oriented toward some urgent societal problems made evident in some great accidents and failures happened in the last years.
As regards the theoretical research the main outputs are about Modelling of thermodynamic processes – diffusion and interface migration.
The contractual research is oriented toward the solution of practical problems proposed by the industries with a limited impact on the global results and budget of the Group.
The overall relevance is considered quite high.

Overall quality of publications

The publications of the Group are generally of high quality: 15 papers are in the top decile, 34 in the first quartile and 13 in the second quartile, while a minority of papers is the the 3rd and 4th quartile (4 and 5, respectively). The 35 papers in journals without AIS reflects the involvement of the group in other than scientific activity (science popularization,…) and publications at national level as well as books and book chapters not ranked in usual databases (ISI, Scopus,…).

Specification of the main achievements

The main scientific achievements can be summarized as follows: (i) High temperature creep in Zr-1wt%Nb alloy under LOCA temperature gradient with a detailed investigation to get the data and the design curves currently not available in literature for designing nuclear power plants by considering possible critical conditions (the investigations includes both mechanical tests with constant stress tests rather then constant load tests and microstructural fine characterization of a complete understanding of the damage mechanisms), (ii) Modelling of thermodynamic processes – diffusion and interface migration (application of the Thermodynamic Extremal Principle to derive of the evolution equation for the characteristic parameters to simulate abnormal grain growth), (iii) Development of new-generation Fe-Al-O based ODS steels, (iv) DDD model of high temperature interactions between low angle dislocation boundaries and precipitates.

Specification of the contributions of the team to publications

The contributions of the Groups to publications is primary since the tests can be done just in the labs of the Group.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The AHTM Group has supervised 4 PhD students (3 thesis defended), 2 MSc students and has supervised 1 PostDoc. The students are directly involved in the running projects.

Particular contributions of students to research

The students are actively involved in the running research projects and are among the authors of the papers published by the IPM.

Number of defended PhD students in relation to students involved (success rate)

The total number of PhD theses defended in the evaluation period is 3 versus 4 PhD students supervised.

Employment of former PhD students (career options)

The possible carrier development is strongly dependent on the successful grants achieved by the group.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

Even if mainly related to basic research, the results of the scientific activities are in topical subjects for the economy and the society. **Their impact on the economy in the mid-term is high.**

In fact, most of the subjects are related to the present major challenges for a better understanding of the behaviour of materials, thus enabling the use in more and more severe conditions thus increasing their efficiency and exploitation in many of the fields now of critical interest as power plants.

The educational activities go in this direction with students in the same area that will be employed in those fields and will introduce new views in the companies. The other activities, pedagogical, research popularization and editorial go in the same direction.

Impacts of the results and other activities on education

The involvement of the Group in education through supervised students is good even if the number of PhD students can be improved.

Impacts of the results and other activities on culture

Further to the scientific papers, as regards the impact of the Institute results and other activities on culture, it is to be underlined the active role of the the AHTM Group in organizing conferences and publishing and editing books. In the evaluation period the Group has organized 1 successful International Conferences and the Seminars CEZ, 4 Summer Schools on TEM and 1 Autumn School on EM.

Professors of the group are involved in scientific committees and in professional societies, thus extending the impacts of the researches and results of the Group.

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

Prof. Vaclav Sklenicka is a member of the Committee of Innovation Strategy of South Moravian Region which is responsible for intercommunication between research institutions and industrial partners, a transfer research results to develop new technologies and is responsible for organizing special courses for experts. Dr. Jiri Dvorak is an external expert of the South Moravian Innovation Centre in Brno, Czech Republic.

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The position of the group in the international context is of primary importance and impact.
This is due to the high expertise of the staff and to the powerful test machines as well as microstructural characterization of materials exercised at high temperature.
The comparison with international leading teams is positive especially if the ratio between the scientific output and the amount of incomes (institutional, competitive grants and contractual research) are considered: this is also an index of the ability to correctly steer the activities in the correct directions.

Role and position in international collaboration

The AHTM Group has a wide number of international cooperation. The cooperation is enforced by the personal relations of many of the researchers of the Group and by the European Projects the Institute is involved in. The position of the Institute is generally complementary.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
The world leading teams active in the same field are generally larger than IPM and with a greater number of researchers. The ability of the Institute to remain competitive is justified by the strong interaction among the different groups and by a correct address of the investments and expenses.

Ability to attract foreign researchers at different levels

The ability to attract students from abroad should be improved with some well finalized action and under the budget from some remarkable project.

Possible missing research directions

The research lines in the High Temperature field are quite wide and should be shared with the Group on Creep before this kind of assessment.

Position of the team in the national context

The AHTM Group is the national leader in the field.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age is improved with respect of the last evaluation but there are still remarkable improvements that could be implemented. The qualification and the international experience are remarkable.

Attraction of research programmes for young people

AHTM Group is not one of the most attractive group for young people, maybe due to the long time needed to get useful results.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding structure reflects the structure of the IPM and is evolving toward a system with substantially stable institutional grants while increasing of competitive grants based on peer review procedure. The contractual research is not negligible even if not quantitatively important as the other two types of funds.

Effectiveness of research (based on comparing size of groups, funding and output)

The effectiveness of research is rather high if the funding total incomes and the scientific outputs are considered and could be improved. The relatively small dimensions of the Group suggest its merge with the Group working on Creep.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The future plans of the AHTM Group are in continuity with the present research activities with new aspects and materials. In particular there are the aspects that the Group is willing to face with:

- New generation of advanced **tungsten modified chromium ferritic steels** are promising material for the next generation of fossil and nuclear power plants. We will carried out complementary creep tests to better understand of each damage process and its individual influence on the creep behaviour. At high-temperature creep exposures, the damage introduced into the complex microstructure of these steels might be critical for safe future applications. However, no systematic attention has been paid up to now to the susceptibility of their microstructures to creep cavitation and micro-crack formation during creep exposure.
- To simulate material degradation a **long-term ageing of materials** by isothermal annealing of selected creep specimens will be performed. The purpose of the creep tests conducted on aged specimens will be an estimation of their recovery of the matrix on the creep strength and to study the influence of precipitation of secondary phases on creep flow and damage of the steels.
- **Niobium-modified zirconium alloys** are currently used as fuel cladding tubes in light water reactors of nuclear power plants. Present knowledge about creep behaviour of zirconium alloys reflects the analyses of very limited and conflicting data as obtained under constant loading conditions. We will plan to perform a systematic experimental study of the creep behaviour and the relationship between creep and microstructure in

selected Zr-Nb alloys under not only constant but mostly under unsteady loading conditions.

- Development and testing of **new-generation Fe-Al-O based ODS steels** will be continued in IPM. The material is extremely cheap and exhibits excellent oxidation resistance. A systematic study will be carried out to provide the whole spectrum of mechanical properties in correlation with processing conditions and microstructure.
- **Elevated temperature stability and plasticity of High Entropy Alloys** is currently considered as a topic of future internationally coordinated research. This emerging new class of alloys demonstrates a considerable potential for being applied as oxidation and corrosion resistant materials in many industrial branches. Data on their high temperature stability and plasticity are almost completely missing. We will first focus on a quinary CoCrFeMnNi alloy, particularly on its creep characteristics and corresponding microstructural evolution.
- **Mechanical properties and structure of metallic glasses** modified by severe plastic deformation. Metal glasses are very perspective and dynamically developing field in material research. Recently was found that severe plastic deformation modifies the atomic structure of metallic glasses by formation of high density of shear bands. Despite of extensive research interest in metallic glasses the effect of severe plastic deformation on their structure and properties has not been studied.

Adequacy of available means and human resources to achieve these plans

The human resources are adequate but the expected achievements are strongly dependent on the amount of the budget available and achieved by competitive grants.

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IMP)

Brittle Fracture Group (BFG)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-Brittle Fracture (BF) Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-BF Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Mission and research topics

Mission: Deep understanding to relationships between macroscopic materials characteristics and their internal (sub)structure stimulates new knowledge generation needed for newly designed (architectured) materials with properties tailored for the given application. These knowledge may enable to explore synergy of various phenomena offered by materials nature. Fracture and fracture surface reflect nicely response of any material under different loading conditions, fracture surface – ideal textbook. Corresponding tools for the understanding – top experimental methods with corresponding top modelling approaches for deep understanding and interpretation.

The selected research fields of the group in the last five years:

Mechanics and micromechanisms of fracture in (metallic) engineering materials

- Brittle fracture of steels - low temperature brittleness, degradation processes
- Cleavage fracture stress and its physical nature
- Effect of strain rate, constraint effects and fracture micromechanism
- FEM calculations of damage, fracture toughness parameters transferability

Fracture of advanced (almost brittle) materials

- Exact characterisation of crack tip phenomena in terms of local parameters
- Fracture resistance of ceramics, intermetalics and brittle matrix composites
- under different condition of thermal exposition, at higher strain rates and temperatures.

Materials:

- advanced steels (Eurofer, X70)
- ODS steels and high entropy alloys prepared by PM route

- TiAl intermetallics (experimental, engineering applications)
- model ceramic matrix composites and nano composites (glass matrix with CNT, BNNT, Graphen, BNNS etc.)
- structural ceramics – composites (Al_2O_3, ZrO_2, Si_3N_4, SiC, TiB_2)
- alumina-zirconia laminates
- fibre-reinforced composites (amorphous carbon matrix, BS glass matrix)

Properties:
- mechanical properties and fracture resistance
- fracture toughness parameters transferability
- Young's modulus, instrumented indentation and nanoindentation
- fracture micromechanisms (3D reconstructions and modelling)
- composite structure design

1.3 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members		5		1	2			1	1		

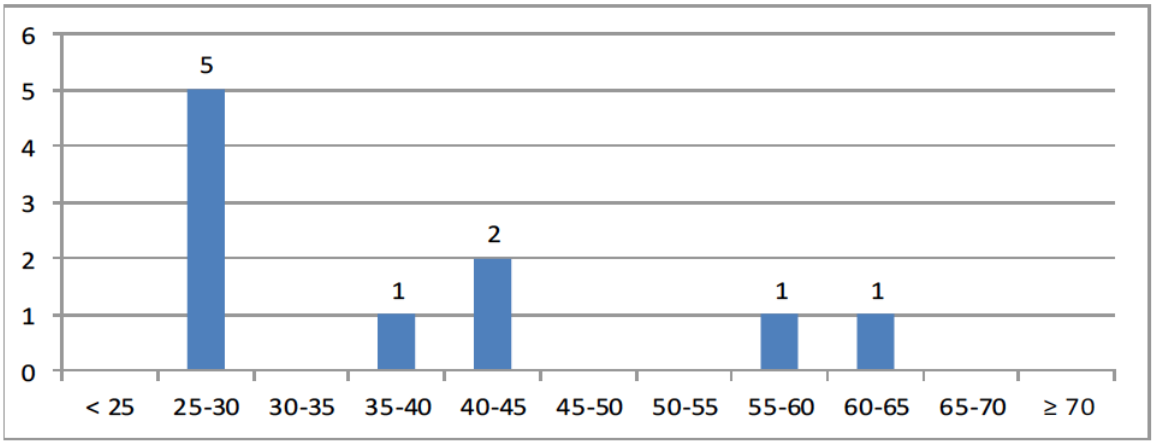

Figure 8: Age distribution of BFG

4 senior researchers (Dlouhý, Chlup, Hadraba, Kozák)
2 junior researchers (Stratil, Tatarko)
1 recruited researcher (attracted from Deakin University - Šiška)
2 hosting professors (M.Hasegawa – JSPS sabbatical, K. Chawla – 2 months)
3+1 technicians
3 PhD students (Husák, Al Khaddour, Halasová)
+ 4 international students on contracts (Saggar, Bertolla, Masini, Taveri)

In terms of full tine equivalent age distribution, the Group is formed by 5.17 FTE researchers and 4.12 FTE other workers. The number of the members of the team is rapidly increasing since 2010 (4.02 and 0.82 respectively).

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research subjects of the BF group are of strict present societal interest: Bioglass Scaffolds Reinforced by Composite (PVA/MFC) Coating, Laminate Structures – Design, Preparation and Fracture Characterisation, Fibre Reinforced High Temperature Composites (from design to properties characterisation), Crack propagation modelling at microstructural level, Development of ODS steel for fusion applications. The equipments, both experimental and numerical, are aligned with the ambicious scope of the research subjects. On the base these comments, the timeliness of the overall research activity is considered **excellent.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The BF Group in the evaluation period has substantially increased its budgets thanks to many grants that were got on competitive base. In particular 3 FP7 EU projects were achieved plus 11 projects from the Czech Science Fuondation, 4 from the Ministry of Education, 2 EU Operational Programs and contractual (107 k€) and collaborative (97 k€) research with industries. The EU based funds are the most relevant source of budget.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:

- intradepartmental:
  T. Kruml, A. Dlouhý – TiAl intermetallics development and fracture properties evaluation
  J. Svoboda – ODS steels development and specialised SEM analyses
  S. Fintová, L. Kunz – micro-deformations by digital image correlation, mechanical properties
  T. Záležák, J. Šmíd, N. Luptáková – fatigue and creep of ODS steels (CSF project - F. Šiška)

- interdepartmental:
  J. Buršík – TEM studies: ODS steels, BNNS
  J. Čermák – confocal microscopy
  P. Roupcová – X-ray difraction analyses

In the National environment (national cooperation):
M. Kotoul, O. Ševeček – FME BUT Brno, FEM computing of toughening micromechanics
K. Maca, M. Trunec – FME BUT Brno, two step sintering, flexural strength, fracture toughness
M. Černý – ASCR - IRSM Prague, CMC composite fabrications
A. Strachota – ASCR IMC Prague, preparation of precursors
L. Malíková – FCE BUT Brno, laminate modeling
B. Strnadel – VŠB TU Ostrava, advanced steel fracture
P. Pavel, T. Chráska - ASCR IPP Prague, spark plasma sintering

In the International environment (International long-term cooperation)

M. Hasegawa, H. Fukutomi, **Yokohama National University**, TiAl intermetallics heat treatment
M. Reece – **QMUL & Nanoforce London**, SPS sintering
Danzer, R. Bermejo – **MSC and University of Leoben**, ceramic laminates fracture
A.R. Boccaccini – **University of Erlangen Nuernberg** – bioglass scaffolds preparation
M. Ferraris, M. Salvo – **Politecnico di Torino** – ceramic joints
N. Chawla – **Arizona State University**, computer tomography
M. Barnett – **Deakin University**, architectured materials
A. Kailer, Iyas – **Fraunhofer IWM Freiburg**, wear in Si3N4
T. Boehlke – **KIT Karlsruhe**, crack trajectory modelling
W. Nakao, **Yokohama National University** – shCMC's
M. Serrano – **CIEMAT Madrid**, advanced steel fracture
P. Tatarko, J. Dusza – **IMR SAS Košice**, CM nanocomposites
KMM VIN Brussels – knowledge based materials - consortium

The long term international co-operations are possible both on complementarity of topics and research interests of the Group and its partners and/or thanks to contributed to EU projects where the complementarity of the research is following directly from the principles of these projects. The intensity of cooperation of the Group is rated as **very good.**

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2.4 Position of the institute within the Czech scientific community and its international position

The reputation of the Group in the Czech Scientific community and the international community is **very high** and the recent scientific reputation of the group is reflected on its invitation to consortia of the top European Institutes and the participation of the key Group members in EU projects GlaCERCo, RoLiCer, EurAtom, and Coach. This fact stimulated additional scientific growth of the younger Group members (comparably to other Institute groups), it has also contributed to higher number of high quality publications and further increased the potential of the Group for making internationally acknowledged science in the field of micromechanics and micromechanisms of fracture.

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 8. From a quantitative point of view, the recent introduction of more young people as well as an increasing as enforced the operative capability of the Institute.

The capacity of the staff **is very good.**

2.6 Comments on the age structure

The age structure of the Group is lower than most of the Groups of the Institute. This is possible due to the increasing reputation of the group and its ability to get funds to support new research positions. A consistent group of researchers (5) is younger than 30 and this is reasonable since a lot of modern facilities were introduced in the last years and well qualified and fresh enthusiast people is desirable to run them. **Very good.**

2.7 Frequency and quality of publications

The total output of the group is 124. In Fig. 9 it is shown the quality of the outputs by journal ranking.

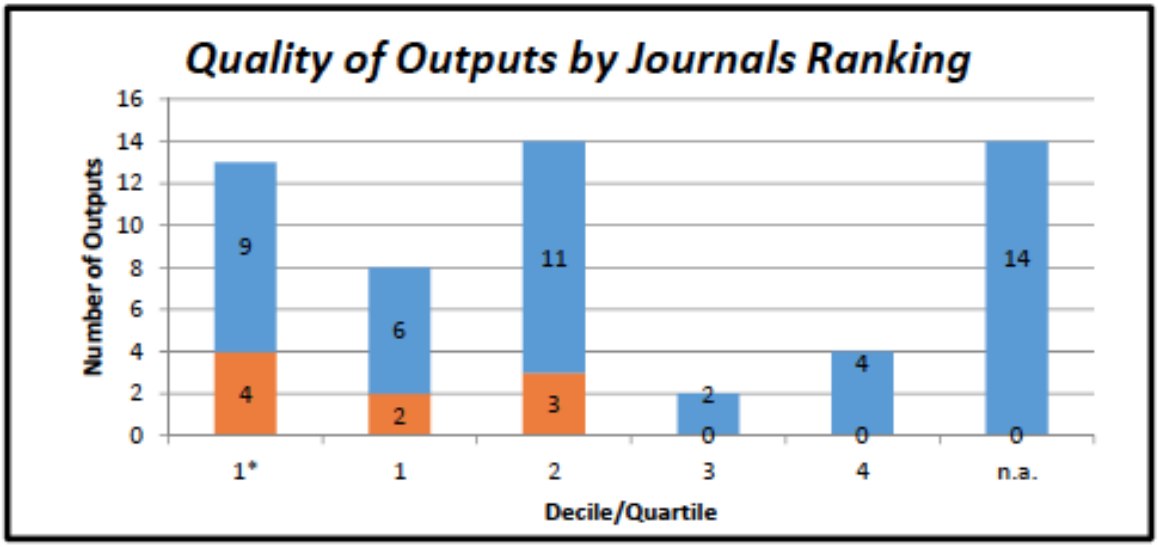

Figure 9: Quality of outputs of BFG by Journal Ranking

While the journals of publications are generally adequate, the number of citations is somehow lower than expected. If we refer to the output as ranked in Phase I: 9 papers were considered and, among them, 1 was ranked 1 (world-leading in terms of originality, significance and rigour) 3 were ranked 2 (internationally excellent) and 5 were ranked 3 (recognized internationally). No papers were ranked 4 or 5 (below the standards). Finally, the quality of the output can be defined **very good**.

2.8 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The structure of the budget as well as the need to run expensive experimental facilities makes necessary to get more and more funds for being sustainable.

3.2 The overall capacity of staff

The quality of the staff is adequate, the group is growing and new researchers would be useful for improving efficiency and quality.

3.3 Comments on the age structure

The age structure can be further improved attracting more PhD students and young researchers.

3.4 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

Based on the strengths, opportunities, weaknesses and threats some recommendations can be elaborated. Sub-sections (topics) may refer to:

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Group is well organized and well identified. Some overlaps are noted with other groups and sharing of facilities and activities would improve the final results.

4.2 Identification of new research topics

The action of the Group for the introduction of new research lines is adequate.

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The research activities are covers the most important present areas in the field of brittle fracture. The research activity, in all the active research lines, is faced with a good balance of experimental and numerical/theoretical activities with good interaction of the people involved in the different phases of the research. The assessment on the characterization on the main research activities is quoted very good.

Overall quality of publications

The publications of the Group are well balanced among the different subject and generally published in high-ranked (1-2 quartile) journals. The total number of papers in journals with IF is 42, in other journals is 20 and the contributions in conference proceedings are 43.
In particular, if we refer to the main research subjects:

- Bioglass Scaffolds Reinforced by Composite (PVA/MFC) Coating, Laminate Structures: 7 papers, 12 conference contributions

- Laminate structures - Design, Preparation and Fracture Characterisation: 8 papers, 11 conference contributions.
- Fibre Reinforced High Temperature Composites: At least one paper was included among the 9 mentioned publications representing the group outcomes.
- Crack propagation modelling at microstructural level: 2 papers, 4 conference contributions.
- Development of ODS steel for fusion applications: 7 papers, 11 conference contributions.

Specification of the main achievements

- Bioglass Scaffolds Reinforced by Composite (PVA/MFC) Coating, Laminate Structures: Development of PVA-coated samples that exhibited approximately more than 5 fold increase of compressive strength compared to uncoated ones and the addition of 5 wt. % of MFC fibers led to a further increase (of the compressive strength). Also tensile strength has been found to be improved by the PVA/MFC hybrid coating; the samples with PVA/MFC coating exhibited more than 10 fold increase of tensile strength comparedto the un-coated samples.

- Laminate Structures - Design, Preparation and Fracture Characterisation, Fibre Reinforced High Temperature Composites: The results of work cover all aspects from the modelling and design of the laminate structures through its precise preparation using fundamental knowledge of the processing up to the description of development of stresses in the context of resulting controlled fracture behaviour and application properties. The understanding of the fundamental aspects of laminated structures with strongly bonded layers incorporating internal stresses allows us to optimise the design of individual layers to achieve the enhanced properties. Basically, two approaches can be applied: i) enhancing strength and fracture resistance together or ii) predetermine threshold (minimal) strength and increase the damage tolerance. The latest effort is targeted to the second area where we have been achieving significant damage tolerance with still high strength values.

- Fibre Reinforced High Temperature Composites (from design to properties characterisation): The critical points in the composite optimisation have been investigated by the Group are : i) the quality of matrix prepared via pyrolysis of polysiloxane resins where shrinkage and cracking due to the development of the residual stresses can be the limitation, ii) the bonding between matrix and fibre which predetermine the toughening effect, iii) the temperature stability of matrices and composites when various fibres are used and as well the loading conditions effect on the fracture behaviour.

- Crack propagation modelling at microstructural level: The main achievements of the Group can be seen in three levels. (i) First one is connected to the development of suitable methodology allowing creation of the realistic 3D model of the microstructure using EBSD and FIB slicing technique, further used for calculation of elastic and thermal properties by FEM. (ii) The other one is the development of the probability damage model of the crack propagation through the microstructure, especially the influence of the grain boundaries interface in the crack development.

- Development of ODS steel for fusion applications: It was found that pronounced morphologic and crystallographic texture of ODS steels leads to a strong anisotropy in fracture properties: the orientation of the fracture plane towards the extrusion direction significantly modifies the impact

response of the ODS steel. It also was found that ferritic 14%Cr-1%W steel and ferriticmartensitic 9%Cr-2%W steel present much better fracture properties than ferritic 9%Cr-1%W ODS steel of Eurofer type considered as reference structural material for fusion reactors.

Specification of the contributions of the team to publications

The contributions of the Groups to publications is primary due both to the available facilities and the expertise of the team.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The BF Group supervised

2 bachelor students (R. Husák, V. Lövy)
9 master students (P. Fukátková, M. Halasová, R. Husák, R. Nedbalová, L. Slabáková, M. Šafář, E. Němčíková, E. Dohnalová, and V. Lövy)
3 PhD students -successfully finished their theses (L. Řehořek, L. Stratil, D. Drdlík)

in addition,
2 bachelor + 2 two master + 6 PhD students (3 of them from abroad - S. Al Khaddour, L. Bertolla, R. Saggar) are currently working on their theses.

Particular contributions of students to research

The students are actively involved in the running research projects and are among the authors of the papers published by the IPM.

Number of defended PhD students in relation to students involved (success rate)

The total number of PhD theses defended in the evaluation period is 3 versus 3 PhD students supervised.

Employment of former PhD students (career options)

The possible carrier development is strongly dependent on the successful grants achieved by the group.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

The research activities are aligned with some of the current societal needs and could ha e a great impact on economy, once the results are exploited in industrial products in the different filed of interest.

Impacts of the results and other activities on education

The involvement of the Group in education through supervised students and through courses (yearly 195 hrs in semester 5 courses) is quite good.

- The Group organized the Summer School on Micromechanics and Micromechanisms of CMC Fracture, IPM Brno. (RoLiCER, 2014).
- I. Dlouhý organized and chaired the "GlaCERCo school" with three days teaching courses for about 30 participants in the field of micromechanics of glass and composites in November 2013, at Politecnico di Torino

Impacts of the results and other activities on culture

The impact of the activities is mainly academic, no data are provided bout the impact of the results on culture.

Outputs providing information relevant for public policy decisions in all fields of life

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

These are the activities in the filed of science popularization:

- Short video "Future of glass-ceramic materials" (in Czech and in English) showing activities of the group in the frame of GlaCERCo EU project.
- Paper in newspaper Metropolitan: "On the way to bone marrow replacement" (in original "Na cestě k náhradě kostní dřeně").

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The position of the Group in the international context is of primary importance and impact.
This is due to the high expertise of the staff, the achieved results and to the powerful recent experimental devices.
The comparison with international leading teams is quite positive and the BF group is more and more involved in important European Research programs.

Role and position in international collaboration

The BF Group has a wide number of international cooperation with a prior role in many of the projects.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
No other activity can be implemented if the staff is not increased.

Ability to attract foreign researchers at different levels
The Group is able to attract students/researchers from abroad.

Position of the team in the national context

The BF Group is the national leader in the field.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age is balanced with respect of the last evaluation. The gender issue is not mentioned in the reports. The qualification and the international experience are remarkable.

Attraction of research programmes for young people

BF Group is one of the most attractive Group for young people.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding structure reflects the structure of the IPM and is evolving toward a system with substantially stable institutional grants while increasing of competitive grants based on peer review procedure. The BF Group has been successful in getting the EU funds so far.
The contractual research is not negligible even if not quantitatively important as the other two types of funds.

Effectiveness of research (based on comparing size of groups, funding and output)
The effectiveness of research is high.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The future plans of the BF Group are in continuity with the present research activities with new aspects and materials. Some of these palns have already got some funding.
In particular there are the aspects that the Group is willing to face with:

ODS steels enhancement:

- composition improvement of the high chromium steels reinforced by fine dispersion of ceramic oxide particles
- room temperature brittleness origin
- crack resistance curves evaluation by small compact tension specimens

✓ *supported by the CSF project (15-212924, Fracture behaviour of fine oxide dispersion strengthened Fe based alloys at high temperatures)*

✓ *supported by the CSF project (14-25246S, Advanced ODS steels for applications in heavy liquid metals environments)*

Materials with internal architecture

- inspiration in natural materials - their behaviour mechanically averaged and macroscopic properties may be controlled in wide interval by changing modulus of the internal architecture
- design of materials with hierarchical internal structure

✓ *CSF proposal submitted (16-04329S, Metallic materials with controlled internal architecture prepared by cold spray).*

Ceramic matrix composites

- glass/ceramics matrices reinforced by nano-objects like nanotubes, nano-sheets (carbon, boron nitride) etc.
- fractions up to 5 % of boron nitride nanotubes and/or nano-sheets could bring an increase in fracture resistance without loss of the strength properties
- new toughening mechanisms have been observed, potential for new findings

✓ *collaboration with Nanoforce Ltd, UK (CoACH, MSCA-ITN-2014-ETN, 642557)*

✓ *bi-national co-operation with IMR SAS Kosice, (MEYS / 7AMB14SK155)*

✓ *CoaCH project (H2020, MSCA-ITN-2014-ETN, 642557, Advanced glasses, composites and ceramics for high-growth industries)*

Self-healing CMC composites

- by introducing a special agent into the composite (e.g. SiC into Al2O3 matrix)

- materials capable to withstand high crack resistance at high temperatures
- supposing the crack healing phenomenon will work at or around operation temperature.

✓ *for co-operation on this topic invitation from YNU, W. Nakao Group, within Core project supported Japanese Ministry of Education*

✓ *International project proposal of Visegrad fund (V47&J program) under review*

Adequacy of available means and human resources to achieve these plans

The human resources are adequate but the expected achievements are strongly dependent on the amount of the budget available and achieved by competitive grants.

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

Creep of Metallic Materials Group (CMMG)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-Creep of Metallic Materals (CMM Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-CMM Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Mission and research topics

Mission

- Explanation of basic mechanisms of high temperature creep in metallic materials allows us to refine the extrapolation techniques for the assessment of long lifetime of in service components.
- Relations between creep behavior and microstructure can contribute to design of new materials with improved creep resistance.
- Small punch test can provide the reliable assessment of residual lifetime by “noninvasive” testing of components.
- The development of new testing facilities and procedures has resulted in a unique equipment of creep laboratories of the Institute.

The selected research fields of the group in the last five years:

Materials

- FeAl alloys – iron aluminides
- heat resistant steels (ferritic-martensitic, austenitic)
- Ni alloys and superalloys
- Al, Mg alloys and their composites
- $MoSi_2$ and composites
- ODS steels and alloys

Properties

- creep properties related to microstructure
- low creep rate behavior, response of creep strain and creep rate to load changes (increase, decrease)
- creep lifetime prediction using extrapolation methods

- relations between unconventional testing methods
- fracture behavior in small punch test

1.3 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members			1		1			1	1	2	

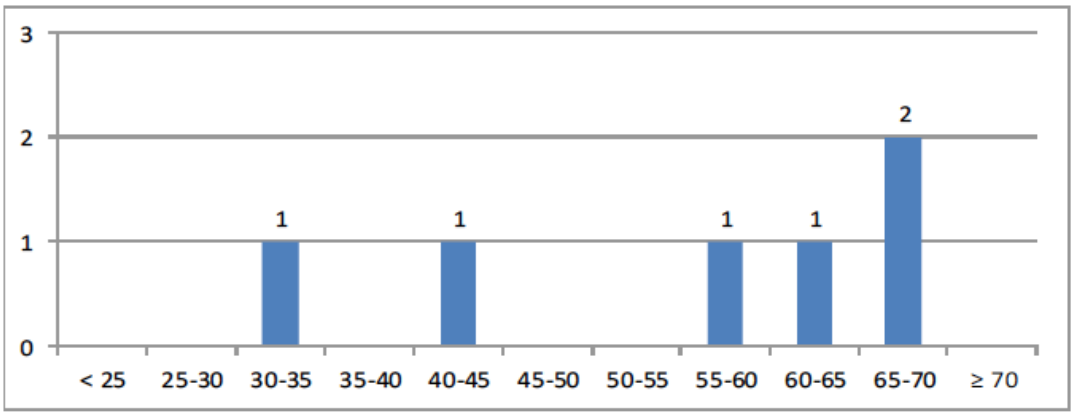

Figure 10: Age distribution of CMMG

3 senior researchers (Ferdinand Dobeš, Luboš Kloc, Petr Dymáček)
1 junior researcher (Natália Luptáková since 2014)
2 technicians (Jaroslav Martinák, Bohumil Vávra)
1 PhD. student of BUT (Denisa Bártková since 2015)
2 MSc. students of BUT successfully defended thesis (2013 and 2014)

In terms of full tine equivalent age distribution, the Group is formed by 3.84 FTE researchersand 2.00 FTE other workers. The number of the members of the team is rapidly increasing since 2010 (4.02 and 0.82 respectively). The age structure of the Group can be improved.

2. STRENGTHS AND OPPORTUNITIES

Based on the findings of the detailed evaluation (see below topic 5) we should come up with some statements referring to:

2.1 Timeliness of research topics

The research subjects of the CMM group are of societal interest: Creep of iron aluminides, Small punch testing (SPT), Al-Al_4C_3 composite, Fe-Al intermetallics, Creep of light materials, Low strain rate creep in metals have a strong impact on the design of powder plants and the light transport systems.

The equipments, both experimental and numerical, are aligned with the ambicious scope of the research subjects.
On the base these comments, the timeliness of the overall research activity is considered **good.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The budget of the CMM Group in the evaluation period is substantially based on CSF and ASCR funded projects. The budget has substantially increased thanks to many grants that were got on competitive base.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:
intradepartmental:

Dr. J. Svoboda – FeAl ODS alloys development
Dr. F. Šiška – characterization of ODS alloys (Junior CSF Project)
Dr. J. Dvořák, Dr. P. Král – SPT of UFG Al
Prof. J. Polák – Sanicro25 creep testing and SPT
Prof. A. Dlouhý – HEA

interdepartmental:

Dr. Y. Jirásková – metallic glasses
Dr. M. Friák – FeAl alloys (CSF grant proposal)

In the National environment (national cooperation):
Charles University, CR, Prof. P. Kratochvíl
FME BUT Prof. I. Dlouhý, Prof. J. Petruška

In the International environment (International long-term cooperation)
IMR SAS, SR, Prof. M. Besterci
TU Freiberg, Dr. M. Abendroth
Swansea University, Prof. R. Hurst
JRC Petten, Dr. P. Haehner
University of Oviedo, Dr. T. García
University of Cantabria, Dr. R. Lacalle, D. Andrés
CENIM, Dr. G. Garcés
INTA, Dr. A. Aguero
CIEMAT, Dr. M. Serrano
KMM-VIN, prof. M. Basista

The intensity of cooperation of the Group is rated as **very good.**
.
2.4 Position of the institute within the Czech scientific community and its international position

The reputation of the Group in the Czech Scientific community and the international community is **good**.

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 10.
The capacity of the staff **is good.**

2.6 Reasonability of the structure of the institute and the departments

/

2.7 Comments on the age structure

The Group is rather small and just two people are less than 50. This should be improved, and more young people and students should be involved in the research activities.

2.8 Frequency and quality of publications

The total outputs of the group is 41. In Fig. 11 it is shown the quality of the outputs by journal ranking.

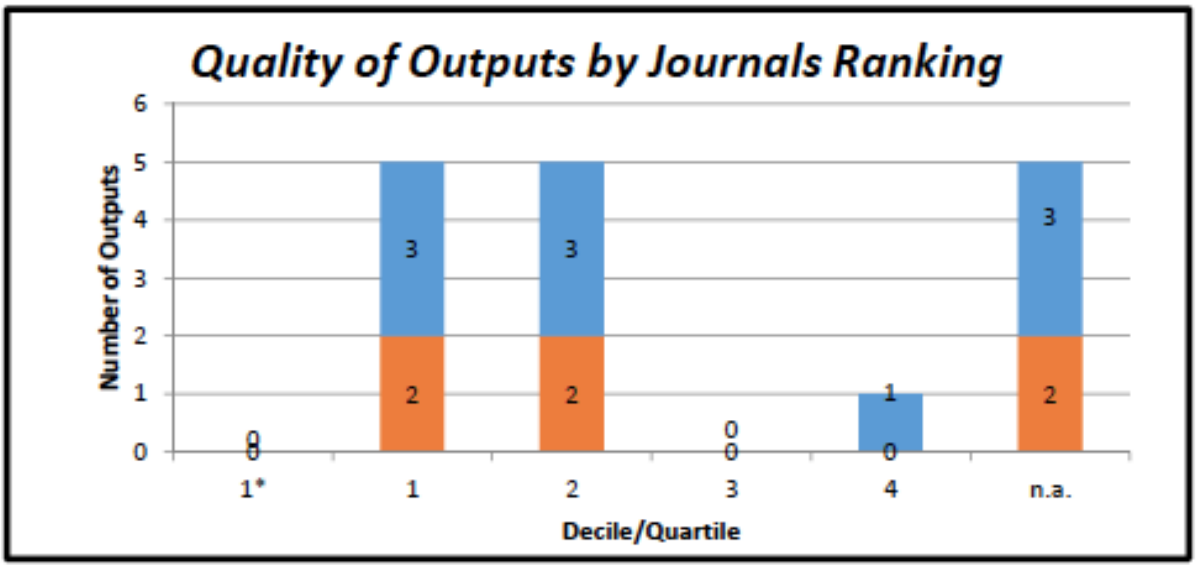

Figure 11: Quality of outputs of CMMG by Journal Ranking.

The number of papers in the first decile and quartile is limited.

If we refer to the output as Ranked in Phase I: 9 papers were considered and, among them, 0 was ranked 1 (world-leading in terms of originality, significance and rigour) 2 were ranked 2 (internationally excellent) and 3 were ranked 3 (recognized internationally), 1 was ranked 4 (recognized nationally. No papers were ranked 5 (below the standards). Finally, the quality of the output can be defined **acceptable**.

2.9 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The Group is able to attract only National funds so far.

3.2 The overall capacity of staff

The staff is formed by few people, most of them are not young researchers.

3.3 Comments on the age structure

The age structure should be improved improved attracting more PhD students and young researchers.

3.4 Frequency and quality of publications

The frequency of publications is limited by the number of people working in the group.

3.5 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

Based on the strengths, opportunities, weaknesses and threats some recommendations can be elaborated. Sub-sections (topics) may refer to:

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Group is quite small and could take advantage from possible increased synergies with AHTM group. Initiatives to attract possible young researchers should be taken.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

The group could join with the AHTM group.

4.3 Identification of new research topics

The plans for the next years have been drawn and looks to further developments in the subjects that are currently running. An internal discussion with AHTM Group as well as with other groups would help identifying new possible subjects.

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The research activity of the group is based on experimental work. During the evaluation period new high temperature creep laboratory was built within the CEITEC project with 2 new creep-electromechanical machines Messphysik KAPPA LA and Maytec furnaces, one up to 1200 °C, second up to 1400 °C. These new installations have increased the tests and allows more accurate and refined measurements of the quantities of interest.

Overall quality of publications

The total number of papers in journals with IF is 11, in other journals is 14 and the contributions in conference proceedings are 15. 1 Chapter in one professional book was published.
While there are no papers published in the first decile, 5 papers were published both in the first and in the second quartile.
In particular:

Small punch testing (SPT): 1 paper in IF journal, 3 papers in int. journals and 5 conference proceedings
Creep of iron aluminides: 8 papers in IF journal, 5 papers in int. journals and 6 conference proceedings
Low creep rates: 1 paper in IF journal, 1 papers in int. journals and 3 conference proceedings

Specification of the main achievements

Creep of iron aluminides - Creep resistance is given not only by the volume fraction of second-phase particles but also by the ratio of Heusler to Laves phase. This can be attributed to a more effective strengthening by particles of Zr(Fe,Al)12 Heusler phase.

Small punch testing (SPT) - The small punch testing under constant force condition was performed in various atmospheres. Materials: stell P91, Fe-Al intermetallics, Al-Al_4C_3 composite. An activity based on FEM simulation i salso running but, looking at the docemnts presented, it seems that the main results dates before the evaluation period.

Low creep rates: Two new constitutive models: elastoplastic model and dislocation bowing model. The latter combines climb of dislocations, controlled by self-diffusion, and viscous glide controlled by diffusion of solute atoms.

Specification of the contributions of the team to publications

The contribution of the group to the publications is strictly related to expertise in the set up and development of complex experimental tests.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The involvement oft he students is quite low: just 2 MSc theses were defended (1 supervisor, 1 co-supervisor) in the evaluation period .

Particular contributions of students to research

The 2 MSc students involved in the group worked in the filed of small puch tests.

Number of defended PhD students in relation to students involved (success rate)

No PhD students were supervised.

Employment of former PhD students (career options)

No former PhD students are in the group.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

The research activities are aligned with some of the current societal needs and could ha e a great impact on economy, both in terms of industrial exploitation and in terms of reduced effort and time toget the experimental data needed for creep design.

Impacts of the results and other activities on education

Dr. Dobeš is a member of the working group of accreditation committee of the Slovak ministry of Youth, Education and Sport (2008-now)

Educational lectures about creep and SPT at VŠB-TU Ostrava, TU Freiberg, Chung-Ang University, Doosan, Honeywell Brno.

Due to the limited involvement of students in the group and the limited involvement of the group members in the education, the impact of the results and the other activities is limited.

Impacts of the results and other activities on culture

The impact of the activities is mainly academic, no data are provided about the impact of the results on culture.

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

These are the activities in the filed of science popularization:

- Dr. Luptáková had 2 popularization lectures in 2014 week of Science and Technology, Science Photogenic competition – semifinal, she participates also in 2015.

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The group is well recognized at international level. The limited dimension of the group makes somehow difficult to maintain a leading position and makes also difficult to get intentarional grants, especially due to the limited number of young researchers involved in the team.

Role and position in international collaboration

The CMM international cooperation were improved in the evaluation period and are no more so critical as in the previous one.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
No other activity can be implemented if the staff is not increased.

Ability to attract foreign researchers at different levels

The Group is able to attract students/researchers from abroad for short internships (up to 3 months).

Position of the team in the national context

The CMM Group is nationally recognized as leader in the field.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age was improved with two young researchers but it would be worth involving further researchers as well as PhD students. The gender issue is not mentioned in the reports. The qualification and the international experience are very good.

Attraction of research programmes for young people

The attractiveness of the group should be improved.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The groups can count on national grants by CSF and ASCR. 4 grants were assigned to the group in the evaluation period. Cooperation with local companies is active but the contractual research is not developed in the report presented.

Effectiveness of research (based on comparing size of groups, funding and output)

The effectiveness of research is high.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The future plans of the CMM Group are in continuity with the present research activities with new aspects and materials. A further improvement of the labs with new devices is planned:

Creep laboratories

- software fully on LINUX platform, resistant to el. power outages

- central server for data storage and retrieval, on-line test monitoring
- upgrading furnaces and grips for 1000-1200°C on several IPM machines
- design and manufacture of micro creep machine for very small specimens

Viscous creep laboratories

- 2 new machines for helicoidal specimens with furnaces up to 1200°C

CEITEC_IPM creep lab

- upgrading machine KAPPA2 (1400°C) to high vacuum
- installation of SPT to KAPPA creep machine (Messphysik)

In particular there are the aspects that the Group is willing to face with:

- Continue in the research of creep of iron aluminides
  - in two-phase field A2+$D0_3$ – effect of Ti and/or V (or Ta prof. M. Palm)
  - creep of newly developed ODS FeAl A2 (with Dr. J. Svoboda, Dr. F. Šiška) or ODS steels (Dr. H. Hadraba)

- Small punch testing
  - developing SPT relaxation technique – recent CSF grant proposal
  - members of international Working Group for preparation of the Small Punch EN Standard, SPT round robin testing of P92 steel
  - members of IAEA round robin (prof. Ivo Dlouhý) - testing 14YWT ODS steel from ORNL

- Low strain rate creep in metals
  - CSF project no. 15-21394S " since 2015 principal investigator Dr. L. Kloc.
  - the goal is to develop creep constitutive equations which can be used for realistic description of the creep effects for FEM models under variable conditions and in wide range of stresses
  - investigation of low-stress creep of the Zr alloys for nuclear power plants will continue moving closer to reactor operating temperatures

- Creep and SPT of light alloys and composites (in cooperation with Univ. of Cantabria)

- Creep of $MoSi_2$ (in cooperation with prof. Besterci)

Adequacy of available means and human resources to achieve these plans

The human resources should be increased to get the expected achievements.

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

High Cycle Fatigue Group (HCFG)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-High-cycle Fatigue (HCF) Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-HCF Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Mission and research topics

Mission:

The mission of the group is to investigate the behaviour of the materials under high-cycle fatigue and to understand the basic mechanisms that lead to high cycle fatigue damage under this load condition for an accurate prediction of damage evolution and of component life. This deep understanding of this phenomenon i salso applied to the development of new materials to study the general principles of the fatigue damage for given group of the materials, the prediction of possible damage of new materials and the optimization of new material structure and technological treatment for superior long-term properties. This is done by combining experimental (Fatigue tests – fatigue data, optical microscopy – fractography, Electron microscopy (SEM, EBSD, FIB, TEM) – fractography, mechanisms…) and theoretical approaches (phenomenological description of the fatigue and fracture damage, methodology of numerical prediction of fatigue damage, lifetime prediction based on FEM..).

Research topics:

- Fatigue and fatigue/creep behaviour of single crystalline and polycrystalline superalloys
- Fatigue properties of ultrafine-grained materials,
- Effect of mean stress on the cyclic stress-strain response and fatigue life,
- Effect of notches (including bi-material notches) and cracks on fatigue life and fatigue/creep life,
- Effect of a free surface on fatigue crack behaviour,
- Effect of the interface between two materials on a crack or notch behaviour,
- Basic fatigue and fracture characteristics of advanced building materials,
- Description of the crack behaviour in polymer materials,
- Description of the crack behaviour in advanced composite materials.

1.3 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members		6	4	4						1	

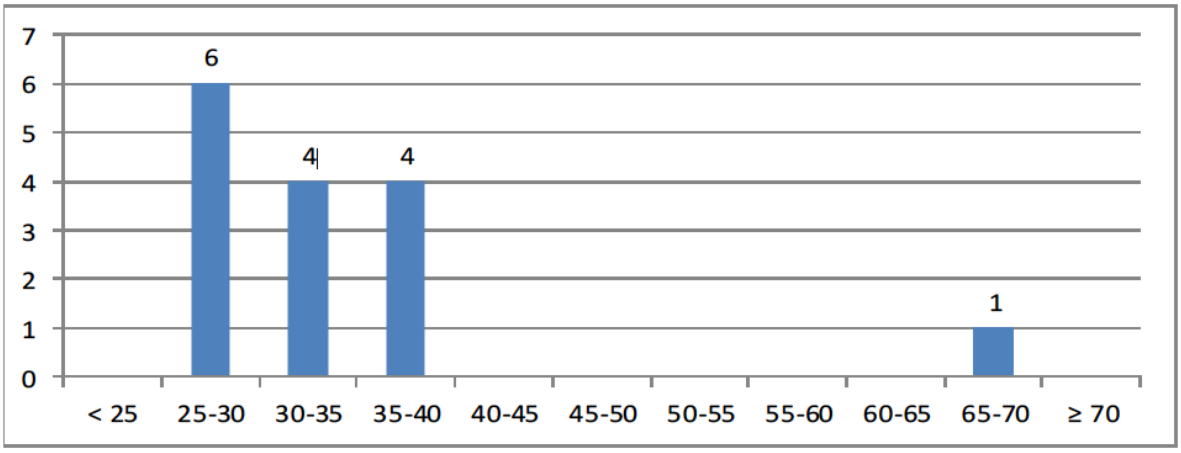

Figure 12: Age distribution of HCFG

5 researchers
- prof. RNDr. Ludvík Kunz, CSc., dr. h. c. – director of IPM
- doc. Ing. Luboš Náhlík, Ph.D. – director of infrastructural projects CEITEC IPM and IPMINFRA
- doc. Ing. Pavel Hutař, Ph.D. – head of High Cycle Fatigue Group
- doc. Ing. Jan Klusák, Ph.D – head of Advanced Metallic Materials and Metal Based Composites (CEITEC IPM)
- doc. Ing. Stanislav Seitl, Ph.D.

3 post-docs
- Ing. Miroslav Šmíd, Ph.D.
- Ing. Stanislava Fintová, Ph.D.
- Ing. Zdeněk Majer, Ph.D.

6 PhD students (Holušová, Horník, Krepl, Poduška, Pokorný, Štegnerová)
4 diploma students
3 technicians (Hirschová, Jaroš, Minařík)

In terms of full tine equivalent age distribution, the Group is formed by 7.14 FTE researchersand 2.14 FTE other workers. The number of the members of the team is substantially stable since 2010.

2. STRENGTHS AND OPPORTUNITIES

Based on the findings of the detailed evaluation (see below topic 5) we should come up with some statements referring to:

2.1 Timeliness of research topics

The research topics of the Group are aligned with the current major international research subjects in the field. The expected results are ambitious but both the expertise of the team and the experimental facilities available are adequate to maintain the expected development of the research.
On the base these comments, the timeliness of the overall research activity is considered **excellent.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The HCF Group in the evaluation period was able to get the following grants:

- **7** projects of Ministry of Education Youth and Science – total budget 5 052 kEUR
- **11** projects of Czech Science Foundation - total budget 1 007 kEUR
- **3** projects of Ministry of Industry and Trade – total budget 344 kEUR
- **4** projects of Czech Academy of Science – total budget 99 kEUR
- **1** project of Technological Agency of the Czech Republic - total budget 22 kEUR

The contractual research with companies is not quantitatively of primary importance for the institute but the names of the some of the foreign companies that assign contract to the group are an index of the quality of the group. The total amount of the budget is **very good.**

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:
- interdepartmental:

Low cycle fatigue Group
- materials for power generation industry - participation on CSF project – T. Kruml
- mechanical properties of superalloys – joint project of MIT – K. Obrtílk
- common cooperation on industrial tasks – J. Polák
- organization of conferences

Brittle fatigue Group
- materials for automotive industry – participation on proposal ISOMACH (Research Fund for Coal and Steel (RFCS)) – I. Dlouhý
- oxide dispersion strengthened Fe based alloys – participation on CSF project – F. Šiška
- common cooperation on industrial tasks – I. Dlouhý

Advanced High-Temperature Materials Group
- mechanical properties of superalloys – joint project of MIT – V. Sklenička, M. Kvapilová

Structure of Pahses and Thermodynamics Group
- properties of ultrafine grain materials – M. Svoboda

In the National environment (national cooperation):
Brno University of Technology – doc. Paloušek

In the International environment (International long-term cooperation):
University of Parma – prof. Nicoletto

Ecole Nationale Supérieure de Mécanique et d'Aérotechnique – prof. Sarrazin-Baudoux
University of Žilina – prof. Konečná
University of Oviedo – prof. Canteli
University of Milano – Dr. Carboni
University of Adelaide – prof. Kotousov
University of Padua – prof. Berto
University of Leoben – prof. Pinter
University of Halle/Wittenberg – prof. Grellmann
École polytechnique fédérale de Lausanne EPFL– Dr. Vasilopoulos
Institute of Macromolecular Chemistry – Dr. Kotek
University of Leoben – Dr. Bermejo
University of Viena – Dr. Merta
University of Gent – Dr. Korte

The long term international co-operations are possible both on complementarity of topics and research interests of the Group and its partners

The intensity of cooperation of the Group is rated **as excellent.**

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2.4 Position of the institute within the Czech scientific community and its international position

The reputation of the Group in the Czech Scientific community and the international community is **very high**.

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 12. From a quantitative point of view, the recent introduction of more young people as well as an increasing as enforced the operative capability of the Institute.

The capacity of the staff **is very good.**

2.6 Comments on the age structure

The age structure of the Group is characterized by many young researchers and just one over 60 one. This is due to premature departure of the two leaders of the team. In spite of this sad and unexpected circumstances the group is showing is ability to react and maintain the high ranked position achieved in the past. **Very good.**

2.7 Frequency and quality of publications

The total outputs of the group is 212. In Fig. 13 it is shown the quality of the outputs by journal ranking.

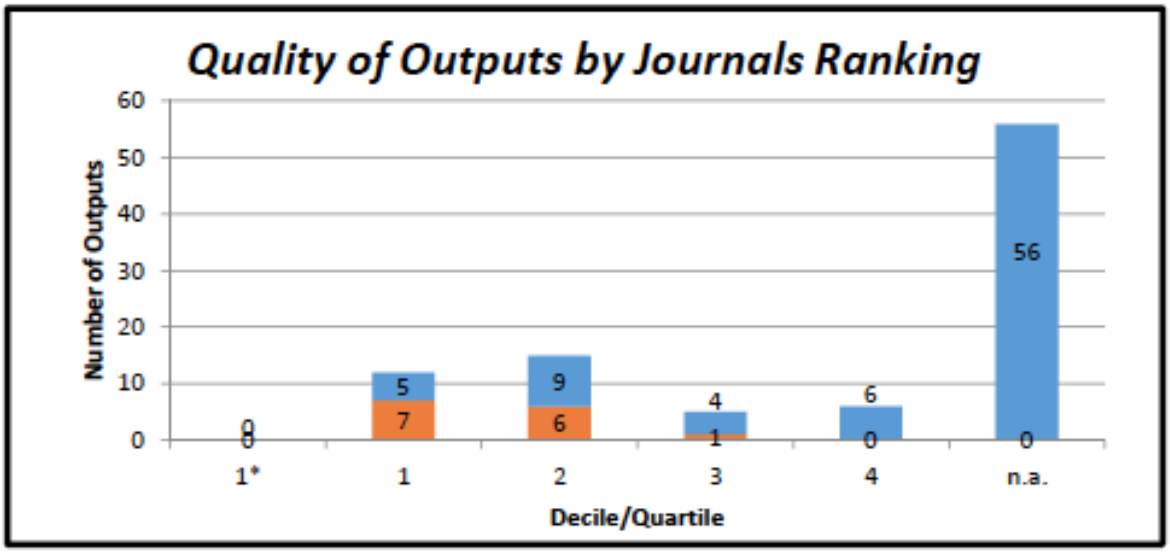

Figure 13: Quality of outputs of HCFG by Journal Ranking.

While the journals of publications are generally adequate, the number of citations is somehow lower than expected.

If we refer to the output as Ranked in Phase I: 14 papers were considered and, among them, 1 was ranked 1 (world-leading in terms of originality, significance and rigour) 8 were ranked 2 (internationally excellent) and 5 were ranked 3 (recognized internationally). No papers were ranked 4 or 5 (below the standards). Finally, the quality of the output can be defined **very good**.

2.8 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

It is noted the absence of grants from FP7/H2020/other EU programs.

3.2 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

Based on the strengths, opportunities, weaknesses and threats some recommendations can be elaborated. Sub-sections (topics) may refer to:

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Group is well organized and well identified, somehow under dimensioned for the running activities.

4.2 Identification of new research topics

The action of the Group for the introduction of new research lines is adequate.

5. DETAILED EVALUATION

According to the guidelines the following sub-sections should be included:

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The research activities of the HCF Group include both very exacting theoretical approaches and sophisticated experimental research. The subjects of interest are mostly very beneficial for many engineering and industrial sectors since fatigue is still the major font of failures in metal structures.

Overall quality of publications

The publications of the Group are well balanced among the different subject and generally published in high-ranked (1-2 quartile) journals. The total number of papers in journals with IF is 38, in other journals is 67 and the contributions in conference proceedings are 104. Three are the chapters in professional books.

Specification of the main achievements

- **Propagation of small cracks** (materials for nuclear reactors): a new model for small crack propagation rate description was deduced in cooperation with Low Cycle Fatigue group.
- **Fatigue behaviour of ultrafine-grained materials**: The investigation performed in the evaluated period helped to answer some recently discussed questions in the research society (what are the mechanisms of the cyclic plastic strain localization in UFG structures, which microstructural, material and severe plastic deformation process parameters influence the strain localization and hence the fatigue lifetime, which factors influence the stability of UFG structure with high stored deformation energy at cyclic loading, what is the difference in the

mechanisms of cyclic slip localization in ultrafine-grained structures and conventionally grained ones).

- **High cycle fatigue of nickel-based superalloys**: the majority of investigation in the evaluated period was targeted on the polycrystalline IN713LC and MAR-M247 superalloys.
- **Numerical simulations of fatigue crack propagation**: effect of the free surface on the fatigue crack propagation. Fast algorithm for prediction of the fatigue crack front shape in the 3D bodies, based on the stress singularity exponent was developed.
- **Theoretical investigation of the generalised linear elastic fracture mechanics**: new methodology based on linear elastic fracture mechanics for description of the fracture behaviour of general singular stress concentrators was developed.
- Lifetime prediction of polymer structures: development of a methodology that combines numerical estimation of the stress intensity factor with fatigue testing of the polymer materials in order to be able to estimate the lifetime of a pressured component without time-consuming hydrostatic pressure tests.

Specification of the contributions of the team to publications

The contribution of the Institute members to the outputs are quite decisive in the published papers.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The HCF Group supervised

8 bachelor students, 8 theses defended
11 master students (and 2 co-supervised), 13 theses defended
8 PhD students (and 7 co-supervised), 4 theses defended

Involvement of doctoral and undergraduate students in research is very extensive and significant. Students are able to do very useful scientific work and help their advisors in their research in the framework of various projects and they are often with co-authors of publications.

Particular contributions of students to research

The students are actively involved in the running research projects and are among the authors of the papers published by the Group.

Number of defended PhD students in relation to students involved (success rate)

The total number of PhD theses defended in the evaluation period is 4 versus 8 PhD students supervised.

Employment of former PhD students (career options)

The possible carrier development is strongly dependent on the successful grants achieved by the group.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

The research activities have a strong impact on economy since the subjects of the research are among the most frequent causes of failure of metal components.

Impacts of the results and other activities on education

The involvement of the Group in education through supervised students and through courses: 5 researchers active as lecturers at Brno University of Technology and University of Žilina.

Impacts of the results and other activities on culture

The impact of the activities is mainly academic, no data are provided bout the impact of the results on culture.

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

L. Náhlík is responsible for preparation of PR texts for public journals (on behalf of the Institute), for PR activities of the Institute, responsible person for realization of Day of open doors of the Institute, preparation of leaflets and brochures of the Institute, preparation of videos for public. In 2012 J. Klusák won the Czech national final of the science popularization competition FameLab®. Thus he advanced to the World Famelab® Final in Cheltenham, UK.

J. Klusák gives science popularization lectures dealing with mechanical properties of materials for public and schools. He is regular lecturer during the Week of Science and Technology in Brno, Prague, and Zlín.

The project “Science Academy - critical thinking and practical application of scientific and technical knowledge in real life” was granted from European Social Fund in the Czech Republic within the call Education for Competitiveness OP. In the range of the project,

experimental stands has been designed and completed for several laboratories of the institute in order to explain complex physical properties of materials in a comprehensible form. Further cooperation with high and basic schools was established, educational papers were created for teacher and students.

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The Group distinguishes by its strong position both in national and international scientific community gained in the past and maintained in recent years. Also the cooperation of with numerous national and international universities in research and education joint activities is wide and important.

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Role and position in international collaboration

The HCF Group has a wide number of international cooperation with a prior role in many of the projects.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
No other activity can be implemented if the staff is not increased.

Ability to attract foreign researchers at different levels

The Group is able to attract students/researchers from abroad in the framework of the different well established international cooperations.

Position of the team in the national context

The HCF Group is the national leader in the field.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age is balanced with respect of the last evaluation. The gender issue is not mentioned in the reports. The qualification and the international experience are remarkable.

Attraction of research programmes for young people

HCF Group is one of the most attractive Group for young people.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding structure reflects the structure of the IPM and is evolving toward a system with substantially stable institutional grants while increasing of competitive grants based on peer review procedure. The contractual research is not negligible even if not quantitatively important as the other two types of funds.

Effectiveness of research (based on comparing size of groups, funding and output)

The effectiveness of research **is high**.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The future plans of the HCF Group are in continuity with the present research activities with new aspects and materials. Some of these plans have already got some funding.
The Group is strongly involved in the strategy of Academy of Sciences of the Czech Republic AV21 (L. Kunz is the coordinator of the programme New Materials Based on Metals, Ceramics and Composites (M3K)).

Adequacy of available means and human resources to achieve these plans

The human resources are adequate but the development of the activities is strongly related to the ability to get competitive funds..

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

Low Cycle Fatigue Group (LCFG)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-Low cycle Fatigue (LCF) Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-LCF Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Mission and research topics

The mission of the group The diversity of the research themes in Low Cycle Fatgiue Group continues and concentrates both ton the basic studies and the industrially important subjects.

The Group have a long-term history of fatigue studies (Prof. M. Klesnil, later Prof. J. Polák) The main view is on the importance of LCF studies: premature failure of structural components cyclically strained under different conditions and environments are dealt with by considering basic LCF characteristics (cyclic stress-strain responses), microstructure of materials (steels, Ni nased superalloys, Ti-based alloys), and fatigue damage mechanisms (SEM-FEG, AFM, ; TEM..).

1.3 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members		4	1		3	1				1	2

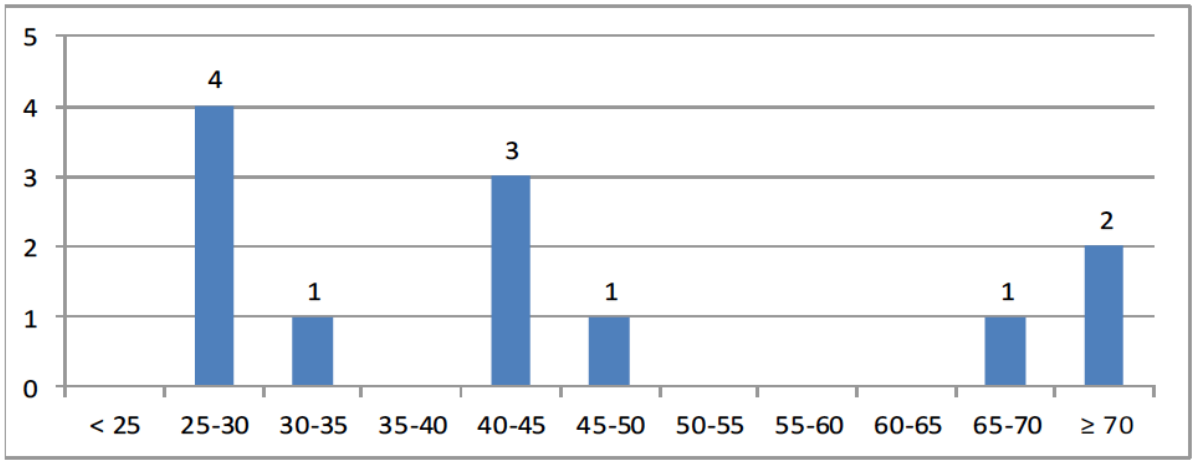

Figure 14: Age Distribution of LCFG

6 researchers
Viktor Škorík, Jaroslav Polák, Karel Obrtlík, Ivo Kuběna, Tomáš Kruml, Alice Chlupová, Jiří Man

4 technicians
Chrastil, R. Mádle, J. Tobiáš, J. Vysloužil

8 PhD students
M. Heczko, I. Kuběna, V. Mazánová, R. Petráš, M. Šmíd, I. Šulák, H. Tesařová, M. Truhlář

4 Diploma students
M. Kaňová, M. Kuběna, M. Kudelka, E. Vraspírová

In terms of full tine equivalent age distribution, the Group is formed by 7.00 FTE researchersand 3.30 FTE other workers. The number of the members of the team is substantially stable since 2010. **Very good.**

2. STRENGTHS AND OPPORTUNITIES

2.1 Timeliness of research topics

The research topics of the Group origins are in the history of the group itself, main actor in this filed of research from a long time. The Group today, even maintaining the consolidated structure of topics is looking with more and more interest at the research lines that are getting and increment interest in the international scene, that is high-temperature low cycle fatigue behaviour of materials and development of coatings for high-temperature protection. Also the experimental facilities park is extending in this direction.

On the base these comments, the timeliness of the overall research activity is considered **very good.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The LCF Group in the evaluation period was able to get the following grants:

- 7 standard projects + 1 POST-DOC project supported by CSF
- 4 smaller one-year projects supported by EFDA (high temperature deformation mechanisms - of ferritic ODS steels, production and characterization of ODS steels)
- 2 projects supported by EU and Ministry of Education, Youth and Sports, CR

The contractual research with companies is not quantitatively of primary importance for the institute but the names of the some of the foreign companies that assign contract to the group are an index of the quality of the group. The total amount of the budget is good.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:

- **Brittle fatigue Group**
  Austenitic stainless steels destabilization of microstructure after mechanical testing
- Ad**vanced High-Temperature Materials Group**
  Development of modern cast TiAl alloys (TiAl-Nb-C) a their mechanical testing
- **High cycle Fatigue Group**
  ODS steels FEM modeling of cyclic stress-strain response and small crack growth vs. experimental
- **Electric and Magnetic Properties Group**

In the National environment (national cooperation):

- Brno University of Technology – doc. Paloušek

In the International environment (International long-term cooperation):
The Low Cycle Fatigue Group has a long-time co-operation with several foreign partners (TU Bergakademie Freiberg, CEA Saclay, EPFL Laussane, EFDA and others), some other international co-operations have started during the period evaluated (TU Kaiserslautern, Oulu University, KIT Karlsruhe and others). Mutual creative co-operation resulted in numerous common publications (see below) which were a result of several study stays of members of Low Cycle Fatigue Group at foreign partners e.g. J. Man, V. Škorík and M. Petrenec at TU Bergakademie Freiberg. Foreign partners Dr. A. Weidner, TU Bergakademie Freiberg.

The long term international co-operations are possible both on complementarity of topics and research interests of the Group and its partners.

The intensity of cooperation of the Group is rated as **very good.**

.

2.4 Position of the institute within the Czech scientific community and its international position

Due to the past and rpesent results as well as the long list of international cooperations the reputation of the Group in the Czech Scientific community and the international community is **very high**.

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 14. The Group structure is well balanced with a good mix of starting, consolidated and advanced researchers. The capacity of the staff **is very good.**

2.6 Comments on the age structure

The age structure of the Group is well balanced. **Very good.**

2.7 Frequency and quality of publications

The total outputs of the group is 133. In Fig. 15 it is shown the quality of the outputs by journal ranking.

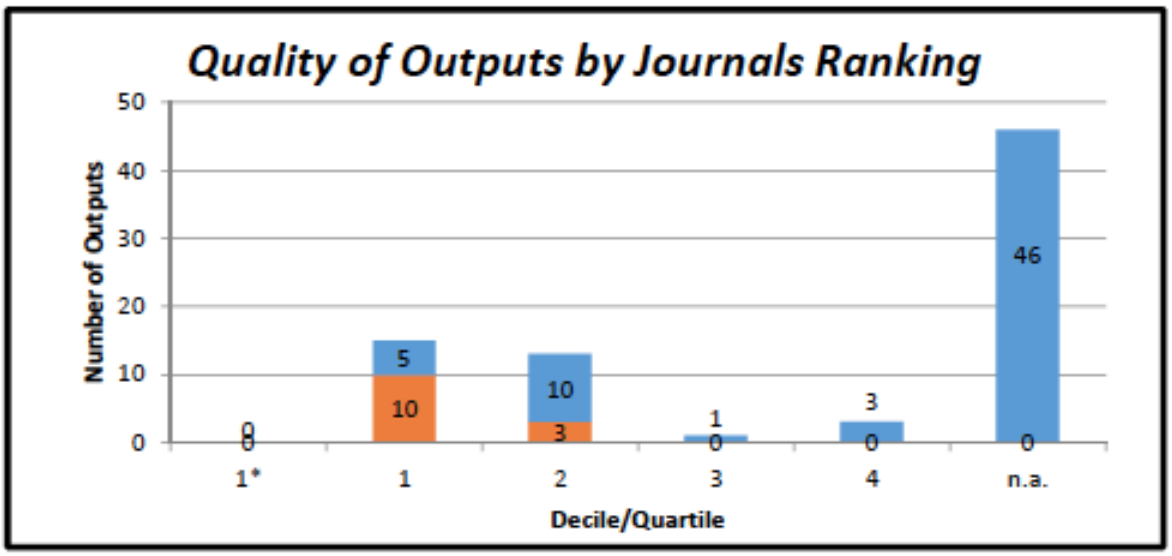

Figure 15: Quality of outputs of LCFG by Journal Ranking

If we refer to the output as Ranked in Phase I: 14 papers were considered and, among them, 1 was ranked 1 (world-leading in terms of originality, significance and rigour) 9 were ranked 2 (internationally excellent) and 3 were ranked 3 (recognized internationally). No papers were ranked 4 or 5 (below the standards). Finally, the quality of the output can be defined **very good**.

2.8 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

It is noted the absence of grants from FP7/H2020/other EU programs.

3.2 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Group is well organized and well identified, somehow under dimensioned for the running activities.

4.2 Internal programs to stimulate actions to enforce strengths and to reduce weaknesses

4.3 Identification of new research topics

The Group has identified promising new areas of investigations related to the new development in technologies that will be implemented in the next years.

5. DETAILED EVALUATION

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The research activities of the LCF Group include both very exciting theoretical approaches and sophisticated experimental research topics. The subjects of interest are mostly very beneficial for the most high-tech engineering field.

Overall quality of publications

The publications of the Group are well balanced among the different subject and generally published in high-ranked (1-2 quartile) journals. The total number of papers in journals with IF is 32, in other journals is 37 and the contributions in conference proceedings are 62.

Specification of the main achievements

- **Model of surface relief formation and fatigue crack initiation.** One of the new results achieved during last 5 years is a formulation and publication of a quantitative model

describing the mechanisms of surface relief formation and fatigue crack initiation in crystalline materials at ambient, depressed and slightly elevated temperatures simultaneously with the numerous experimental observations of the internal structure and surface relief evolution using high resolution techniques.

- **Advanced TiAl-Nb alloys** – optimization of microstructure and properties. In the project, the development and structure optimization of new advanced cast multiphase gamma based TiAl-8Nb-X alloys with the graded carbon content (0.2 to 1 at. %), produced so far only by powder metallurgy was followed. The main pertinent applications of the alloys suggested are turbocharger rotor or gas turbine blade in automotive and power industry.
- **Protective coatings for high temperature applications of Ni based superalloys**. Characterization of the protective coatings produced by the application of the diffusion layer on the surface of the cast nickel base superalloys were tested in high temperature (800 °C) cyclic loading.

Specification of the contributions of the team to publications

The contribution of the Institute members to the outputs are quite decisive in the published papers.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The LCF Group supervised

4 master students (and 3 co-supervised), 5 theses defended
7 PhD students (and 2 co-supervised), 5 theses defended

Involvement of doctoral and undergraduate students in research is very extensive and significant. Students are able to do very useful scientific work and help their advisors in their research in the framework of various projects and they are often with co-authors of publications.

Particular contributions of students to research

The students are actively involved in the running research projects and are among the authors of the papers published by the Group.

Number of defended PhD students in relation to students involved (success rate)

The total number of PhD theses defended in the evaluation period is 5 versus 7 PhD students supervised.

Employment of former PhD students (career options)

The possible carrier development is strongly dependent on the successful grants achieved by the group.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

The research activities have a strong impact on economy since the subjects of the research are of interest to the most advanced technological fields.

Impacts of the results and other activities on education

The involvement of the Group in education through supervised students and through courses. The members of LCF group in the evaluated period have regularly participated in the education of students of Faculty of Mechanical Engineering (FME) BUT Brno and Masaryk University Brno (T. Kruml and others). They have been supervisors or cosupervisors of numerous bachelor, master and doctoral students (see pedagogical activities of individual members below). They have been members of committees for the defence of PhD Thesis (J. Polák, J. Man, K. Obrtlík) and reviewers of PhD Thesis (J. Polák, J. Man, K. Obrtlík). K. Obrtlík has been the member of the committee for final examination in bachelor program for two specializations in years 2010-2014.

Impacts of the results and other activities on culture

The impact of the activities is mainly academic, no data are provided about the impact of the results on culture.

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

- members of LCF group annually participate on the “Open day of IPM” for public visitors (scholars + individual visitors)
- excursions of students of secondary technical schools and grammar schools
- excursions of students of Brno University of Technology (Faculty of Mechanical Engineering, Faculty of Civil Engineering), visits of laboratories

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The Group distinguishes by its strong position both in national and international scientific community gained in the past and maintained in recent years. Also the cooperation of with numerous national and international universities in research and education joint activities is wide and important.

.

Role and position in international collaboration

The LCF Group has a wide number of international cooperation with a prior role in many of the projects.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
No other activity can be implemented if the staff is not increased.

Ability to attract foreign researchers at different levels

The Group is able to attract students/researchers from abroad in the framework of the different well established international cooperation.

Position of the team in the national context

The LCF Group is the national leader in the field.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age is balanced with respect of the last evaluation. The gender issue is not mentioned in the reports. The qualification and the international experience are remarkable.

Attraction of research programmes for young people

LCF Group has a good number of young researchers.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding are mainly national and based on competitive calls. The contractual research is not negligible even if not quantitatively important as the other two types of funds.

Effectiveness of research (based on comparing size of groups, funding and output)

The effectiveness of research is high.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.6 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The most important research direction in the coming time period are high temperature behaviour of structural materials high temperature fatigue damage mechanisms. The new themes introduced will be behavior of materials in biaxial (axial/torsional) cyclic loading and thermomechanical fatigue of heat resistant materials. Both are relevant in the next technological developments.

Adequacy of available means and human resources to achieve these plans

The human resources are adequate but the development of the activities is strongly related to the ability to get competitive funds.

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

Electrical and Magnetic Properties Group *(EMPG)*

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-Electrical and Magnetic Properties Group (EMP) Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-EMP Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Mission and research topics

Mission.

The selected research fields of the group in the last five years:

Properties:
- **Low-/room-/high-temp. magnetic** and **(low-/RT) electrical** properties
- Local atomic **magnetic moments** (using both Mössbauer and *ab initio*)
- Local atomic **structure, thermodynamics and magnetism** of grain boundaries (employing quantum-mechanical calculations)
- **Mechanical (elastic and plasticity-related) properties** using theoretical tools (single crystals -> **scale-bridging methods** -> macroscale)

Materials:
- **Nano-particles** as well as micro-/macro-scopic systems
- Both **structural** (e.g., Fe-Al-/Mg-based alloys) and **functional** materials
- **Crystalline** materials with Fe (steels, Fe-Si, Zr-Fe-V, or Fe-Al, Fe-oxides, …)
- **Bio**materials (bio-composites) and materials for **medical** applications
- **Amorphous** metals ($Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$) and bio-materials ($CaCO_3$)
- **Ferrohydrides and hydroxides for nano particles synthesis**

1.3 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members	2	1	3	4	4		1	1	3	1	

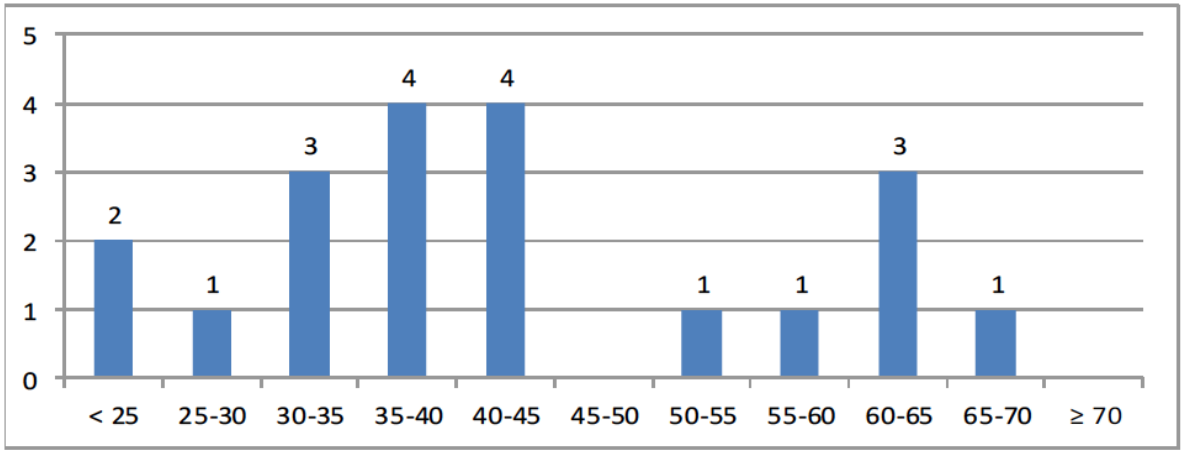

Figure 16: Age distribution of EPMG

5 senior researchers:
(DSc. O. Schneeweiss*, Dr. Y. Jirásková*, Dr. T. Žák*,
Prof. M. Šob, Assoc. Prof. I. Turek)
13 researchers:
(Dr. M. Friák, Dr. N. Pizúrová, Dr. J. Pavlů, Dr. P. Roupcová,
Dr. E. Švábenská, Dr. M. Všianská, Dr. H. Elhadidy*, Dr. *et* Dr. R. Gröger*,
Dr. A. Ostapovets*, Dr. J. Fikar*, Dr. P. Šesták, Dr. P. Řehák, Assoc. Prof.M. Černý)
3 Technicians:
(Dr. Hapla*, J. Mateovič, M. Radkovič)
4 PhD students:
(Ing. A. Titov, Ing. M. Hrabovský, Mgr. D. Wagenknecht, and Ing. K. Zábranský)
2 undergraduate students:
(Mr. O. Svoboda and Mr. P. Procházka)

In terms of full tine equivalent age distribution, the Group is formed by 14.34 FTE researchers and 1.50 FTE other workers.

2. STRENGTHS AND OPPORTUNITIES

Based on the findings of the detailed evaluation (see below topic 5) we should come up with some statements referring to:

2.1 Timeliness of research topics

The research subjects of the EMP group are being developed in suitable timing with respect of the current scientific trends. The research can be divided in two major areas, theoretical and experimental.

As regards the first, the activities has been devoted to Magnetically dead layers at , Σ5 (210) grain boundaries in Ni, Anisotropic magnetoresistance, combination of atomistic simulation and HRTEM image analysis of dislocations. The experimental research focused on Nanoparticles systems prepared by plasma-chemical synthesis, Materials for bio-applica-tions: Fe-oxides for hyperthermia treatment, Amorphous and nano-crystal alloys for elec-trotechnical applications, Studies of natural ferrihydrite, Fe-oxides, and iron hydroxides as the precursors for the preparation of the nanocrystalline iron based powders, Studies of thermal stability in different environmental surroundings, Structure and phase transformation on the surfaces of friction materials used in brake systems (environmental and health (public safety) issues), Continuous maintenance of the CONFIT software, that was earlier developed at IPM, to be used when analysing Möss-bauer spektra, Magnetic nanoparticles (related to air pollution) in bodies of, e.g., bumblebees.

The results and ability of the group to find a number of international cooperation with high ranked institutions as well as the papers published in steering journals (together with authors of those prestigious institutions) is another sign of the timeliness of the research subjects.

On the base these comments, the timeliness of the overall research activity is considered **very good.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The EMP Group in the evaluation period has got 14 research projects, with 2 COST project and 11 national grants (not specified if form CSF and/or ASCR, Ministry of Education).
The total amount is not specified. The contractual research is a minor source of budget and limited to few national companies.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:

intradepartmental: strict cooperation within the Dept of Structure of Materials (Dr. M. Svoboda, Dr. A. Kroupa, Dr. J. Buršík and Dr. T. Káňa)

interdepartmental: among the other departments of the IPM, the cooperation is active with all the groups of the Dept. of Mechanical Properties but High cycle Fatigue.

In the National environment (national cooperation): the members of the group have active cooperation with the Universities and CEITEC in Brno as well as with other universities in the Czech Republic mainly in terms of Educational activities (teaching, lecturing).

In the International environment (International cooperation): cooperation is active with many European and oversea universities and research Labs: ETH Zurich, Univerity of Oxford, University of Cambridge, Los Alamos National Labs, University of Pennsylvania, Max Planck Inst. are among the partners of the EPM researchers.

The intensity of cooperation of the Group is rated as **very good.**

2.4 Position of the institute within the Czech scientific community and its international position

The reputation of the EPM Group in the Czech Scientific community and the international community is **very high** and supported by the excellent journals where some appers with authors by the group are published (Nature Materials, Progress in Material Science, Acta Materialia, ..)

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 16. The number of the researchers as well as the age structure is adequate and do not requires substantial changing. The capacity of the staff **very good.**

2.6 Comments on the age structure

The age structure of the Group is well designed and defined **very good.**

2.7 Frequency and quality of publications

The total outputs of the group is 149. In Fig. 17 it is shown the quality of the outputs by journal ranking.

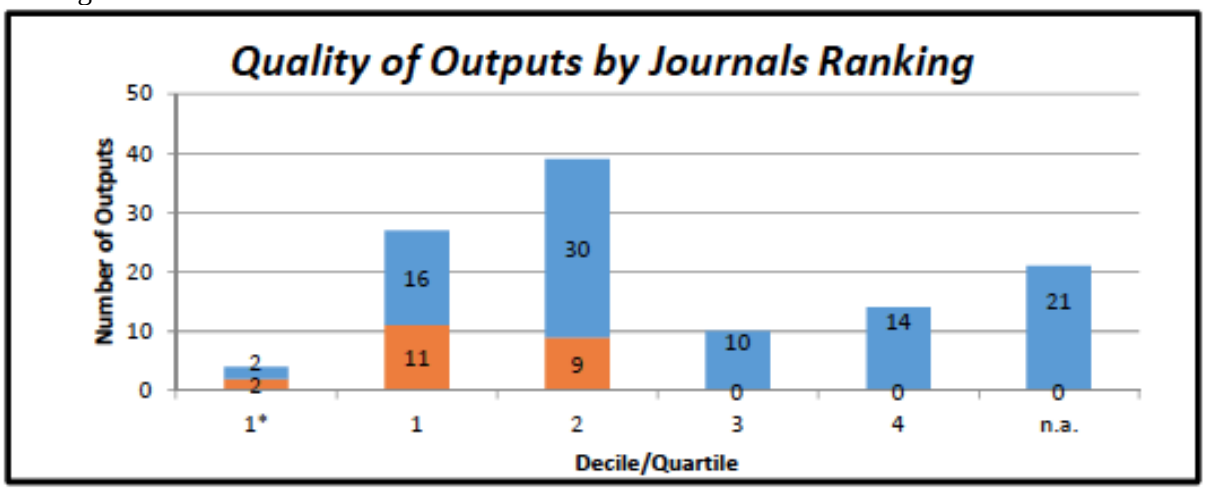

Figure 17: Quality of outputs of EPMG by Journal Ranking.

If we refer to the output as Ranked in Phase I: 22 papers were considered and, among them, 2 was ranked as "world-leading in terms of originality, significance and rigour", 8 were ranked as "internationally excellent" and 10 were ranked as "recognized internationally", 2 were ranked as "recognized nationally". No papers were ranked as "below the standards". Finally, the quality of the output can be defined **very good**.

2.8 Patents and role in contractual work

The role of the institute on contractual work is generally not related to patents but in the solution of practical problems. The amount of time and resources coming from contractual research is limited with respect of the other source of budget.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The structure of the budget as well as the need to run expensive experimental facilities makes necessary to get more and more funds for being sustainable. No detailed information about the budget were given.

3.2 Comments on the age structure

The age structure is balanced

3.3 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

Based on the strengths, opportunities, weaknesses and threats some recommendations can be elaborated. Sub-sections (topics) may refer to:

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Group is well organized and well identified. Some overlaps are noted within the group.

4.2 Identification of new research topics

The action of the Group for the introduction of new research lines is adequate.

5. DETAILED EVALUATION

According to the guidelines the following sub-sections should be included:

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The research activities are covers present a balanced mix of theoretical and experimental studies aimed at a deep and multiscale understanding of the electro magnetic properties with a view on possible practical exploitation for new findings in the different fields of social and economic interest. The assessment on the characterization on the main research activities is quoted **very good**.

Overall quality of publications

The publications of the Group are well balanced among the different subject and generally published in high-ranked (1-2 quartile) journals. The total number of papers in journals with IF is 99, in other journals is 20 and the contributions in conference proceedings are 28.

Specification of the main achievements

For the period 2010-2014 we have proposed following focusing of our effort.

- theoretical studies of electronic and magnetic properties of disordered alloys, epitaxial multilayers, surfaces and interfaces as well as quantum-mechanical studies of extended defects in metallic materials
- experimental investigations of relations among structure and magnetic, transport and mechanical properties in metallic materials

In the first topic the research encompassed several topical fields as e.g. surface magnetism, magnetic exchange coupling and spin-dependent transport in multilayered systems, magnetic properties of amorphous materials, solute segregation in bulk disordered alloys and at grain boundaries and computer simulations of atomic configurations of defects. Quantum mechanical and quantumstatistical methods are applied to these problems, and most studies are performed from the first principles. Important part is theoretical studies of dislocations in metals.

The second of the mentioned topics is based on broad experimental macroscopic and microscopic investigations of crystal structure in relation to electrical and magnetic properties, both integral and microscopic. Predominate amount of results has been obtained from applications of Mossbauer spectroscopy. Crystalline, microcrystalline, nanocrystalline and amorphous materials have been investigated.

The main achievements of the Group can be identified in the publication of papers on high-ranked and steering journals. In particular:

X. Marti, I. Fina, C. Frontera, J. Liu, P. Wadley, Q. He, R.J. Paull, J.D. Clarkson,
J. Kudrnovský, I. Turek, J. Kuneš, D. Yi, J.-H. Chu, C.T. Nelson, L. You, E. Arenholz, S. Salahuddin, J. Fontcuberta, T. Jungwirth, R. Ramesh, Nature Mater. 13 (2014) 367.

Specification of the contributions of the team to publications

The main publications of the Group are in cooperation with other prestigious universities and/or organizations. The contribution of the group is strictly related to the expertise of the group.

5.2 Declaration on the involvement of students in research

Involvement of students (doctoral, undergraduate) into research

The EMP Group in the evaluation period supervised 2 MSc and 3 PhD theses plus 2 BSc, 1 MSc and 4PhD co-supervised. The number of defended theses is 1 8MSc and 1 PhD.

Particular contributions of students to research

The students are actively involved in the running research projects and are among the authors of the papers published by the IPM.

Number of defended PhD students in relation to students involved (success rate)

The total number of PhD theses defended in the evaluation period is 1 versus 3 PhD students supervised. The this ratio should be improved.

Employment of former PhD students (career options)

The possible carrier development is strongly dependent on the successful grants achieved by the group.

5.3 Declaration on societal relevance

Impacts of the results and other activities on economy

The impact of the activities of the Group on the economy is potentially high.

Impacts of the results and other activities on education

Members of the Electrical and Magnetic Properties group have been involved in a number of pedagogical activities in last 5 years.

Impacts of the results and other activities on culture

The impact of the activities is mainly academic, no data are provided bout the impact of the results on culture.

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

These are the activities in the filed of science popularization:

- Dr. Roman Gröger organized two seminars for the public and non-expert scientific audience that were both given in Czech: "Basic tools for scientific research – Let the computers compute" (held in 2012)
- "Introduction to computer typography – It is not LaTeX as Latex" (held in 2013) The

materials from these lectures are available free of charge at http://groger.ipm.cz under Workshops.

5.4 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The position of the Group in the international context is of primary importance and impact. The Group is able to establish durable relations with well known institutions and helps maintaining a high position among equivalent international Groups.

Role and position in international collaboration

The EMP Group has a wide number of international cooperation.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.

Ability to attract foreign researchers at different levels

The Group is able to attract students/researchers from abroad.

Position of the team in the national context

The EMF Group is a national leader in the field.

5.5 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age is balanced with an increasing numbers of young researchers introduced in the staff. The gender issue is not mentioned in the reports. The qualification and the international experience are remarkable.

Attraction of research programmes for young people

EMP Group is one of the most attractive Group for young people.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding structure is not well specified. From the documents available it is understood that the Group should start a systematic action to improve the international amount of the international funds.

Effectiveness of research (based on comparing size of groups, funding and output)

The effectiveness of research is high.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.6 Declaration on the strategy and plans for the future

The strategy of the EMP Group for the future is based on a stronger and stronger synergy of the experimental and theoretical teams forming the group. This is encouraged and supported by the leader of the group, Mgr. Martin Friák, Ph.D., a theorist combining state-of-the-art theoretical andvexperimental research tools in designing new advanced materials for industrial applications. This synergy is considered strategic to achieve breakthorugh results in the different areas of interest of the group.

In paeticular Dr Friak successfully improved and applied the concept of a theory-guided materials design. This state-of-the-art approach has only recently emerged as a modern alternative to classical metallurgical casting and testing of hundreds of compositions. Different solute combinations are first virtually tested in computer in a high-throughput manner and the most promising ones are selected for subsequent synthesis, characterization and testing. Significant reductions in both time and costs are achieved. Importantly, this new type of materials design is dominantly knowledge-driven and based on newly accumulated basic-science information.

An important nano-patterned composite materials system that will be considered are the new Fe-Al-based superalloys. They are required to meet multiple casting, processing and operational criteria including high-temperature creep strength, oxidation resistance and room-temperature ductility. In order to design them, a highly challenging combinatorial approach should be adopted in order to identify suitable combinations of alloying elements.

A theory-guided development of ultra light-weight materials for automotive and transport industries is another example of future research direction that includes an international collaboration with scientists from the Max Planck Institute in Düsseldorf, Germany.

Adequacy of available means and human resources to achieve these plans

The human resources are adequate but the development of the activities is strongly related to the ability to get competitive funds..

Missing issues in the strategy

No main issues in the strategy are missed.

EVALUATION OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

Structure of Phases and Thermodynamics Group (SPTG)

1. INTRODUCTION

This report refers to the Evaluation of the Institute of Physics of Materials (IPM)-Structure of Phases and Thermodynamics (SPT) Group of the Academy of Sciences of the Czech Republic, 2010-2014, and is written according the to the guidelines reported in the Appendix 6.1 and 7.1 as well as the Recommendation for Elaboration of the Final Report drawn by the CAS.

1.1 Location of the institute and its dept., labs. & sub units.

The IPM-SPT Group is sited in Brno, Zizkova 22, in the centre of the city.

1.2 Mission and research topics

Mission:

Mission of the group is advance the state of the art in three main research fields of serious importance both for the basic and applied research – theoretical and experimental modelling of phase diagrams, including size-dependent phase diagrams; studies of material structures by means of Analytical Electron Microscopy (AEM); measurements of diffusion characteristics and study of hydrogen desorption

1.3 Staff size and full time equivalents age distribution

Age category	< 25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	≥ 70
Number of members			1	2	1	1	2	2	2		

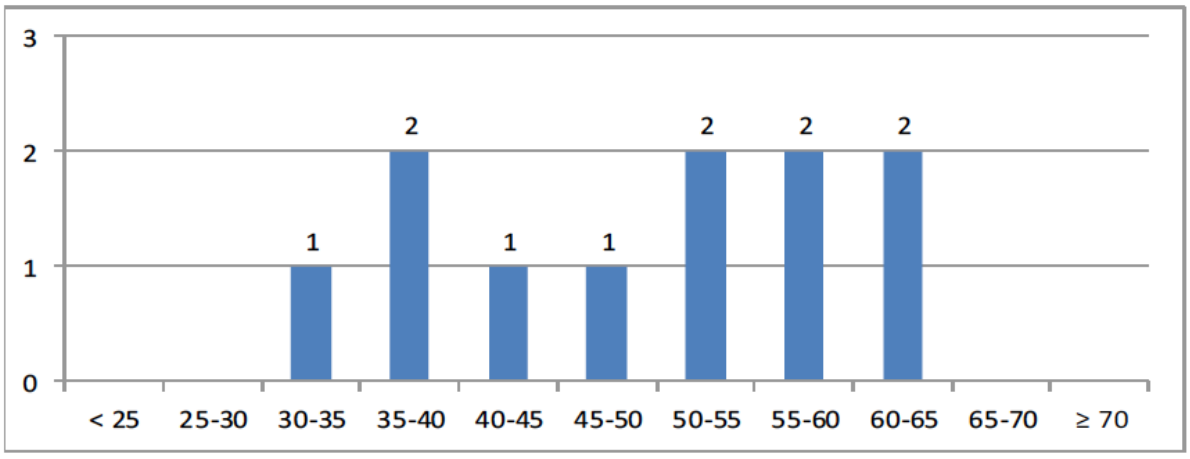

Figure 18: Age distribution of SPTG

7 researchers:
Aleš Kroupa, Jiří Buršík, Jiří Čermák, Lubomír Král, Věra Rothová, Milan Svoboda, Adéla Zemanová

In terms of full tine equivalent age distribution, the Group is formed by 6.11 FTE researchers and 2.76 FTE other workers. The number of the members of the team is substantially stable since 2010. **Good.**

2. STRENGTHS AND OPPORTUNITIES

Based on the findings of the detailed evaluation (see below topic 5) we should come up with some statements referring to:

2.1 Timeliness of research topics

The research lines identified and investigated by the Group are relatively news and strongly related to the use of advanced experimental facilities, available at IPM. This allows to develop up-to-date research lined. The timeliness of the overall research activity is thus considered **very good.**

2.2 Budget: Ratio of institutional budget, grants and contractual resources, international funds

The SPT Group in the evaluation period was able to get the following grants:
- 11 successfully solved national projects funded by CSF and MEYS
- 2 international COST projects (Chair of MC in COST MP0602, member of MP0903)

The contractual research with companies is quite low. The total amount of the budget is adequate even if not large. **Good/ Very Good**.

2.3 Intensity of collaboration among teams and among institutes, national collaboration and international involvement

In the Institute:

Intradepartmental
Y. Jirásková – Powders, metallic glasses
M. Šob – Ab initio modelling of thin films and nanocomposites
P. Roupcová, B. David – XRD study of sorption kinetics
A. Ostapovec – twins in hexagonal metals
Advanced High-Temperature Materials Group

Interdepartmental
J. Svoboda, H. Hadraba – Z-phase, Oxide Disp. Steels
A. Dlouhý – High entropy alloys
I. Dlouhý - Boron nitride nanosheets
P. Král – Study of P92 and SUPER 304H welds
V. Sklenička – ECAP, Advanced High-Cr steels

In the National and International environment (International long-term cooperation)

- **Lead free solders, phase diagram studies, database development, nanomaterials**
  Profs. J. Vřešťál, J. Pinkas, P. Broz, J. Sopoušek, Institute of Chemistry, MU Brno, CR
  Dr. A. Dinsdale, NPL, Teddington, UK
  Dr. A. Watson, University of Leeds, UK
  Prof. H. Ipser, Prof. H. Flandorfer, Prof. K. Richter, Universität Wien, Austria
  Prof. G. Borzone, University Genova, Italy

Dr. S. Mucklejohn, Ceravision Ltd., UK
Dr. N. Hoo, ITRI Ltd, UK
Dr. D. Andersson, Swerea, Sweden
Prof. J. Drápala, Dr. B. Smetana, VSB-TU Ostrava, CR
Dr. R. Mishra, Bhabha Inst. of Nuclear Reseach, Mumbay, India
Prof. D. Zivkovič, Univ. of Belgrade, Serbia
Dr. Erwin Hüger, Clausthal Univ. of Techn. Germany
Dr. J. Mrázek, Institute of Photonic and Electronic

- **Advanced steels, boron containing systems**, **phase diagram studies, thermoelectrics**
  Prof. J. Janovec, Slovak University of Technology, Bratislava/Trnava, Slovakia
  Dr. A. Vyrostková, Dr. V. Homolová, IMR SAS Košice, Slovakia
  UJP Praha a.s., CR
  Prof. P. Rogl, Universität Wien, Austria
  Dr. M. Kraus, VSB-TU, Ostrava, CR

- **Materials for Nuclear Reactors,** surface corrosion assessment, studies in near-surface layers
  Energovýzkum s. r. o., CR

- **Hard coatings, defects in Si**
  Dr. V. Buršíková, Dr. M. Meduňa, Institute of Physics, Masaryk University, CR

The assessment of cooperation is finally **very good.**

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2.4 Position of the institute within the Czech scientific community and its international position

Due to the past and present results as well as the long list of international cooperation the reputation of the Group in the Czech Scientific community and the international community is **good**.

2.5 The overall capacity of staff

The overall capacity and the age structure of the staff is illustrates in Fig. 18. The Group structure is completely lacking young researchers as well as students**.**

2.6 Comments on the age structure

The age structure of the Group is rather balanced.

2.7 Frequency and quality of publications

The total outputs of the group is 157. In Fig. 19 it is shown the quality of the outputs by journal ranking.

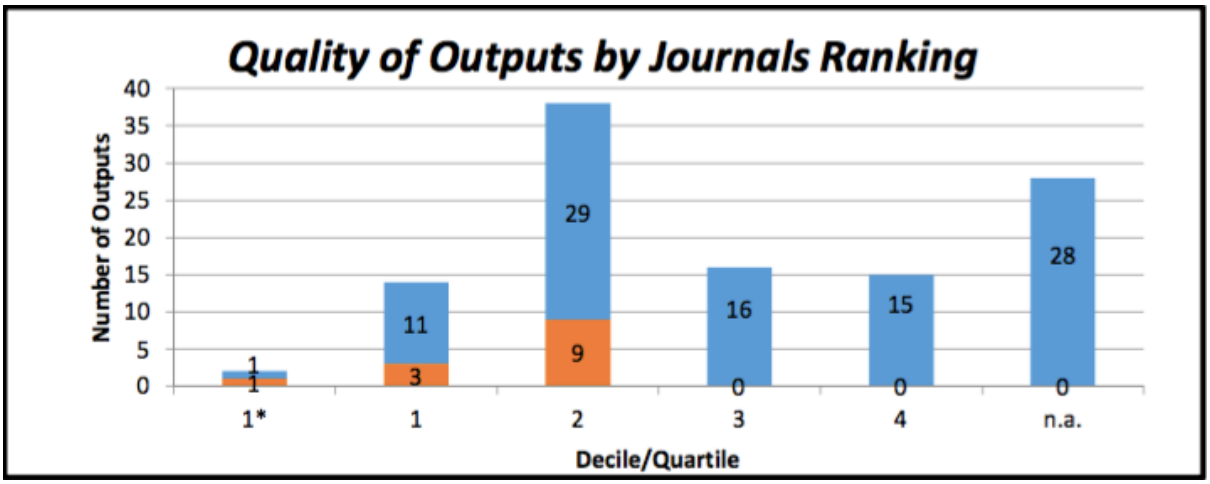

Figure 19: Quality of outputs of SPTG by Journal Ranking.

If we refer to the output as Ranked in Phase I of the evaluation: 13 papers were considered and, among them, 0 was ranked 1 (world-leading in terms of originality, significance and rigour) 5 were ranked 2 (internationally excellent) and 8 were ranked 3 (recognized internationally). No papers were ranked 4 or 5 (below the standards). Finally, the quality of the output can be defined **very good**.

2.8 Patents and role in contractual work

A patent has been submitted but no revenue has come so far.

3. WEAKNESSES AND THREATS

3.1 Budget: Ratio of institutional budget, grants and contractual resources, international funds

Low institutional budget.

3.2 Comments on the age structure

The complete lack of young researchers and PhD is a weak point of the group.

3.3 Patents and role in contractual work

Patents are not a significant output in the evaluation period.

4. RECOMMENDATIONS

Based on the strengths, opportunities, weaknesses and threats some recommendations can be elaborated. Sub-sections (topics) may refer to:

4.1 Re-organisation of the internal structure of the institute and departments, laboratories, teams and groups considering the critical mass of each unit, the overlap of units

The Group is well organized and well identified, even if with overlaps with other groups.

4.2 Identification of new research topics

The Group has identified promising new areas of investigations related to the new development in technologies that will be implemented in the next years.

5. DETAILED EVALUATION

According to the guidelines the following sub-sections should be included:

5.1 Declaration on the quality of the results and share in their acquisition

Characterisation of the main research activities (experiments, theoretical areas)

The research activities of the SPT Group include both very exciting theoretical approaches and sophisticated experimental research topics. The subjects of interest are mostly very beneficial for the most high-tech engineering field.

Overall quality of publications

The publications of the Group are well balanced among the different subject and generally published in high-ranked (1-2 quartile) journals with one paper in the 1st decile. The total number of papers in journals with IF is 86, in other journals is 8 and the contributions in conference proceedings are 52. 1 book and 9 chapter in professional books complete the scientific output.

Specification of the main achievements

- **Nanomaterials and Modelling of Size-dependent Phase Diagrams** New and original method for the modelling of the complex size-dependent phase diagrams with intermetallic phases was developed in co-operation with the team from "Electrical and Magnetic Properties Group". Here the ab initio calculations were used to calculate the surface stress of intermetallic phases, which are not available from experiment. New model is under construction for the modelling of surface stress of nonstoichiometric intermetallic phases

- **AEM Studies on Relations between the Structure and Properties of Materials** The AEM methods were applied by members of our Group for the study of the nucleation and growth of oxygen precipitates in silicon. The experimental results were compared with theoretical modelling, based on theories of nucleation and growth, going beyond the classical theory of nucleation. The numerical analysis allowed us to determine the associated material constants needed for appropriate numerical modelling of the precipitate growth. The prediction and understanding of precipitation processes kinetics lead to development of recipes for annealing treatments resulting in controlled sample parameters.

- **Diffusion and Transport Properties, Hydrogen Storage Studies** Important results were obtained in the field of hydrogen desorption and their results have both scientific value and importance for practical application. The project as devoted to Hydrogen storage materials in complex hydrides based on Mg.

Specification of the contributions of the team to publications

The contribution of the Institute members to the outputs are quite decisive in the published papers.

Involvement of students (doctoral, undergraduate) into research

The SPT Group did not supervise any student. Now 1 PhD student is working in the group.

Particular contributions of students to research

The students are actively involved in the running research projects and are among the authors of the papers published by the Group.

Number of defended PhD students in relation to students involved (success rate)

No theses were defended.

5.2 Declaration on societal relevance

Impacts of the results and other activities on economy

The research activities have a strong impact on economy since the subjects of the research are of interest to the most advanced technological fields.

Impacts of the results and other activities on education

Two members of the group took part in pedagogical activities at several universities and research institutes, both as lecturers in semestral courses and giving lectures in the scope of specialized seminars and projects. Following is the list of their main pedagogical activities

Impacts of the results and other activities on culture

Further to the scientific papers, as regards the impact of the Institute results and other activities on culture, it is to be underlined the active role of the the SMT Group in organizing conferences and publishing and editing books (! Monography and 1 edited book). In the evaluation period the Group was:

- Organizers of TOFA 2014 (Thermodynamics of Alloys) international conference in Brno (105 participants, 90% from abroad)
- Organizers of final conference of COST MP0602 project (over 70 participants from 18 countries)

Services for research (libraries, data bases, collections,..)

These services are integrated in the University.

Popularisation and similar activities

J. Buršík gave lectures on transmission electron microscopy at Autumn School of Electron microscopy in 2011 and 2013 (organized by ISI ASCR, Brno), other members of the research group (A. Kroupa, M. Svoboda, A. Zemanová) took part as demonstrators in the electron microscopy laboratory in the scope of this Autumn Schools.

All members of the research group took part in regular annual Open Days, where the IPM is opened to public and introduced the scientific topics done at the Institute and in the laboratories to the laymen, mainly to the students of high school from Brno. In the scope of this event they give lectures and practical demonstration of the use analytical electron microscopy in the basic and applied research.

5.3 Declaration on the position in the international and national context

Comparison of the position, recognition, outputs and impacts with leading and international teams

The Group distinguishes by its strong position both in national and international scientific community Also the cooperation of with numerous national and international universities in research and education joint activities is wide and important.

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Role and position in international collaboration

The SPT Group in two COST projects as partner.

Breadth/completeness of the research activities compared to world leading teams of comparable size

The research activities cover a wide range of the subjects that are of present major interest.
No other activity can be implemented if the staff is not increased.

Position of the team in the national context

The SPT Group is one of the national leaders in the field.

5.4 Declaration on the vitality and sustainability

Composition of staff with respect to age and gender, qualification, international experience

The structure of the staff with respect of the age is rather balanced but the lack of students is underlined.

Funding (structure of the resources and its comparison with the outputs, grants and project activity)

The funding are mainly national and based on competitive calls. The contractual research is not negligible even if not quantitatively important as the other two types of funds.

Effectiveness of research (based on comparing size of groups, funding and output)
The effectiveness of research is good.

Organisational structure, recruitment methods, career system, incentives for females, young researchers, international researchers.

This reflects the organizational structure of the IPM.

5.5 Declaration on the strategy and plans for the future

Relevance of the out lined strategy and research plans

The research plans for the next future go in the direction of the current research subject and it is expected that will be supported mainly by CSF funds.

Adequacy of available means and human resources to achieve these plans

The human resources are adequate but the development of the activities is strongly related to the ability to get competitive funds.

Missing issues in the strategy

No main issues in the strategy are missed.

Date: February 28, 2016

Commission Chair: em Prof.DI.Dr.Dr.hc. Hans Peter Nachtnebel