Institute for Materials Research

Tohoku University

External Evaluation Report 2018

Preface

This is the report of the external evaluation which was made for the Institute for Materials Research (IMR), Tohoku University, in 2018.

The external evaluation of IMR has been made approximately every 6 years since 1995: 1st in April 1995, 2nd in November 2000, 3rd in October 2006, 4th in January 2013, and this time was the 5th in October to December 2018. A characteristic in this 5th external evaluation different from the past ones was to be international, inviting 6 overseas members among 17-strong members in the evaluation committee.

The external evaluation in 2018 was made with two stages. In the first stage overseas members were invited to join the international conference "Summit of Materials Science (SMS) 2018" organized by IMR on October 29th to 31st. Each overseas member made an evaluation report based on the presentations of IMR researchers in SMS2018. In the second stage, domestic members gathered in IMR on December 4th and 5th, to interview IMR researchers, and summarized an integrated report based on the interviews and with reference to the reports by overseas members.

The external evaluation has covered different activities in IMR: research including project-type and collaboration-type, education, management, organization, personnel, infrastructure, budget, and cooperation with industry. The report includes a lot of valuable suggestions and advice for us to consider the future of IMR. On behalf of IMR, I would like to express the deepest gratitude to Prof. Tomoyuki Kakeshita, the chair of the external evaluation committee, and all the committee members for their great efforts.

During the external evaluation, we had got good news: IMR was certified as the international joint usage/research center (IJURC) for materials science by the Ministry of Education, Culture, Sports, Science and Technology, MEXT. The IJURC system is a new system established in 2018, and only six research institutes in four national universities, including IMR, Tohoku University, were selected as IJURC among more than 100 research institutes and centers in Japanese universities. This evidences our high research activities with international collaboration in IMR. Making full use of the advice and suggestions in this report of the external evaluation, we will further enhance our activities, and contribute to the development of materials science and communities.

Finally I would like to thank again the the external evaluation committee members, and also all the IMR people concerned with the external evaluation.

December 2019
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External Evaluation Report

Contents

1. Introduction

This report summarizes the findings of the fifth external evaluation of the Institute for Materials Research (the "IMR", also known as *"Kinken"*) of the Tohoku University performed over a total of five days, from 29 to 31 October 2018 (Heisei 30) (Foreign Committee members) and on 4 and 5 December 2018 (Heisei 30; Domestic Committee members). After being incorporated, national universities are obliged to formulate and operate in accordance with a statement of its mid-term goals and plans, and to undergo evaluation of implementation. Each university is also subject to institutional certified evaluation and accreditation once every seven years, a program for evaluation on fulfillment of basic conditions as a university. Unlike that program of prescribed external evaluation, the present evaluation is based on independent evaluation parameters established by IMR.

The evaluation was made based on on-site investigation during the abovementioned 5-day on-site visit and the progress report submitted prior to the visit. The previous (the fourth) external evaluation, covering FY2007 (Heisei FY19) to FY2012 (Heisei FY24), was performed in January 2013 (Heisei 25) under the leadership of committee chairman Tatau Nishinaga, with the fourth External Evaluation Report issued in May 2013 (Heisei 25). In this (fifth) evaluation was, at the first time, experts from outside the IMR as committee members were selected not only from Japan but also from foreign countries, and requested to evaluate the performance of the institute. This External Evaluation Report shows the findings on the general research activities of the IMR in the six years from FY2013 (Heisei FY25) to FY2018 (Heisei FY30).

The evaluation is an inquiry into the validity of the IMR principles and objectives, whether its operation is performed without problem, whether the present research activities are indeed being performed well, and whether it contributes sufficiently to industry-academia-governmental collaboration or to regional society, and other aspects. Unlike the institutional evaluation, it is conducted through external eyes without accompanying matters such as bestowal of awards or modes of punishment. Rather, its mission is to perform rigorous assessment of IMR achievements and to provide valuable advice on the future perspective.

The parameters of this external evaluation requested by the IMR are as shown in Annex 1 at the end of this report. Together with the above-described evaluation of the present overall state of the IMR are included evaluations of the present performance of each research laboratory and its joint usage and affiliated facilities. For this purpose, evaluation was performed on the basis of manager interviews together with overviews prepared by the IMR on research laboratories and affiliated facilities, reference documents including the response to recommendations from the IMR fourth external evaluation, overviews of the IMR and various relevant pamphlets. The evaluation was performed by the 17 members of the Evaluation Committee shown in Annex 2. The on-site investigation by the External Evaluation Committee was performed under the schedule shown in Annex 3. The Foreign External Evaluation Committee members participate in the 29 and 30 October 2018 (Heisei 30) symposium called the Summit of Materials Science 2018 (SMS2018), with the lectures and poster sessions given by the IMR director, Koki Takanashi, and other IMR faculty members. On 31 October, the Foreign Evaluation Committee was convened and a general discussion was held on how to proceed in the evaluation. In the Domestic Evaluation Committee meeting, a description on the principles and goals, history, operational state, and achievements in research and education was presented by the IMR director. After a general discussion on the manner of proceeding in the evaluation, interviews of IMR laboratories and centers were made by separating areas of responsibility for two days. The evaluated laboratories or centers and related Committee member are listed in Annex 4. After these interviews, a general meeting of the Committee members was next convened on the second day, followed by further exchanges between the IMR administrative executives and the committee members.

2. Research institute principles and goals

The IMR has a long tradition marked in 2016 (Heisei 28) by the centennial of its founding in 1916 (Taisho 5) as the 2nd division of the Provisional Institute of Physical and Chemical Research at Tohoku Imperial University Faculty of Science. In 1919 (Taisho 8) it was renamed the Tohoku Imperial University affiliated Iron and Steel Research Institute, with

Dr. Kotaro Honda as its director. It was the first research institute in Japan established at a university by governmental mandate. In 1922 (Taisho 11), together with its establishment anew as the Institute for Materials Research with a three-laboratory structure, its range of research was expanded from iron and steel to include light metals and non-ferrous metal alloys. As part of the postwar university system reform, in 1949 (Showa 24) under the research institute development program it gained a 21-laboratory structure. This was later followed by the addition of four new departments of nuclear reactor materials, and in 1987 (Showa 62), it was reorganized as a countrywide collaborative research institute, and with the expansion of its research materials to the present wide range of industrial applications and no longer limited to metals. With the national university incorporation of 2004 (Heisei 16), the IMR was designated an affiliate of National University Corporation Tohoku University. In 2010 (Heisei 22) it was certified as a Joint Usage/Research Center for materials science. In 2016 (Heisei 28) this center was accorded the highest S rating and it received renewed certification. The IMR was certified in 2018 (Heisei 30) as an International Joint Usage/Research Center.

In accord with this history of development and growth, the IMR honors the following principles in its performance of research and education.

"The Institute for Materials Research (IMR) contributes to human civilization and well-being through the creation and application of truly useful materials by research on metals, semiconductors, ceramics, organics, and many others, including its compounds, composites, and structures."

With this as its guiding concept, the IMR is advancing in its third mid-term goals and plans for FY2016 (Heisei FY28) to AY2021 (Heisei FY33) with the following basic goals.

"Since its founding as a center of excellence (COE) in research on substances and materials, the IMR has worked at the forefront and led internationally in substance and materials scientific research and created many new substances and materials that have contributed substantially to forming the basis for the high-level industrial societies in the

20th century. The basic goals of the IMR are to continue to work in the 21st century as an international COE for elucidation and creation of a wide range of new metals and other substances and materials through theoretical exploration and applied research in materials science, and for education and development of leading researchers in materials science, as well as to strive for advancements in materials science that provide the base for environment and energy, biology, information and communication, high-level safe spaces, and other fields at the leading edge of science and engineering, for contributions to sustainable growth of human civilization and human prosperity."

More specifically, we are working to:

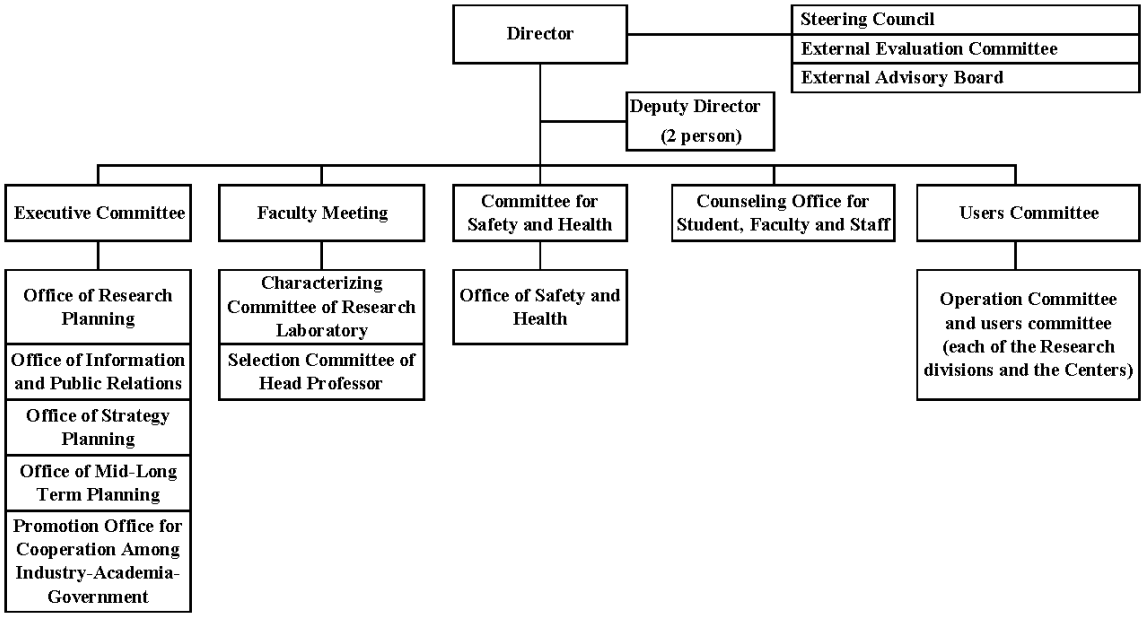
1. Create new metals and other substances and materials in a wide range as an international Center of Excellence (COE).
2. Educate and develop researchers who will advance materials science in Japan, as a core base for joint research in materials science.
3. Advance the level of applied research in environmental energy, biology, information and communication, high-level safety in life spaces, and other fields of leading-edge materials science and contribute to sustainable development of our society and human prosperity.

This is conducted by 27 research laboratories comprising four research fields of (1) Energy-Related Materials, (2) Infrastructure Materials, (3) Electronic Materials, and (4) Fundamentals of Materials Science. They are working to advance research in these fields and have constructed systems that stimulate and advance inter-field and inter-division cooperation. These research efforts are supported and external dispatch of information of achievements and internal and external cooperation in IMR research are strengthened by five research facilities, three Collaboration Research Centers, and two government projects and are supported by Administrative Office and other research support organizations. These organizations are listed in Annex 5.

3. Operation, organization and personnel, infrastructure, and budget

(1) Operating organization

The IMR operation is essentially managed with the following configuration.



In response to the national university incorporation of 2004 (Heisei 16), the IMR established its Executive Committee which facilitates strong leadership by the director. Under it, various offices have been provided to enable clear, definitive embodiment of the determinations. In correspondence, faculty meetings perform the role of a parliamentary assembly. The system provides a superior separation of deliberation and implementation, analogous to that of executive and parliamentary branches. This structure is estimable and all aspects of the operating organization necessary for the IMR activities are effectively considered and adopted.

IMR operation involves determination of the personnel, budgeting, research strategy with consideration for future of the IMR, and education. Key questions include the manner and extent to which the leadership of the director is reflected in these aspects. The leadership of the director and the IMR executives supporting the director is desirable in its effects on the

personnel, budgeting, and research strategy with consideration for future of the IMR. It is deemed key to achieving favorable results that the director, the Office of Strategy Planning, the Office of Research Planning, and other related faculty members discuss these aspects effectively and apply leadership in advancement of the operation. In this regard, the empathy of staff members for strategic determinations by the executives is crucially important. We recommend deepening the usual discourse and information sharing with the staff members. In that sense, the current customary lunchtime interchange with professors (discussing with all professors the matters for decision in deliberations at Executive Committee and obtaining consensus) and similar exchanges are of the essence. In summary, the following are particularly important for effective leadership by the director.

(I) Decisions on personnel are extremely important. Securing able researchers can indeed secure the future of the IMR. On the organization chart, the Characterizing Committee of Research Laboratory and the Selection Committee of Head Professor perform their activities under the Faculty Meeting. However, whether such operation is effective may not be so clear from the director's leadership perspective. It is of course deemed important that the abovementioned Characterization Committee, with full communication of the view of the executives (director and Office of Strategy Planning), seeks the view of internal Faculty Meeting. As an example, it is expected that adding multiple external experts to the Characterization Committee can eliminate the common tendency of large organizations for conservative movement (simply maintaining the status quo or continuity of custom), and thus enable neutral, unbiased deliberation. In this regard, it is desirable to delineate what is necessary. Other aspects relating to personnel will be noted in the description of faculty organization.

(II) Possibility of growing financial problems in future decades (annual decline in revenues from management grants. Budgeting will be described below.) is undeniable. In view of the decline, the mid- to long-range concept of future research activities together with future equipment utilization should be determined as soon as

possible and strategic measures such as reducing or constraining costs will be necessary. It will also presumably be necessary to utilize the leadership of the director to show in specific terms the research activities in view of the future of IMR (more on this in the description of research organization). In that regard, it is important to consider the level as international research institute that to be pursued by the IMR among present vigorous research activities in the U.S., China, and Europe. Elucidating the areas of superiority to top-ranking overseas research institutes will enable objective evaluation of the world level of IMR and each division. Delineation will be required in all of the above.

(III) With the rising burden on the IMR faculty for decision making such as regarding organizational operation, project, and research funding strategy, it will presumably be important to construct an organization in which URA and other research management experts can perform efficient long-range activities, and a plan for the future in that regard should be delineated.

(2) Research organization

The IMR is a leading Japanese university-affiliated collaborative research institute with a tradition of preeminent advances in research extending more than a century since the time of its initial director Kotaro Honda. It is recognized as a world-renowned core research institution for research on substances and materials. Its research organization, with deep consideration for current social circumstances and the results of internal and external evaluations, has transitioned as appropriate through establishment of new organizational modes in concert with reformation and integration of existing modes. The detailed present IMR organization (the research configuration) are shown in Annex 5 and, as previously noted, the research activities are performed in a structure comprising the 27 research laboratories (but excluding guest divisions) under four major research divisions of (1) Materials Property, (2) Materials Design, (3) Materials Development, and (4) Materials Processing and Characterization, five research facilities (International Research Center for

Nuclear Materials Science, Cooperative Research and Development Center for Advanced Materials, High Field Laboratory for Superconducting Materials, Collaborative Research Center on Energy Materials, and Trans-Regional Corporation Center for Industrial Materials Research), three Collaboration Research Centers (Center for Computational Materials Science, International Collaboration Center, and Center of Neutron Science for Advanced Materials), and two government projects (Creation of Life Innovation Materials for Interdisciplinary and International Researcher Development and Professional Development Consortium for Computational Materials Scientists) and supported by the Technical Service Center affiliated with the research support organization and the Administrative Office. The new organization constructed in the time period under current external evaluation is the Collaborative Research Center on Energy Materials established in 2015 (Heisei 27), which is a key organization for the IMR and is worthy of high evaluation for its construction. The research organization of the IMR, including the new organization which has been achieved as a consequence of historical transition. Combination of research divisions based in traditional and innovative fields and affiliated facilities and centers noted for joint usage of large-scale equipment in its main mission along with other organizations is recognized as an organization opening doors domestically and overseas which is worthy of high evaluation. It will thus attract external funding and invite interplay among different fields. The following indicates some of the paths that lie ahead for further advances in research.

(I) To cultivate new seeds generated through bottom-up research in multiple fields and bring them to blossom and fruition as future materials research, the IMR takes the basic policy of maintaining the existing small-laboratory system (four research divisions - 27 research laboratories). However, isolation of the small laboratories may occur and pose a problem if the walls between them are too high. This was noted in the previous external evaluations. It is worthy of high evaluation that in the post-incorporation mid-range plan you have therefore newly established the three priority-research fields (Infrastructure Materials, Energy-Related Materials, and Electronic Materials) and the Fundamentals of Materials Science field and, while

maintaining the four research divisions - 27 research laboratories as the base removed the boundaries and constructed a system for cooperation between the three priority-research fields with high societal needs and the Fundamentals of Materials Science field. The allocation of engineering and science faculty performed in awareness of the basic and applied dimensions of each field is also acknowledged. As noted in the previous external evaluation, however, rough clarity emerges as to which research laboratory is affiliated with which priority-research field and the state is not one in which every research laboratory tends to cooperate with each other within each priority-research field and issue research outputs actively. It can be noted that the achievements in a given field are in effect mainly limited to a collection of achievements of each laboratory. It will therefore be necessary to delineate improvements in that regard, such as constructing a system in which managers are allotted to the three priority-research fields and the Fundamentals of Materials Science field for establishment of specific field-related goals and their implementation.

(II) The established three priority fields undoubtedly exemplify the direction for future research at the IMR, but clarity is still lacking in specific subject setting. Maintaining a given number of faculties in the face of declines in available funds may represent a growing problem and therefore in that light selection and concentration of research subjects will be necessary in each field. As mentioned above, it will be necessary to formulate an embodiment of the IMR future research concept and visions in this light. Although this is extremely difficult and requires extensive rigorous discussion for that purpose, the expectation is for the IMR to delineate without fail a clear concept for future research, before the rest of the country and the world.

Clarity also seems to be somewhat lacking on the relationship between the establishment of three priority-research fields and the Collaboration Research Centers. As two examples, the relationship between the Energy-Related Materials field and the previously described Collaborative Research Center on Energy Materials established in 2015 (Heisei 27), and between the Infrastructure Materials

field and the Cooperative Research and Development Center for Advanced Materials is vague and should be set forth.

(3) Faculty organization and personnel

The prescribed number of faculty at the IMR has not changed substantially in the past five years. It was 129 (professors, associate professors, lecturers, assistant professors, research associates, and specially appointed professors/associated professors/assistant professors) as of May 2018 (Heisei 30), which was not significantly different from the 120 on the previous evaluation as of April 2012 (Heisei 24).

As previously noted, the basic faculty organization at the IMR is in four research divisions - 27 research laboratories. The faculties are affiliated with the 27 research laboratories, the research facilities and centers, and related branches, and perform research activities in accordance with the objectives assigned to the laboratories, centers, and branches. Each of these laboratories belongs to one of the four research divisions, and performs research activities primarily in accordance with the objectives of that research division and in cooperation with the other research divisions. As necessary, the faculty affiliated with the research laboratories also affiliate with and perform duties of the research facilities and centers.

These basic research activities under the basic faculty organization are pursuant to coping with the current challenges of society through the research capabilities of the IMR in designating and performing research in the three priority-research fields (Infrastructure Materials, Energy-Related Materials, and Electronic Materials) and the Fundamentals of Materials Science field. In this environment, the faculties are called on to apply their powers to the utmost to maximize the IMR's contribution to the society including their research achievements.

Each research laboratory maintains a small-laboratory system of one professor, one associate professor, and two assistant professors. Overall, 23 contract research fellows are allotted to the site. This personnel number supports the research organization of IMR comprising the research laboratories, facilities, centers and projects. This is deemed the

minimum number necessary to carry forward research in the four research fields—the number necessary to utilize the vigorous strength of young researchers while deepening the traditional research fields under excellent leadership by the professors and facilitating border-crossing joint researches. This number, however, is insufficient for extra freedom in activity, and it is therefore desirable to increase it and thereby maintain and the strength of the organization.

The organization has been successfully maintained in part by designating the terms of service for the associate and assistant professors, in addition to acquiring the employment budget and other expenses. It is difficult to assess the wisdom of discontinuing the term of service for full-professor since FY2014 (Heisei FY24), but since that time the average number of replacements has been approximately three professors per year due to retirement or transfer and four associate professors and approximately ten assistant professors per year due to transfer. These and other trends indicate the development of a constant process of voluntary researcher replacement and have raised the percentage of those aged 50 years or younger to 70% in the age structure. This program has not given rise to any problem and for the present will therefore be continued. The following findings and requests are made in light of these observations.

(I) Advancement of diversity is important for stimulating creation of innovation in research and multifaceted internationalized education. Concerning foreign faculty, the Japan Association of National Universities in 2013 (Heisei 25) composed *Further Promotion of Internationalization of Education at National Universities*, and set as a goal for internationalization of education at national universities a doubling of the proportion of foreign faculty by 2020 (Heisei 32). Concerning female faculty, the *5th Science and Technology Basic Plan* sets 20% and 15% as goals for rapid achievement proportions of females among newly employed researchers in science and engineering, respectively. In response the proportion of female full professors at national universities rose to 3.8% in science (9.3% of associate professors) and 2.1% in engineering (5.9% of associate professors) [Promotion of Gender Equality at National Universities, *Report on 14th Follow-up*

Survey, October 2017 (Heisei 29), Japan Association of National Universities], but is still described as far behind international levels in Japan and overseas. It must be noted that at the IMR the number of foreign faculty (including specially appointed faculty) has not increased at all since its level of twelve in FY2013 (Heisei FY25). In the five years from FY2014 to FY2018 (Heisei FY26 to FY30), moreover, among the 80 faculties (including specially appointed faculty) who transferred to the IMR, just 7 (8.8%) were female, and among the 79 faculties who transferred out, a larger number were female (9, 11.4%), thus leaving a smaller number and proportion. In those five years, there was just one foreign professor and no female professor. Employment of foreigners and females has severely lagged, and it must be observed that in terms of diversity the IMR has also lagged far behind the averages for national universities in science and engineering. To improve on the present state, the IMR should establish numerical targets with reference to the action plan of the Japan Association of National Universities and in accordance with the mid-range goals and plans of Tohoku University, and engage in steady implementation under the leadership of the director.

The International Union of Pure and Applied Physics (IUPAP), as an indicator for supported international conferences, requests female participation rates of 20% or higher not only as lecturers, but also as international advisory committee members, program committee members, and local organizing committee members (http://iupap.org/sponsored-conferences/conference-policies/). It is also desirable to actively survey and announce at international conferences and other events held by the IMR and the International Collaboration Center, the female participation rates in lectures and the above three committees.

(II) Have you performed retrospect on the decision to discontinue, starting in AY2014 (Heisei 24), the assignment of full-professorship terms and analyzed the present state given its implementation? Delineate the finding if necessary.

(III) Appropriate reconstruction for selection of research fields necessitated by events such as professor retirement had until now been performed in response to requests from society. However, in determining a field for a laboratory after a professor's retirement, the use of a strategic means has recently become necessary because such requests have become highly divergent, marked by non-transparency, and are rapidly changing. As one example, the time and labor consumed in analysis and review of the research field portfolio, which are performed at the Office of Research Planning and are used as an aid in the subsequent determination of a research field, may require a joint effort involving the whole of Tohoku University, and some arrangement to this end is requested.

(IV) A high proportion of assistant and associate professors who excel in research capability is essential to maintaining the requisite fluidity in the stream of researchers, and it is therefore deemed important in the personnel procedure for employing young candidates to maintain a rigorous approach to examining research capability (creativity in research). The problems inherent to the small-laboratory system may sometimes arise in personnel changes, and it is highly advisable to avoid as much as possible dramatic upheaval in the research environment and mental stress for young and mid-age personnel that can occur with change in a professorship.

(4) Research support organization

The number of support organization staff (technical, administrative, and contract office staff) engaged as of May 2018 (Heisei 30) was 148, which was nearly 100 fewer than the 225 engaged on the previous evaluation as of April 2012 (Heisei 24). The research support organization comprises the Technical Service Center, the Analytical Research Core for Advanced Materials, the Laboratory of Low Temperature Materials Science, and the Administrative Office. It also includes participation in the Electron Microscopy Center and Center for Low Temperature Science under the Tohoku University Technology Center for Research and Education Activities. These facilities and centers are particularly important

and are vital assets to the IMR and to the entire university.

Other vital links in research support are the Committee for Safety and Health, which is directly under the director and presides over safety and health, and the Office of Safety and Health with one of the deputy directors as its office director, for close and thorough safety and health management. A deputy director is also the Head of the Counseling Office for Student, Faculty and Staff (formerly the Student Counselling Office). Systems are thus in place to respond to any problem that may arise for IMR registered staff or students. Special praise is in order for the united effort of faculty and staff to aid recovery from the earthquake of 2011 (Heisei 23). Key notes include the following.

(I) Maintaining human resources and technical capabilities amidst reductions in technical staff is a major need that requires the support of all in the IMR. In particular, if the course of reductions in designated staff throughout the IMR tends to result directly in decreased technical staff of the above small facilities and centers, the activities will rapidly decrease. It is desirable to delineate the means of improvement with consideration for future personnel reductions. In that regard, it will be vital to discuss technical staffing with the main office of Tohoku University.

(5) Research institute infrastructure

Universities and their related facilities are now more fully equipped than in the past. In this circumstance, the role of collaborative research institutes is undergoing a major change but joint usage is the most practical approach for special large-scale equipment that cannot be installed at most universities. The advanced large-scale equipment of the IMR is mainly installed and operated at affiliated centers and laboratories, where it has yielded many advances. Large-scale equipment installation during the present evaluation period includes the world's most powerful (25T) steady-state high magnetic field generator in 2017 (Heisei 29) and the new MASAMUNE-IMR computer system featuring the Cray XC50-LC in 2018 (Heisei 30). These systems promise to yield new advances in materials science and bring new increases in collaborative usage. The volume of domestic and foreign collaborative

research is clearly increasing. The effort leading to this increase and their effective operation are worthy of high praise. As also noted in the previous external evaluation, some research laboratories have managed the facilities for joint usage. As typical examples, the Materials Science of Non-Stoichiometric Compounds Research Laboratory and the Quantum Beam Materials Physics Research Laboratory were respectively performing operational management for the electron microscope group in the Electron Microscopy Center and the two neutron diffraction and scattering systems on the JRR-3 research reactor in the Tokai Research and Development Center of the Japan Atomic Energy Agency. In such cases, a heavy burden may be on the laboratory researchers. The following findings are made in light of these observations.

(I) Direct operational management of advanced equipment groups by the research laboratory for joint usage in some cases has exceeded the capabilities of laboratory researchers. It is necessary in this regard to consider measures including arrangement of personnel involved in the operational management of laboratory equipment such as at the Center of Neutron Science for Advanced Materials established in the institute in April 2010 (Heisei 22).

(II) To heighten its functions and meet its many expectations, the IMR should, as a collaborative research institute, work to renew and improve its existing old and aging equipment, and delineate a strategy for annual planning and budget acquisition for that purpose. Related proposals are shown in the description on budgeting.

(6) Budget

The current budget strongly affects the principles held and goals attained by the IMR. It is a key determining factor of faculty number and institute scale. The following table shows the transition in MEXT allocation of Management Expenses Grants for labor and equipment costs since the previous external evaluation.

Fiscal year	2013	2014	2015	2016	2017	2018	Ave. percentage
Labor (billion yen)	1.9	1.9	1.9	1.9	1.9	1.8	50%
Equipment (billion yen)	2.1	1.9	2.0	1.8	1.8	1.7	50%

As shown, along with the trend of decreasing Management Expenses Grants to Japanese National University Corporations ever since their incorporation, the grants to the IMR for management expenses have declined in the past five years, with a gradual decline in the grants for equipment cost but those for labor cost remaining at nearly the same level. As a result, the grants for labor cost have risen to 50% of the revenues from Management Expenses Grants (from the previous level of 46%). In contrast, the revenues from Management Expenses Grants declined from approximately 5.1 billion yen in 2007 (Heisei 18) to approximately 3.5 billion yen in 2018 (Heisei 30). The trends in other revenues (e.g., Grants-in-Aid for Scientific Research, Commissioned Research Fund, and Joint Research Fund) during the present evaluation period were essentially as follows. Revenues from Commissioned Research Fund declined with the end of major projects led by two professors in the second half of the evaluation period but the previously noted decline in Grants-in-Aid for Scientific Research ended and in the past two or three years they have increased substantially to 600 million yen, thus compensating for the declines in Commissioned Research Fund and other sources. During this evaluation period, the Joint Research Fund and other revenues remained nearly the same. Thus, funding other than Management Expenses Grants has remained nearly constant. The amount is approximately 2 billion yen and has risen by several hundred million yen over the previous evaluation periods and before. As shown by that amount, IMR acquisition of external funds and cooperation with industry based on built-up trust are advancing steadily without being strongly affected by general economic trends, but the annual rate of decline in revenues from Management Expenses Grants is more than 1% and in the long perspective is larger than the revenue gains achieved through strong efforts, thus tending to necessitate a smaller budget. As a

result, considering the above IMR research activities and related aspects, their maintenance may be regarded as close to the edge and labor costs may weigh particularly heavily. In summary, the observations indicate the following.

(I) As noted in operating, research, and faculty organization, declining revenue from Management Expenses Grants is a major unresolved future problem. At present, the systems of excellent research and joint usage are maintained with acquisition of external funds and grants-in-aid, but it is predicted that equipment maintenance, expansion of international joint usage, measures against aging, and other aspects will require a certain cost. Thus, future decades may well bring deepening financial problems. In this perspective, it will apparently be necessary to move to formulate as soon as possible the mid- to long-range vision for future equipment usage and research activities and progress to measures for solving problems with foresight and effective planning to reduce necessary cost and smooth the way forward. These steps should be considered and delineated.

(II) It will be necessary to consider an industry-academia-government collaboration to achieve new progress and to maintain increased revenues and contributions.

4. Research activities

(1) Current state of research and planning for the future

One of the two main roots of materials research at the IMR is that on magnetic materials, starting with the development of KS magnet steel by the first director Kotaro Honda, which proceeded through the development of Sendust and amorphous alloys and has led to the present research on nano-crystalline alloys, spintronics and spin currents. The other main root is the research on iron and steel, also started by the first director Honda. That research continued with special steels, heat-resistant steel, and other metals and together with creating the stream of research on structural metallic materials led to research on other new

nonferrous, ceramic, and semiconductor materials. Based on such research history, the present research principles of the IMR are “The Institute for Materials Research (IMR) contributes to human civilization and well-being through the creation and application of truly useful materials by research on metals, semiconductors, ceramics, organics, and many others, including its compounds, composites, and structures.”

Following to these principles, the IMR performs its activities in a research organization comprising four research divisions containing 27 research laboratories, five research facilities, three collaboration research centers, and two government projects. Concurrently, to respond to the needs of modern society it has established the interdivisional and interdisciplinary three priority-research fields (Energy-Related Materials, Infrastructure Materials, and Electronic Materials) and the Fundamentals of Materials Science field and is working to advance the research in all these fields. These above organizational activities are extremely strong and have brought many advances. This research institute has in fact since its inception been recognized domestically and overseas as a world-leading base for materials research and development. The following findings and requests may be raised with the expectation of bringing further progress.

(I) This point was briefly noted in the Research organization section above, and here will be more fully described. The interdivisional and interdisciplinary three priority-research fields (Energy-Related Materials, Infrastructure Materials, and Electronic Materials) and the Fundamentals of Materials Science field can be generally recognized as directly linked to the IMR future research concept, but at the present stage remain rather vague and lacking in clear delineation. Rigorous budgetary consideration must also be performed and much discussion will be necessary for their materialization, but it is highly desirable to formulate a vision of future research and to construct and delineate the organizational mechanism for its realization. When the mechanism starts functioning, introduction of the research group (project) strongly propelling each field and of project funding from inside or outside the university that supports the researchers should be possible. What must be considered at that time is the maintenance of both basic and applied research in the IMR mission

in accord with the IMR research principles. If the IMR were to slight basic research, it would become indistinguishable from the research entities of government offices and industry. The Fundamentals of Materials Science field may be thought to exist for that reason, but it is deemed necessary to determine precisely how the results from the field will contribute to both aspects of research. In research aimed at specific engineering applications, it will be necessary to clarify the type of social need the research is to fulfill by innovation after formulating a future prospective on the needs of society. Obviously, in not only Energy-Related Materials, but also in Infrastructure Materials and Electronics, it is presumably essential to depict such a future scenario. Since aiming for a balance between science and engineering is a basic prerequisite for the IMR, it is important to avoid excessive concentration on prospects or a scenario for an application. However, it is also desirable to avoid resulting in research lacking a strategy for practical application, and to determine goals for future applications and scenarios for industrial utilization in the three priority-research fields.

(2) Research outputs and dispatch of information

Research outputs at the IMR in academic papers, presentations at conferences, press releases, patent applications, and other means is sufficient and worthy of special note. Some 512 papers (in the journal covered in Web of Science) were published in FY2017 (Heisei FY29), in a spectrum ranging from fundamental properties to applied materials, at a rate of approximately four papers per researcher. With a mean IF rating of 4.1, they rank in the world's top class of research achievements in materials science and include 27 papers ranked IF 10 or above in 13 academic journals, an indication of their high quality. The number of international jointly authored papers has increased since 2013, and in 2016 (Heisei 28) reached 43% of all IMR papers published in that year, presumably reflecting the success of the International Collaboration Center as a hub for international research collaboration. In acquisition of competitive funding, the Grants-in-Aid for Scientific Research won by the IMR have been increasing since 2013, reaching 600 million yen, a

further indication of the vitality of its research activities. It also shows the high evaluation and expectation accorded by neutral observers to research planning by the IMR. The total annual budget usage per researcher, exclusive of labor costs, is approximately 28 million yen which is equal to approximately 6 million yen per published paper. It is difficult to judge whether this represents an appropriate evaluation of cost versus result, but it appears to be a valid level for a collaborative research institute bearing the high cost of maintaining large-scale systems.

The number of patent applications, including those of both laboratories and centers, was 71 in FY2017 (Heisei FY29), which represents a sufficient industrial contribution. In summary, the findings indicate the following.

(I) In the IMR outline presented by the director to the Evaluation Committee with examples of research results in 2012 to 2017 (Heisei 24 to 29) may be seen as representative highly valued achievements. When categorized by research laboratory and center, many of highly valued achievements were issued from the Materials Property Division (17 advances from five research laboratories) and the Materials Development Division (16 advances from seven research laboratories), and comparatively few were from the Materials Design Division (one advance from one research laboratory) and the Materials Processing and Characterization Division (four advances from two research laboratories). Moreover, the project, research facilities, and laboratories brought just four advances. Research divisions and laboratories thus show a biased tendency in accomplishment of advances. It is natural to expect further effort by the head professor in each research laboratory. It is then desirable for the executives to examine carefully whether problems exist in the organizational operation and whether special measures will be necessary in this regard.

(3) Joint usage and research with domestic and overseas parties

The importance of the IMR as a joint usage/research facility is recognized domestically

and internationally, and this is worthy of high evaluation. One factor in this is its ability to learn from experience and incorporate new systems. One example is its introduction of the refereeing system for adoption, in a move to ensure objectivity. ICC-IMR which attained the 10th anniversary has hosted some 570 researchers from 37 countries—numbers quite large for a university-affiliated research institute. With these activities, the number of its adopted subjects for collaborative research has been rising gradually since 2013 (Heisei 25), reaching 446 as of 2018 (Heisei 30). The number of researchers hosted is more than 1,800 (FY2017), and thus also quite large. The number of its announced and reported advances have maintained a constant level. This is another indication of the high level of activity in its joint usage, as is its ranking of S in the FY2018 (Heisei FY30) mid-range evaluation. The IMR's provision of high magnetic-field, test-reactor, and other special test venues unavailable at other sites demonstrate its function as an institute supporting the research community of the entire country. Conversely, the IMR may be held responsible for supporting the research community and therefore need to constantly bear a certain cost (manpower and finances) necessary to maintain convenience for users and a high-quality experimental environment. Concurrently, the activities of ICC-IMR promote forthright international links and cooperation, as shown by the AY2018 (Heisei 30) selection of the IMR as an International Joint Usage/Research Center for Materials Science. IMR aims to form the materials open alliance by build bridges between Japan and other countries in this newly establishing joint research projects. It is also preparing to enrich its administrative function through coordinator establishment for hosting and employing foreign researchers. It can thus be expected to move increasingly for expansion of international joint usage and research. The following findings and requests are made in light of these observations.

(I) The Users Committee has been set to perceives joint usage and research in their entirety. And the users committee set separately for each of the research-divisions and the centers performs the actual operation on that basis. The process from adoption to implementation is clear, but a routine attitude can easily arise in joint research. It is therefore held necessary to check for progress in research results and to perform evaluation, and a system for that purpose may need to be established. In

recognition of its high value, moreover, a process for systematic maintenance of obtained research data at the IMR is without question highly desirable.

(II) Given reductions in management expenses and declines in grants, operation efforts to ensure coverage of the costs of joint usage are essential. It is also necessary to drive the expansion of knowledge among foreign users of the joint usage system and the provision of convenient accessibility for users from overseas. Securing the budget for this purpose is important for the institution, and must be considered.

(III) In the future, it is desirable to consider adopting a system that can promote a long-range joint research extending over some years with the objective of developing a system of large-scale facilities and a long-range joint research propelled by original ideas of a talented young researcher from a small-scale university who holds promise for the future.

(4) Collaboration with other departments and institutions

As described below, vigorous research activities are being performed in collaboration with other departments and institutions and are accorded high evaluation. Some of the collaborations are with the main office or other departments of Tohoku University itself. In the MEXT Nanotechnology Platform Program (2012 to 2021) (Heisei 24 to Heisei 33), IMR leadership is opening up to users its aberration-corrected transmission electron microscope, low-acceleration scanning microscope, and focused ion beam system, mainly for fine-structure analysis and providing support for research involving industry, academia, and other organizations. In another development, Tohoku University was recognized by the minister of MEXT in 2017 (Heisei 29) as worthy of ranking of “the development of educational and research activities at the world’s highest level”, and selected as a “Designated National University.” In its acceptance of this recognition, the university main office described the university conception for a future in which the IMR is assigned the role of contributing to construction of the world’s top research center in materials science and

spintronics and to advancing cooperation with society. The IMR already participates in the Materials Solution Center (MaSC, established in January 2014 (Heisei 26)), the main office organization, and has made major contributions. It is also cooperating with the MEXT Program for Leading Graduate Schools (Interdepartmental Doctoral Degree Program for Multi-dimensional Materials Science Leaders 2013 to 2019 (Heisei 25 to Heisei 31)) and contributing to the development of doctoral students as human resources and to applications for what may be termed its successor, the Doctoral Program for World-Leading Innovative & Smart Education. In another vein, it is strongly active in the Graduate Program in Spintronics and the International Joint Graduate Program in Materials Science.

The IMR is also collaborating with other research institutions in many domestic and foreign joint researches mentioned above.

The IMR, moreover, engages in collaboration through programs based on competitive funding. Examples include the Innovative Nuclear Research and Development Program (2016 to 2019 (Heisei 28 to Heisei 31)), the Building Consortia for the Development of Human Resources in Science and Technology (2015 to 2019 (Heisei 27 to Heisei 31)), and the Priority Issue on Post-K Computer (2016 to 2019 (Heisei 28 to Heisei 31)).

The Creation of Life Innovation Materials for Interdisciplinary and International Researcher Development, a project actively introducing other institutions, has been established for collaboration. The organization of this collaboration includes the IMR, Tokyo Institute of Technology Laboratory for Materials and Structures, Osaka University Joining and Welding Research Institute, Nagoya University Institute of Material and Systems for Sustainability, Tokyo Medical and Dental University Institute of Biomaterials and Bioengineering, and Waseda University Research Organization for Nano & Life Innovation. The six research institutions of these members perform joint research and development on biomedical and welfare materials and on environmentally sustainable materials. The following aspects may be of particular note:

(I) This collaborative project, the Creation of Life Innovation Materials for Interdisciplinary and International Researcher Development, includes convening of international conferences and active publication of papers and patents, but the

relationships among the six institutions remain difficult to perceive, and discussion should be held and consideration given to delineating them more clearly.

5. Educational activities

(1) Undergraduate and graduate education

As of May 2018 (Heisei 30), the IMR included 54 doctoral students in four graduate courses (Graduate Schools of Science, Engineering, Environmental Studies, and Biomedical Engineering), 130 students studying for master's degrees, and ten special research students (total of 194 students), together with enrolment of six students granted Research Fellowship for Young Scientists of the Japan Society for the Promotion of Science (JSPS) and three foreign students granted Postdoctoral Fellowship for Overseas Researchers of the JSPS. Over the past five years, the student number has not undergone large change except for the doctoral students, whose number has fallen dramatically. This decline consists almost entirely of Japanese doctoral students, as the number of foreign doctoral students has remained constant. The decline was particularly evident in the Graduate School of Engineering, where the number of Japanese doctoral students declined by half, from 40 in FY2012 (Heisei FY24) to just 20 in 2018 (Heisei 30). This decline represents a serious problem, and has decreased the number of graduate students per faculty member including assistant professors to the very low rate of approximately 1.4. This low ratio may imply very close guidance for students in development of their research capability but presents particular difficulties for the IMR, with its provision of preeminent research systems and faculty and thus an outstanding venue for student training and study in a high-level research environment. An effective means of increasing the number of graduate students is therefore desirable.

The IMR is passionate in its provision of lectures, researches and seminars for development of outstanding researchers and engineers. For doctoral students in particular, it performs practical education in a wide range of substances and materials and aggressively advances interchange with cutting-edge researchers, for example through international

conferences, while providing guidance in presenting research results in papers and obtaining their publication in internationally top-ranked scientific journals. The IMR also involves participation in Leading Graduate School Programs (the Interdepartmental Doctoral Degree Program for Multi-dimensional Materials Science Leaders (2013 to 2019 (Heisei 25 to Heisei 31)), the Graduate Program in Spintronics (from 2015 (Heisei 27)), and the International Joint Graduate Program in Materials Science (from 2019 (Heisei 31)), thus also contributing to doctoral student development. These efforts can be accorded high evaluation. In summary, the above observations lead to the following findings and requests.

(I) The marked decline in doctoral student number (and particularly the Japanese doctoral students in the Graduate School of Engineering) is a matter of concern. This trend is not unique to the IMR but is found throughout the entire graduate school. The inherently high level of research at the IMR indicates that it should never be impossible to maintain a higher number of doctoral students. Analysis of the reason for the decline in number of students entering doctoral study (and particularly Japanese students in the Graduate School of Engineering) and consideration of possible countermeasures, in other words a strategy of concerted and aggressive appeal that encourages both Japanese and foreign entry, are needed.

To raise the research capabilities of graduate students is to raise their mastery in basic subjects and in English. In educational content and lecture method, the request is to keep a place for unending discussion with the majors where the students belong.

(2) Development of young researchers

Extremely important factors for development of young researchers include spurring the growth of independent thought and creativity, stimulating domestic and international interchange between researchers, and providing financial support. One program that advanced their achievement was the Global COE (GCOE) Program adopted for 2007 to 2011 (Heisei 19 to 23). It was provided on a major basis rather than a university main-office basis, and was an extremely effective program. It included efforts to increase the number of

doctoral students and actively stimulate research interchange with overseas parties, and in FY2011 (Heisei FY23) resulted in a total of 61 individuals sent overseas and 26 foreign researchers invited and hosted. The program that followed was called the Leading Program. It was a university-wide program, and the number of doctoral students that could be supported by a single department was small. The IMR therefore engaged in its own effort for development of various aspects of young researcher development. It achieved considerable progress and deserves high evaluation. The effort included the Materials Science School for Young Scientists (KINKEN-WAKATE) aimed at giving lectures by researchers active at the leading edge both domestically and overseas and having young researchers present their research results (in English), as well as the Summit of Materials Science providing a venue for lectures by researchers in differing fields of specialization and practical training of presentation of research results by young researchers. Moreover, the IMR is involved in advancement of cross-field collaborative research by young researchers (construction of Ensemble Project for Young Researchers) for creation of germinal research that fuses different fields. Four new funds (Mirai, Yui, Habataki, Create) for support of research and education were established, based on monetary contributions received at the IMR centennial in 2016 (Heisei 28) in addition to previous activities. The following is of particular note.

(I) The funds currently available for educating the young cannot yet be deemed sufficient, and it is important to consider ways to increase them.

(3) Adult education

The IMR holds open lectures at the IMR Summer School. They release the results of materials research at the leading edge and other information to the general public and students affiliated with industrial or other institutes of research and education, for use in the future activities of the participants. These annual open lectures have set a trend for an increasing number of participants. The results of IMR research are also brought to the public through other lectures and means, to stimulate future application. These efforts are worthy

of praise. It is hoped that they will lead to increasing the number of adults holding doctorates. The following is of particular note.

(I) Delineation is desirable, concerning available directions for recurrent education (further development and growth).

6. Industry-academia-government and society-academia collaboration

University incorporation has led to a growing demand for university collaboration with industry and with regional communities. It is clear that the IMR, with its basic and applied research in materials science, has contributed greatly to progress among universities in Japan and around the world. Linking of these achievements to industry-academia-government collaboration and to contributions to regional communities will further heighten the evaluation of the IMR. A note regarding industry-academia-government collaboration in the IMR may now be made.

In 2016 (Heisei 28), the Kansai Center for Industrial Materials Research was reorganized and the Trans-Regional Corporation Center for Industrial Materials Research was founded. The Kansai Center served the Kansai area, but the Trans-Regional Center is designed to contribute to society in a larger region by linking the academic results of joint usage/research to innovation. This establishes a new IMR base for industry-academia-society collaboration and a new venue for effective liaison with the Material Solutions Center in the main office of the Tohoku University. Furthermore, four new ventures were established by the IMR since 2013 (Heisei 25) thus bringing the total number to five, and two joint research laboratories were formed in 2018 (Heisei 30), These activities can be accorded a high level of evaluation. It is hoped that further new proposals will accelerate social implementations by the Trans-Regional Corporation Center for Industrial Materials Research.

In society-academia collaboration, activities are in progress (1) in local communities centering on Sendai and (2) in the Kansai area through the Trans-Regional Corporation Center for Industrial Materials Research. In Sendai, classes, home-visit schooling held for

students and children, citizen lectures, and other events are held at (a) Miyagi Prefecture Citizens' University, (b) Katahira Festival Open House, and (c) Super Global High Schools. The citizen lectures represent valuable learning activities for the general citizenry. The Trans-Regional Corporation Center for Industrial Materials Research involves industry-academia collaboration but can also place the IMR in a historical perspective as a regional contributor to the Kansai area. Osaka business interests present commercial operations based on university findings and advances. Technical consultation and guidance are provided to small- and medium-size businesses, open lectures are held for individuals in business and industry, and support is provided for employment of IMR students. These activities are worthy of special note as practical contributions of the university to regional industry. The following in particular may be noted in this regard.

(I) It is necessary to analyze and determine the level of evaluation accorded by industry to the activities of the industry-academia joint research with the IMR.

(II) Payments by industry to the IMR seem too small in consideration of the quality, volume, and effort expended for the services provided, and it therefore seems advisable to confer with industry and set a "valid compensation standard" for the value of research effects and technologies provided by the IMR.

(III) A business support system may be necessary for achievement of a stable market position by ventures based on IMR research, and it is desirable to consider, for example, a protective measure by which payment of a license fee is on hold until achievement of the stable position and securing profit.

7. State of progress in mid-term goals and plans

Since Tohoku University was transformed to an national university corporation in FY2004 (Heisei FY16), research and education by the IMR have been performed under mid-range goals and plans with addition of fiscal year plan, implementation composition, attainment evaluation, and other aspects. In the third mid-range plan period (2016 to 2021

(Heisei 28 to Heisei 33)) the three fields of Infrastructure Materials, Electronic Materials, and Energy-Related Materials were chosen as fields of priority research at the world's highest level. Although the current state of research shows these were valid selections, some problems may exist. The desire does not seem very strong within the laboratories to achieve the mid-range goals, and collaboration among laboratories within a field seems insufficient. Further consideration seems necessary on specific subjects and their significance which have been stated in this report, but it appears that despite the problems being borne by research and educational activities at the IMR, sufficient progress is being made for achievement of mid-range goals and mid-range plans.

8. Summary and recommendations

As an international Center of Excellence for a wide range of metals and other substances/materials, and as a core base for joint research in materials science, the IMR is working toward the following goals; (1) elucidation of scientific principles and creation of new materials, (2) development of researchers who will lead progress in materials science in Japan and (3) advancement of applied research in materials science and contribution to sustainable societal development and human prosperity. To accomplish these goals, the IMR is engaged in voluminous basic research with a long-range perspective, promoting the world's highest level of research, international collaborative research through international network construction, and research that brings new forms of innovation, and functional strengthening of affiliated research facilities and joint usage/research centers. Given these goals as well as its longstanding tradition and outstanding record of achievement, the IMR may be expected to fulfill the role of a research institution that advances the national strategy of Japan. It will accordingly have the responsibility to provide the government with advice affecting formulation of the national strategy.

In the present evaluation it was found that the IMR personnel are strongly conscious of the above matters and are working in cooperation based on the leadership of the director, judged by their achievements in research, education, and contribution to society which are also at the top level in the global context. Although the response in some of the above

matters is not yet complete as noted in this report, the present evaluation differs from a systemic evaluation accompanied by penalties or awards. Its indications are given in the hope that they will be taken as representing our mission of providing the best possible advice with a future perspective based on rigorous observation of the IMR and its activities. It would be a source of humble pleasure if it is found useful and contributes even in a small way to the further development and growth of the IMR.

Furthermore, as mentioned earlier, the IMR holds the role of a research institution that supports the national strategy of Japan. It is therefore desirable to relate appropriately the place the IMR holds, in other words, how its research activities are performed in line with the national science and technology policy (the 5th Science and Technology Basic Plan). It is described, for example, as an engagement in the mode of materials science with a focus on society as given in Industry 4.0 and Society 5.0, and thus supporting the development of substances and materials through utilization of informatics technology to shorten the period from basic research to practical application, and developing research through utilization of big data. It is considered that these will be increasingly important tasks in the future. They may have already been considered, but their further discussion is desirable.

In this evaluation, the External Evaluation Committee members were asked for written responses concerning the following three aspects.

1. Leadership in the domestic and overseas research community and international visibility.
2. The form and approach that would be desirable in the future for the IMR as an international COE. What aspects should be improved for that purpose?
3. Other questions (including requests concerning the evaluation).

The responses received may be summarized as follows.

1. Leadership in the domestic and overseas research community and international visibility.

1) The IMR has already gained a reputation as a research institute at the global top level in materials science research and materials research. Together with continuing its issuance

of scientific papers and English publications with high impact and thus informing academic circles of the existence of IMR, it would also seem necessary to perform aggressive public relations using the power of a website and the media, and to place in the Administrative Office a specialist in PR including media control. For international visibility, the invitation of both domestic and foreign researchers to participate in this external evaluation is a valid measure. It maintains an internationally open window on the IMR research activities and will generally heighten international understanding of the IMR. With regard to joint usage, the Users Committee and the Operation Committee in the system seem to provide an opportunity to expand communication in the related field of research as well as deliberating on IMR joint usage operation. These committee activities together with workshops and other events can be expected to consolidate community opinion and manifest IMR leadership.

2) Since its founding, the activities of the IMR—ranging from its exploration of scientific principles in materials science to activities for the advancement of applied research—have brought it what can be judged as high international visibility as a center of global materials science. To further accelerate the growth of this visibility, it may be effective for a combination of three entities consisting of a well-known materials science research institute in a developed country, overseas private enterprise, and the IMR (for example: Max Planck Institute, Volkswagen, and the IMR) to establish an international joint research center and apply it to advancement of international joint development research that includes personnel interchanges.

3) In the perspective of building and maintaining international visibility, on the occasion of being selected as an International Joint Usage/Research Center, further growth of substantial joint research between nations can be expected. It is necessary to construct a cyclic system in which many talented researchers from overseas come knocking on the door of the IMR, and then make use of their experiences at the IMR to seek new posts and transfer to other well-known research institutions. To enable this, it is essential that advances in IMR research be further publicized overseas.

2. The form and approach that would be desirable in the future for the IMR as an international COE. What aspects should be improved for that purpose?

1) The IMR is building on its history of more than a century since 1916 by continuing to maintain a high-level approach to cutting-edge materials science research and materials development. This is most praiseworthy. Amidst widespread concern that the research capability of universities in Japan may be declining relative to the rest of the world, the high ambitions and capabilities of the research at the IMR have obviously led to many outstanding advances and IMR contact with the outside world and contributions to society have clearly grown with its program of joint usage/research. This has apparently secured its research funding, brought it stronger public recognition, and contributed to maintenance of a positive cycle. The root causes of this progress may be surmised as including: (1) setting goals at a high global level, (2) gaining and rotating outstanding researchers together with respect for the judgment of each researcher, (3) high organizational leadership, (4) collaboration with the research community through joint usage/research, (5) operation of unique research equipment and systems, and (6) collaboration with industry. Going forward, and given the limits on its funding strength, it would seem essential for the IMR to maintain strength in all these six aspects if it is to rank internationally in future with the rising strength of China or Singapore in science and technology supported by their funding strengths and national strategies. Most of all, it would seem essential for the IMR to attract and host young research talent. It will also be necessary for the IMR, rather than simply serving as a COE for metals and materials in general, to develop and apply a strategy of determining and engaging in those areas among them that will require and reward a focused strengthening. A natural part of that strategy is thought to be a focus on new research and developments in metal glass as an existing base for overwhelming research results and cumulative technological advances. Among existing problems, relevant data appear to be highly dispersed, but a promising approach may lie in simply systemizing and using the data found in existing papers for new research by new material informatics.

2) It is good to think about the balance and integration between science and engineering. In this, the scientific elements involved in construction of the microscopic properties of matter by a basic-science approach may be combined with the engineering elements of creating materials and devices useful to society, and interplay and collaboration between these two may provide the vital energy necessary to produce new streams of research. Advancing joint research utilizing large-scale equipment with distinctive features such as materials testing reactors, high magnetic-field facilities, neutrino facilities, or supercomputers, provides a venue for researcher development and for growth of the individual research field.

3) It is suggested that the IMR takes the opportunity afforded by the certification as an International Joint Usage/Research Center to construct a priority joint research network with top foreign groups in regions where the IMR is strong or relating to themes that are now scheduled for strengthening, and to promote interchange, long-term stays, and other approaches for researchers and students. It is considered to be important to narrow themes somewhat and perform prioritized top-down investment rather than receiving themes widely from the community as in domestic joint usage/research. In the long view, the ideal would be centers where talented human resources from around the world gather without distinguishing between Japanese and foreigners. For that purpose, it may be good for the IMR to consider the possibility of discovering foreign talented young researchers through close-knit joint research and employing them as IMR personnel.

4) Joint research using large-scale facilities is one of the strong attractions of the IMR, but equipment development and maintenance require funds and manpower exceeding the reach of individual group research activities. The circumstances of the neutrino facility seem somewhat difficult in this regard. With the expected reopening of the JRR-3 reactor, it would therefore seem necessary to consider strategic planning involving securing the necessary human resources and the possibility of external funding including industrial usage, while collaborating with another institute. It also seems necessary to establish a cycle in which many talented researchers from overseas can spontaneously

visit and perform research at the IMR and make use of these experiences to seek new posts and transfer to other well-known research institutions. This would provide a means of stimulating the energy of the IMR and lead to further heightening of its evaluation overseas as well as domestically.

5) The level of activity at present seems sufficient, but it might be advantageous to have domestically an organization similar to a German MPI. It is important to discuss with industry the form and content of an industry-academia collaboration center based on manufacturing, which includes industrial cooperation with the NIMS, considering the fact that steel products are still an important strategic export.

3. Views on other aspects (including operation)

1) One possible mechanism involves the establishment of a discretionary director's fund consisting of externally funding for indirect expenses of 140 million yen, or 2.7% of the 5.3 billion yen annual budget of the IMR. The director's fund might be used for a collaborative system for young faculty and researchers (assistant professor and associate professor level) from foreign universities and research institutes to reside and perform research at the IMR for several months to one year, as a means of advancing the exchange of young researcher talent, heightening the level of IMR recognition by the network of those with the experience, and further raising the level of joint research. This would comprise a policy showing the director's leadership to the university main office and to MEXT.

2) In the comments on laboratory/center and other interview content, some research laboratories did not provide a list of results shown in papers or present the results of activities. It would seem necessary to unify the understanding of the laboratory directors on content that should be presented in the interview. In particular, the progress in paper publication and obtaining funding, and other statistics on research activities, are important as reference.

3) A little more time is needed for questions and answers, and advance distribution of explanatory materials is essential.

Appendices

Appendix 1 Evaluation Parameters

Appendix 2 Evaluation Committee members

Appendix 3 Evaluation Committee on-site investigation schedule

Appendix 4 Interview by Evaluation Committee

Appendix 5 IMR Organization Chart

【Appendix 1】

Evaluation Parameters

(Evaluation Committee members from Japan)

1. How do you evaluate the current status of IMR's research activities – their strengths and weaknesses from the perspectives of domestic and international standards?
   (Evaluations of overall activities and activities in each member's area of expertise)

   <Criteria>
   - Organizational management
   - Research activities and output
   - Joint use of research facilities and knowledge, and collaborative research
   - Education, industry-university cooperation, public outreach, etc.
   - Leadership in research communities within and outside the country, and international visibility

2. What should IMR's future vision be as a global COE, and what do you suggest for further improvements for IMR to achieve the vision?

3. Comments on other matters (management/operations, etc.)

4. Comments on the content of the hearings with research divisions/centers that each member is in charge of

(Evaluation Committee members from abroad)

1. How do you evaluate the activities of IMR with respect to international standard?
   (its strengths and weaknesses)

   <Criteria>
   - Organization and Management
   - Research Activity and Output
   - Collaborative Research
   - Education, Industry-University Cooperation, Public Outreach and so on
   - Leadership in the Communities and Visibility in the World

2. What do you suggest for further improvement?

3. Other comments

Evaluation Committee members

(in alphabetical order)

Organization (Article 3, Internal Regulations of the External Evaluation Committee): The Committee shall consist of members listed in the following items.

- Experts from universities, research institutions, the private sector and other relevant entities within and outside the country

Term of Office: From the date of appointment up to the conclusion of the relevant external evaluation

*Chairperson

Dr. Thierry Duffar, Professor, Grenoble Institute of Technology
Dr. Shunichi Hayashi, Fellow, Nippon Steel & Sumitomo Metal Corporation
Dr. Burkard Hillebrands, Professor, Technische Universität Kaiserslautern
Dr. Hideki Iba, Project General Manager, Battery Material Engineering Division / Material Platform Engineering Division, Toyota Motor Corporation
Dr. Yuichi Ikuhara, Professor, The University of Tokyo
*Dr. Tomoyuki Kakeshita, President, Professor, Fukui University of Technology
Dr. Koichi Kakimoto, Professor, Kyushu University
Dr. Nack Joon Kim, Professor, Pohang University of Technology
Dr. Hiroshi Kitagawa, Professor, Kyoto University
Dr. Yasuo Koide, Executive Vice President, National Institute for Materials Science
Dr. Hidenori Takagi, Professor, Max Planck Institute for Solid State Research / The University of Tokyo
Dr. Masashi Takigawa, Professor, The University of Tokyo
Dr. Eiko Torikai, Professor Emeritus, University of Yamanashi
Dr. Shinji Tsuneyuki, Professor, The University of Tokyo
Dr. Eric van Walle, Professor, Belgian Nuclear Research Centre / Katholieke Universiteit Leuven
Dr. Hajimu Yamana, President, Nuclear Damage Compensation and Decommissioning Facilitation Corporation
Dr. Andreas Züttel, Professor, École Polytechnique Fédérale de Lausanne

【Appendix 3】

Evaluation Committee on-site investigation schedule

An external evaluation of IMR was implemented according to the following program.

(Evaluation by the committee members from abroad)

October 29, 2018 (Mon)

10:00 – 11:30 Evaluation committee meeting <Bldg. 2 Auditorium>

Overall performance of IMR (Koki Takanashi, Director, IMR)

Questions and answers

13:00 – 17:05 Summit of Material Science 2018 <Bldg. 2 Auditorium>

17:15 – 18:30 Laboratory tour

<Center for Computational Materials Science>

<High Field Laboratory for Superconducting Materials>

<Material Solutions Center> (Chiba Lab.)

October 30, 2018 (Tue)

09:00 – 17:00 Summit of Material Science 2018 <Bldg. 2 Auditorium>

October 31, 2018 (Wed)

09:30 – 11:30 Evaluation committee meeting

<Honda Memorial Hall Meeting room>

(Evaluation by the committee members from Japan)

December 4, 2018（Tue）

13:00 – 14:30 Overall performance of IMR (Koki Takanashi, IMR Director)
Questions and answers
<Bldg. 2 Auditorium>

14:30 – 15:00 Discussions on the evaluation process
<Bldg. 2 Auditorium>

15:15 – 17:45 Hearings with each of Groups A to D <Appendix 4>

December 5, 2018（Wed）

09:00 – 11:30 Hearings with each of Groups A to D <Appendix 4>

13:30 – 14:50 Hearings with each of Groups E and F <Appendix 4>

15:00 – 17:00 Evaluation committee meeting
<Honda Memorial Hall Meeting room>

17:00 – 17:30 Get-together <Honda Memorial Hall Meeting room>

【Appendix 4】

Interview by Evaluation Committee

Group A: Analytical Science, Structural Materials, Nuclear Materials

<Honda Memorial Hall Conference room>

[Committee members in charge: Dr. Ikuhara, Dr. Hayashi and Dr. Yamana]

Date	Time	Research Lab. / Center	Presenter
Dec. 4 (Tue)	15:15-15:45	Materials Science of Non-Stoichiometric Compounds (Konno Lab.)	Prof. T. J. Konno
	15:50-16:20	Nuclear Materials Engineering (Kasada Lab.)	Prof. R. Kasada
	16:30-17:00	Irradiation Effects in Nuclear and Their Related Materials (Nagai Lab.)	Prof. Y. Nagai
	17:05-17:50	International Research Center for Nuclear Materials Science	Head Prof. Y. Nagai
Dec. 5 (Wed)	09:00-09:30	Deformation Processing (Chiba Lab.)	Prof. A. Chiba
	09:35-10:05	Microstructure Design of Structural Metallic Materials (Furuhara Lab.)	Prof. T. Furuhara
	10:15-10:45	Environmentally Robust Materials (Akiyama Lab.)	Prof. E. Akiyama
	10:50-11:20	Analytical Science (Wagatsuma Lab.)	Prof. K. Wagatsuma

Group B: Environmental and Energy Materials, and Electronic Materials

<International Center of Educational Research Seminar room>

[Committee members in charge: Dr. Iba, Dr. Koide and Dr. Kakimoto]

Date	Time	Research Lab. / Center	Presenter
Dec. 4 (Tue)	15:15-15:45	Crystal Physics (Fujiwara Lab.)	Prof. K. Fujiwara
	15:50-16:20	Structure-Controlled Functional Materials (Ichitsubo Lab.)	Prof. T. Ichitsubo
	16:30-17:00	Hydrogen Functional Materials (Orimo Lab.)	Prof. S. Orimo
	17:05-17:35	Collaborative Research Center on Energy Materials	Head Prof. S. Orimo
Dec. 5 (Wed)	09:00-09:30	Physics of Electronic Materials (Matsuoka Lab.)	Prof. T. Matsuoka
	09:35-10:05	Magnetic Materials (Takanashi Lab.)	Prof. K. Takanashi
	10:15-10:45	Advanced Crystal Engineering (Yoshikawa Lab.)	Prof. A Yoshikawa
	10:50-11:20	Crystal Chemistry (Uda Lab.)	Prof. S. Uda

Group C: Condensed Matter Physics

<Bldg. 1 5th floor Conference room>

[Committee members in charge: Dr. Takigawa, Dr. Torikai and Dr. Kitagawa]

Date	Time	Research Lab. / Center	Presenter
Dec. 4 (Tue)	15:15-15:45	Theory of Solid State Physics (Bauer Lab.)	Prof. G. E. W. Bauer
	15:50-16:20	Solid-State Metal-Complex Chemistry (Miyasaka Lab.)	Prof. H. Miyasaka
	16:30-17:00	Low Temperature Physics (Tsukazaki Lab.)	Prof. A. Tsukazaki
	17:05-17:35	Physics of Crystal Defects (Onose Lab.)	Prof. Y. Onose
Dec. 5 (Wed)	09:00-09:30	Magnetism (Nojiri Lab.)	Prof. H. Nojiri
	09:35-10:05	Low temperature Condensed State (Sasaki Lab.)	Prof. T. Sasaki
	10:15-10:45	Quantum Beam Materials Physics (Fujita Lab.)	Prof. M. Fujita
	10:50-11:20	Actinide Materials Science (Aoki Lab.)	Prof. D. Aoki

Group D: Non-Equilibrium Materials, Computational Materials Science, Industry-Academia Corporation, Center of Neutron Science for Advanced Materials, Research Center PJ

<Bldg. 1 7th floor Seminar room>

[Committee members in charge: Dr. Tsuneyuki and Committee Chairperson Kakeshita]

Date	Time	Research Lab. / Center / Project	Presenter
Dec. 4 (Tue)	15:15-15:45	Non-Equilibrium Materials (Kato Lab.)	Prof. H. Kato
	15:50-16:20	Chemical Physics of Non-Crystalline Materials (Sugiyama Lab.)	Prof. K. Sugiyama
	16:30-17:00	Materials Design by Computer Simulation (Kubo Lab.)	Prof. M. Kubo
	17:05-17:35	Trans-Regional Corporation Center for Industrial Materials Research	Head Prof. N. Masahashi
Dec. 5 (Wed)	09:00-09:30	Center of Neutron Science for Advanced Materials	Head Prof. M. Fujita
	09:35-10:05	Center for Computational Materials Science	Head Prof. M. Kubo
	10:15-10:35	Professional Development Consortium for Computational Materials Scientists	Project Leader Specially-appointed Prof. T. Mohri
	10:40-11:10	Creation of Life Innovation Materials for Interdisciplinary and International Researcher Development	Project Leader Prof. H. Kato

Group E: High Field Laboratory for Superconducting Materials, ICC-IMR

<Honda Memorial Hall Conference room>

[Committee members in charge: Dr. Takigawa, Dr. Koide, Dr. Kakimoto, Dr. Torikai and Dr. Tsuneyuki]

Date	Time	Collaborative Use / Center	Presenter
Dec. 5 (Wed)	13:15-14:00	High Field Laboratory for Superconducting Materials	Head Prof. H. Nojiri / Prof. S. Awaji
Dec. 5 (Wed)	14:05-14:50	International Collaboration Center	Head Prof. G. E. W. Bauer

Group F: Collaborative Use of Research Laboratories, Cooperative Research and Development Center for Advanced Materials

<International Center of Educational Research Seminar room>

[Committee members in charge: Dr. Ikuhara, Dr. Hayashi, Dr. Iba, Dr. Kitagawa and Dr. Yamana]

Date	Time	Collaborative Use / Center	Presenter
Dec. 5 (Wed)	13:15-14:00	Collaborative Use of Research Laboratories	Head Prof. K. Fujiwara
Dec. 5 (Wed)	14:05-14:50	Cooperative Research and Development Center for Advanced Materials	Head Prof. T. Furuhara / Prof. N. Masahashi

IMR Organization （2018.10.1）

※ Laboratory of Visiting Professor