Joachim Bill, Fumihiro Wakai, Fritz Aldinger (Eds.)

Precursor-Derived Ceramics

Synthesis, Structures and High Temperature Mechanical Properties

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Weinheim · New York · Chichester
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Preface

The preparation of inorganic materials by thermolysis of preceramic compounds has gained substantial interest during recent years. The general idea of this process route is that elementorganic precursor molecules already contain structural units of the residual inorganics formed by thermolysis, thus providing novel paths of controlling composition, atomic array and microstructure of materials. Of special interest is the manufacture of amorphous or nanocrystalline covalently bonded inorganics on the basis of silicon, boron, carbon and nitrogen, revealing a potential of properties not known from conventionally prepared materials. In order to develop a sound basis for a successful use of such materials and to judge their potential for application, there is a need for profound basic research in the field of their synthesis and processing and in the characterization of their structure and properties.

It was with this intention, when in 1995 the Japanese Science and Technology Corporation (JST) and the Max-Planck-Institut für Metallforschung (MPI-MF) signed a five-year contract for the cooperation on the synthesis of nanostructured materials by precursor thermolysis and the investigation of their superplastic behavior. It is the aim of this international cooperation to combine studies of elementorganic chemistry, materials processing and materials characterization in order to tailor the microstructure and thus the properties of covalent materials. Of special interest are nano-grained materials and their mechanical properties at high temperatures and to study superplasticity and other dynamic grain boundary phenomena. This cooperation is the most recent item in a long lasting and fruitful cooperation of the Max-Planck-Institut für Metallforschung and its representatives together with Japanese scientists and institutions active in materials research. In the light of this cooperation an international workshop on Grain Boundary Dynamics of Precursor-Derived Covalent Ceramics was arranged in order to present the status quo in the field of precursor-derived materials and to discuss the mid-term results in this project with the worldwide leading scientists in this research field.

As directors of this cooperation project on the German and Japanese side respectively, we would like to take the opportunity to thank the Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V. and the Japanese Science and Technology Corporation for their generous support of the joint research programm. We also would like to thank all the scientists who participated in the workshop for their contributions to the scientific presentations and discussions. We would like to express our special thanks to Dr. W. Hasenclever, former Secretary General of the Max-Planck-Gesellschaft, Dr. J. Roemer-Mählcr (Bundesministerium für Bildung, Forschung und Technologie, BMBF) and Professor Dr. Dr. h.c. mult. Günter Petzow, Emeritus of the
Preface

Max-Planck-Institut für Metallforschung for their introductory contributions on the globalization of research and Japanese-German Research Cooperations.

The organizers of the workshop gratefully acknowledge the financial support given by Deutsche Forschungsgemeinschaft (DFG), Bonn/Germany; Dr. Ernst-Rudolf-Schloeßmann Stiftung, Germany; Japan Science and Technology Corporation (JST), Japan; Max-Planck-Gesellschaft zur Förderung der Wissenschaften e. V. (MPG), München/Germany.

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I. Globalisation of Research
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Globalization of research is the title, which the organizers of this workshop have given to this morning's opening session. Globalization has become a very fashionable term:

- globalization of production,
- globalization of learning,
- globalization of trade, of criminality, of pollution, of communication etc. etc.

And this morning we are to discuss globalization of research! Globalization of research, is this really a controversial issue? Hasn't research, hasn't science, used in the German sense of „Wissenschaft“ i.e. including social sciences and humanities - hasn't research always been universal, global, international? Is there really any room for making it so, to universalize, to globalize, to internationalize research? The spontaneous answers of most of us will be negative!

And yet, the relationship between national, regional, transnational, multinational, universal research has been a subject of discussion for quite a time, not only among politicians or in the media, also among scientists. Globalization is just a new, a fashionable word which draws our attention to the fact that new, modern means of transportation and communication give a new intensity, a new quality to the well-known worldwide interaction among people and institutions of research - normally regardless of borders and without reference to expectations of particular loyalties for political, institutional or economic reasons.

But research is - like most if not all human activities - a social phenomenon, i.e. something that happens not in the famous isolated ivory tower, but in interaction with its environment. Pure thought, of course, the creative process, knowledge as such might have little social relevance, is neither national nor international. Research, however, is quick to transcend its bounds of utter intellectuality and individuality. Research takes place within a social context. It is conducted by individuals, but it occurs on the basis of knowledge that has been acquired and passed on by others. Science is communication, it needs collaboration and discussions with others. Knowledge transfer, competition, application of research results, also the contrary: the dissemination restrictions by patents or for military reasons reveal the societal context of research.

Research as a social phenomenon is not only exchanging information with its environment, it also needs encouragement, support and protection by the society. Research, at least research in the 20th century, depends on favorable institutional structures, on appropriate labs, big facilities, a good educational system etc., i.e. it depends on access to resources and research activities need legal boundary conditions
and arbitration in case of conflict with the interests, goods, values of individuals or of
the general public surrounding the research activity.

With respect to these interactions of research with its social environment it is only
natural and justified to distinguish between national and international and to discuss the
consequences of shifting responsibilities and addressing expectations from one
community to another.

This is not a theoretical question and we are not free to choose one or the other option.
The trend to more internationalization and globalization is irreversible, is a fact. It is
obvious for industry as a result of hardly controllable market forces.
Globalization of industry research, the subject of the next presentation, is confirmed by
relevant statistics (of Physics World 10/96):

"Germany looks abroad
Since 1990, German companies have
increased their investments in R&D
by 50% - in overseas R&D, that is.
But domestic investment has declined
rapidly from 2.1% of the gross
domestic product in 1989 to 1.5% in
1995. Over the last five years, more
than 30000 jobs in R&D have been
cut or moved abroad, and about 32000
scientists and engineers are
unemployed. 15% of R&D spending
by German companies now goes
overseas, most of it to the US."

But coming back to the field of non application oriented, of curiosity driven research it
has always been understood, that it is only quality of results, that it is only the world
wide recognition of the validity of results that count.

- In so far so-called fundamental research has always been international and global.
The international and global character of fundamental research is not controversial,
and when I have been invited by Professor Aldinger to talk to you this morning on
Research between nationality and internationality he wanted me to report on a
pertinent discussion in Germany which centers around the question wether the
reality, the way in which nationality and internationality of research correlate today
is the best reality possible. The Max-Planck-Gesellschaft dedicated two 2 .5 days
long colloquia here at Ringberg Castle to this issue. In 1995 MPG invited
representatives of its most important partners in the very pluralistic landscape of the
German system of research institutions and research supporting agencies:
- representatives of the Hermann von Helmholtz-Gemeinschaft deutscher
Forschungszentren HGF the association of the big national labs working in the field
of new energies, health, environment etc.,
Research between Nationality and Internationality

- managers of the Fraunhofer Gesellschaft FhG, which concentrates on applied research and technology transfer,
- the president of the rectors' conference of the German universities,
- the Chairman of the Wissenschaftsrat, a forum for the discussion of science policy questions among politicians, administrators and scientists and also a platform for the adjustment of interests among the federal government and the 16 Länder governments which according to our constitution share the political responsibility for research promotion and the educational system.

As part and a very important part of internationalization of research happens through the exchange of people (students, postdocs, guest scientists),
- the Alexander von Humboldt-Foundation, AvH,
- and the Deutsche Akademische Austauschdienst, DAAD, the German student exchange organizations,

were given opportunity to present their views.

And last not least our ?national science foundation" the Deutsche Forschungsgemeinschaft, DFG, actively participated in the discussion.

MPG and all these institutions presented their experiences and views and participated in this exercise to gain more consciousness of the consequences of this permanent and accelerated evolution to more internationality in research and education.

- What are the advantages?
- What are the disadvantages of this development?
- How should the scientific system react or rather not only react, but try to participate actively in coping with the challenge of inevitably growing internationalization?

Origin for the actuality of this discussion in our country and in Europe has been the Maastricht treaty, which stipulates new competences for the Brussels Commission for research issues and science policy questions.

I cannot deny, that the concern of the German research organizations is consciously or rather unconsciously part of the general feeling of uncertainty with respect to the consequences of the politically decided, partly welcomed, partly feared, partly supported and partly resented evolution to more European unity.

There is a general distrust about the growing bureaucracy in Brussels, there is fear that too much Deutschmark becomes European ECU or EURO and there is serious concern that in distributing the money political criteria like ?juste retour", ?cohesion" etc. replace criteria of quality and competition. There is a also general complaint about too little transparency in procedures, lack of impartial reliable peer review. In short: the research policy of the European Community is perceived as having too much top down approach rather than bottom up inspiration.
In this respect the German scientific community is particularly sensible because we realize that - compared to the situation in most countries around us - we are still in a very favorable position.

In the context of the world wide and again and again upcoming discussion of the "eternal" question concerning an appropriate balance between application oriented or curiosity driven research the German system allows still much room for the latter element, considering fundamental research and the definition of its programmes by the scientists themselves as a long term investment and an indispensable condition for real innovations not for tomorrow but for the time after tomorrow.

This situation is, of course - also in our country - not undisputed and we see the risk that the unequivocal orientation of European research policy toward economic targets might influence and strengthen corresponding tendencies in Germany.

As we know that our neighbours in Europe and practically all our essential partners in the world have the same or rather similar problems, MPG decided to have a second colloquium in order to include in this discussion experience from abroad.

In 1996 MPG invited its foreign partners, not only from Europe, like
- Guy Aubert and Francois Kourilsky, president and past-president of the CNRS in France,
- Hubert Curien, former French minister of science and member of the MPG senate,
- Richard Brook from the British Research Councils (by the way, for some years in the eighties director in this institute MPI fuer Metallforschung in Stuttgart),
- Jan Borgman, chairman of the European Science and Technology Assembly (ESTA), but also
- Neal Lane from the U.S. National Science Foundation (NSF) and
- Minoru Oda from Japan.

All of our illustrious guests were aware of the growing globalization and they discussed with scientists and managers of the German institutions, which had met the year before, many aspects of this situation:
- advantages and disadvantages,
- expectations and risks,
- obstacles and supporting mechanisms,
- national experience and future trends,
- setbacks and challenges of the internationalization of research.

It would go beyond the scope of an introductory presentation if I would try to report on this exchange of ideas, hopes, fears and experiences in detail. The proceedings of the meeting will be published soon and can be made available to anybody of you who is interested.

But I'll try to give a short resume in saying that from the two aims of these colloquia:
- to reach a common understanding how nationality and internationality of research interact
- and to find a science oriented common strategy to optimize this relationship,
only the first has been attained. Diagnosis is always easier to agree upon than on therapy.

During these discussions at Ringberg in 1995 and 1996 nobody expressed the faintest doubt, that methods and contents of research do not possess a national character - that they are international. There was, also, a general understanding that it is the researcher's competence and not his or her nationality which counts. Internationality is in this respect the only possible and undispensable boundary condition for permanent competition, and it is internationality that provides the only valid standards and criteria to discover and guarantee quality.

And yet, in spite of this, it is in the correlation between research and society, between science and political authority where we encounter a wide array of national elements.

In this relationship between research and its social environment, the predominant representatives of society are still the national governments which - and here I quote Hans F. Zacher, the former president of the MPG and spiritus rector of these two Ringberg colloquia - there are the national governments, the national legislator which relate to research in three different ways:

- either in that they make research possible
- or put research into their service
- or restrict research.

Government does so by establishing the structures of research, by entrusting the system with resources and in cases where freedom of research conflicts with other interests, goods and values by defining its scope of freedom.

It is also the state which in general defines the expectations concerning the return on these investments. Such expectations may be of a general cultural nature, conceived as contributions to more and better understanding and knowledge. But in general expectations take on very concrete forms directed towards the solution of specific problems, problems of economic; industrial, educational, in general problems of a socio-political nature.

In spite of the international character of science as such it is national predominance that coins the day to day reality of research.

Features of a particular scientific system,

- idiosyncrasies rooted in the culture and the civilization of a country,
- the geographic situation,
- common language,

all these factors are apt to establish common bonds which enhance the significance of national frontiers to science. A state may promote or obstruct the communication and mobility of researchers. And then there are unintentional obstacles deriving from national legislation e.g. in the domain of fiscality, of social security, last not least legislation on the protection of intellectual property, which - though they do not eliminate the mobility and the communication of researchers, nonetheless demand often a considerable compensation to be paid for.
Let me repeat: As long as research is viewed as a quest for new and more knowledge, i.e. as much as research per se is international in nature, research as a social phenomenon is predominantly national.

There was a general agreement without much discussion that more internationality in research as such would always bring more benefits than disadvantages.

Internationality of research in this sense is rather an indispensable boundary condition than an obstacle for excellence in science.

In economics, in the industrial world it has already become evident that globalization leads inevitably to a redistribution of work, of employment and of wealth. Industry has been realizing this for some time and even politicians have become aware that the notion of a national economy as an object of government control and influence has become more and more obsolete.

Competition among global players reduces the role of governments to petitioners, offering all kinds of bribes, called favorable site conditions, in order to convince potential investors to choose their country for the creation of new employment.

In this context the reputation of a country's research and educational system is valued as an essential asset and it is in this meaning of research as a social phenomenon where the growing internationalization leads to a considerable potential of conflict, worth to be watched and influenced by the scientific community on a national as well as on an international level.

During the discussion of these questions in Germany, a discussion which has been called „Standortdiskussion“, the contribution of science to improve the attractiveness of a German site for industry has concentrated very much on the aspect of a good research capacity as the potential for technology transfer.

This question of more or less successful technology transfer is unfortunately and wrongly considered as the most obvious manifestation of return on investment for research as a social phenomenon.

I fully agree on the importance of this issue, but it is futile to reduce this discussion on the question whether there should be more or less application orientation in research and it is to my mind even contraproducive to try to cope with the problem by subordinating research to short term economic aims within programmes defined by politicians and industry without due and appropriate input from the scientists.

If you reduce the meaning of the national research system for economic competitiveness on its success in technology transfer another considerable danger is that such an understanding will strengthen tendencies to more seclusion and counterproductive if not deadly isolation. We have witnessed extreme cases in totalitarian systems. But the danger also exists in our liberal democratic societies: I only
remember of the information restriction policy of the Reagen administration at the time of the SDI effort.

It was obvious in all presentations during the last Ringberg colloquium that in all countries which were represented and reported from and especially in the framework programmes of the European Community the top-down approach has gained considerable weight and has become the dominant factor for Research promotion. All national science communities were concerned and engaged to defend the diminishing room for science driven elements within those programmes.

As I mentioned before, the Ringberg colloquia have not led to a well formulated common strategy how to optimize the interaction between nationality and internationality in research and science. But I dare to point to some generally accepted and confirmed essentials, which constitute important elements for a strategy in a national as well as on an international level:

1. Globalization of science has always been considered by the scientific community as an indispensable stimulus for competition.
2. The best return in investment in research and science is excellence. Competition is a strong driving force; it is essential to be considered among the best worldwide.
3. Standards of quality only count if they are formulated and recognized on a global level.
4. Interaction between nationality and internationality in research as such poses no problem. It should be promoted by a continuous exchange of information and people bilaterally or within multilateral networks.
5. Of general concern of the scientific community is and should be the growing tendency of government as well as of international institutions to overemphasize expectations of short term results and define expected results in place of unresolved problems as domaine of research.
6. The contribution of a successful and recognized national science community to the competitiveness of a national economy should not be judged on the merits of direct technology transfer successes only. The quality of research has its most important impact as integral part of the countries educational system. This simple truth, by the way, has been known and formulated ever since the beginning of the last century as the so-called Humboldt principle which has guided the formation of the university systems in Germany and in many other countries around the world.

The real return on investment in research consists of its contribution to create the potential for solving problems of the sponsoring environment, it consists in producing imaginative and creative people, in fostering their talents for the solution of societal problems of all kinds. To solve these problems innovations are needed in technology as well as in the fields of health, environment, agriculture, education, international relations etc. etc.

I think, we must realize that the trend to more and more globalization also includes a trend to more and more globalization of problems, which need global solutions. This insight can be taken as a favorable basis to reconcile the advantages and disadvantages
of a stronger internationalization of research in its social relevance for the still predominantly national environment of research promotion.

At Ringberg Castle in May 1996 one of the last contributions of the debate came from Neil Lane, Director of the U.S. National Science Foundation NSF, under the title „Erasing the boundaries but retaining the identities.“ „By erasing the boundaries“, he said „I mean recognising the perspective to define those unsolved problems larger than scientific disciplins that are common to all peoples that scientific cooperation can and should adress.“

And by retaining the identities I acknowledge a recognition that most things get done by local and regional collaborations which take advantage of the unique cultural qualities of all participants. By means of this delicate balancing we can hopefully define a global agenda for scientific research with clear overarching direction in which all of us have a role and a responsibility.
Globalization means worldwide interdependence, division of labour and exchange of information within the business and science communities.

The globalization process requires both individuals and institutions to develop a high degree of internationality, that is the ability to cooperate across national and cultural borders and to set up new efficient organizations.

I. The German Government's position

In this report to the Cabinet on globalization, the Federal Minister of Education, Science, Research and Technology stated on 2 September 1996 that within the close-knit world economic system of the 21st century only those countries will be able to hold their ground which, on account of their openness and the competence of their human resources, have become centres of information, communication and application of knowledge.

Germany's high performance in the fields of science and research as well as its ability to develop and apply advanced technologies are its most important resources, which it should use wisely and strive to improve continuously.

A new government policy with regard to science and technology should, therefore, not be confined to setting up an efficient science base and providing funds to encourage the development of new technologies, but must endeavour to ensure the necessary feedback between research, development and innovation as well as the integration of various policy fields which influence the innovation process.
Consequently, cooperation with scientific and business experts abroad is important for a successful science and technology policy. Exchanges of students in higher education and scientists is an important basis for such cooperation, think, it is alarming news to find that German universities, while still enjoying a worldwide reputation for scientific excellence, have lost some of their international attractiveness, with more students now going to other countries with highly renowned universities.

As a country with high export figures and a science-based economy, Germany must ensure international access to and the attractiveness of its education and research systems.

The Federal Government therefore promotes cooperation with other countries.

The German Government or the research establishments and project management agencies it supports are members of more than 30 multilateral research institutions, and have concluded bilateral agreements on scientific and technological cooperation with more than 50 countries.

The number of cooperation agreements signed by German and foreign institutions of higher education by far exceed 6,000. In addition, there are numerous European, and other bodies, e.g. those set up by OECD, UNESCO and the Council of Europe, in which scientists as well as government officials jointly discuss important issues, moving forward to solve relevant problems. Together, all these bodies form a close network of cooperative relations in science, research and education, which has, 'in Europe in particular', resulted in a collaboration environment which may well be unique in the world in terms of intensity, strength and variety of subjects covered.

II. Strategies

With the slogan "Internationalization of German science, education and training", BMBF has decided to provide impulses to strengthen Germany's ability to cooperate and compete in the world against a background on increasing globalization.