Smart Materials

Implementation Plan
of the National Research Programme NRP 62

Berne, 3 November 2008

FNSNF
Swiss National Science Foundation

Contents

What are National Research Programmes (NRP)?

The research carried out by National Research Programmes consists of targeted research that contributes to the solution of contemporary problems of national importance. Under the provisions of Article 6, paragraph 2, of the Law on Research of 7 October 1983 (as of 25. February 2008) the Federal Council selects the topics and foci to be researched in NRPs and mandates full responsibility for implementing the Programmes to the Swiss National Science Foundation (SNSF, Division IV).

Article 4 of the Federal Ordinance on the Law on Research of 10 June 1985 (as of 1 April 2008) describes the purposes and contents of NRPs as follows:

«[1] National Research Programmes are a means to direct and support coordinated research projects that have a common goal. Where needed, National Research Programmes should strengthen scientific research capacities.

[2] Topics of research are appropriate for National Research Programmes if, in general,

- *a. scientific research on the problem is of national importance;*
- *b. Swiss research can make a significant contribution to the resolution of the problem;*
- *c. solutions require research contributions from multiple disciplines;*
- *d. the research goals cannot be met exclusively through basic research, through research within a specific section of the administration, or through industrial applications research;*
- *e. research on the problem can be expected to produce research results that have practical applications within a five-year time period.*

[3] The following criteria should be taken into consideration in setting forth the topics of National Research Programmes:

- *a. the programmes can provide the scientific basis for decision-making by government and the administration;*
- *b. the programmes can be conducted with international collaboration and are also of great interest to Switzerland.»*

1. Summary

Materials with novel properties and intelligent combinations of materials are a key to innovation in several fields of strength of the Swiss industry and of its export orientation. Materials have characteristic physical, chemical, biological and engineering properties. Many of these properties are sensitive to external parameters such as temperature, chemical or biological environment, physical forces and electric and magnetic fields. For many traditional applications of materials it was a challenge to overcome or at least limit or compensate that dependence of the materials properties on external parameters. Sensors and measuring techniques, however, use that effect of external parameters on the materials characteristics to create a signal response. With adaptive materials we use that effect of external parameters to adapt a material or material combinations to reach an auto-control of a process with an actuator. With the National Research Programme 62 “Smart Materials” (NRP 62) one now seeks to go far beyond these traditional approaches and develop novel smart materials that are capable of responding with highly selective and reversible property changes to external stimuli. Such “smart” materials play the role of both a sensor and actuator, regulated by a continuous and simultaneous feedback.

NRP 62 promotes the design of new adaptive materials, their synthesis and the investigation of their e.g. electro-magnetic, thermomechanic, optical or biocompatible properties as a function of specific external stimuli. It will not only stimulate the development of combinations of materials for new functionalities, but also the modelisation and simulation of their properties. A particular emphasis will be given to the development of applications with a focus on the following sustainable needs of the society: energy, mobility and environment, engineering and functional materials, health, including aspects of safety & security. This development of new adaptive materials and intelligent systems based on novel microscopic and macroscopic properties and fostering multi-scale and interdisciplinary work between physics, chemistry, biology and engineering will strengthen the exploitation of the innovation potential by Swiss industry and society.

NRP 62 will operate with a total funding of CHF 11 million and is implemented as a cooperative programme between the Swiss National Science Foundation (SNSF) and the Innovation Promotion Agency CTI. The SNSF-funding of the research projects will be based on two phases, where in a first period of three years projects will be selected primarily based on their scientific quality. In the second phase only those projects of the first phase with a high potential for applications and successful transfer will then receive financial support by SNSF for another two years. Furthermore, the programme also foresees a third phase under the auspices of CTI where successful projects of the first and second phase shall be transferred to industrial R&D collaboration projects supported by CTI.

2. Introduction

2.1 Background

The use of materials and materials combinations in bulk, surface, film/membrane, powder and various other small structures is primarily based on the specific properties they possess under these conditions. An important recent development has been the discovery that materials can reach particular and novel properties due nanostructuration and quantum phenomena. However, these characteristic physical, chemical, biological and engineering properties of materials and systems are frequently susceptible to changes of the physical, chemical and biological environment, i.e. they respond to external stimuli. This susceptibility might appear as an annoying effect (e.g. dilatation and bending of railway tracks in a very hot summer) or as a technically useful advantage (dilatation and bending of a bimetal thermal switch). For many traditional applications of materials it has been a challenge to overcome or at least limit or compensate this dependence of the materials properties on external parameters. Sensors and measuring techniques on the other hand use the effect of external parameters on the materials characteristics to create a signal response. Other areas where the effect of external parameters on materials properties are already actively used include the application of adaptive materials or materials combinations as actuators in order to reach an auto-control of a process. Why should one not go one step further and invent materials with a particularly strong, even radical response of some specific materials properties to stimulating external parameters that could then be used in order to create smart structures capable of automatically adapting to changing environmental conditions and possessing both sensing and actuation capabilities?

It is here where the National Research Programme 62 “Smart Materials” (NRP 62) intends to initiate a major development. The innovation potential of adaptive materials clearly is very large, in particular when adaptive materials are combined with other materials into smart/intelligent structures and systems of highly specific functions. Mastering materials with novel properties and intelligent combinations of such materials can give a key competitive advantage to Swiss industry, in particular in industrial sectors such as watch, machine and electrical equipment, med-tech and pharmaceutical, and energy and building technologies industry and thus strengthen their global competitiveness.

In view of these opportunities, the Swiss Federal Council decided on 28 November 2007 to launch NRP 62 and the Swiss National Science Foundation (SNSF) was mandated with its implementation. For the planned duration of five years, NRP 62 operates with a total funding of CHF 11 million. The National Research Council elected a Steering Committee and mandated it with the elaboration of the present Implementation Plan based on the programme draft (SNSF, August 2007) and the feasibility study (SNSF, April 2007). The Steering Committee began its work on 3 July 2008. The Implementation Plan has been approved by the Head of the Federal Department of Home Affairs on 17 October 2008.

In the framework of NRP 62, visionary research combined with innovative applications, using interdisciplinary approaches, should lead to the successful research and development of new smart materials, i.e. to high-performance materials which have special functions and react adaptively and reversibly to changing environmental stimuli. In order to take into account the scientific requirements and the distinct practical orientation, the NRP 62 will be implemented and operated as a cooperative programme between SNSF and the Innovation Promotion Agency CTI.

The NRP 62 simultaneously addresses researchers from natural and engineering sciences as well as from life sciences, this means physics, chemistry, materials science, biology, pharmaceutics, medicine, environmental science and engineering, mechanical engineering and electrical engineering.

2.2 The research field on the national and international levels

Switzerland is well prepared for the launch of a focused programme on smart materials. Preparatory work in various completed programmes (e.g. NRP 47 "Supramolecular Functional Materials", TOP NANO 21) has led not only to increased scientific competence but also to fundamental building blocks of smart materials.

A significant number of Swiss research groups of high international standing, at the institutes of the ETH-Domain, the science faculties of the universities, and the universities of applied sciences, focus part of their research efforts on smart materials. Switzerland's potential in smart materials research and applications is highly promising. This is documented by the following institutions and special ongoing or starting initiatives:

- National Centre of Competence in Research (NCCR) "Nanoscale Science";
- National Centre of Competence in Research (NCCR) "Materials with novel electronic properties" (MaNEP);
- National Research Programme NRP 64 "Opportunities and Risks of Nanomaterials" (to be started in 2009);
- Competence Centre for Materials Science and Technology (CCMX) of the ETH-Domain;
- nano-tera.ch – the Swiss initiative in engineering and information technology for health and security of the human being and the environment;
- Swiss Nanoscience Institute (SNI) Basel;
- Micro- and Nano Science Platform ETH (MNSP); Materials Research Centre ETH (MRC);
- Adolphe Merkle Institut (AMI), Fribourg Centre for Nanomaterials (Frimat), Freiburg.

On an international scale, research in this field is evolving rapidly. Various industrial nations have recognised the future significance of smart materials in science and technology and are actively promoting research within special programmes, such as:

Europe: Research on materials was an important topic in the sixth framework programme (FP6), and it continues to be so in FP7. Although the subjects "functional materials", "multi-functional materials" and "smart materials" appear explicitly in the calls and in the project descriptions, the orientation of this research is rather in the direction of materials with application-specific properties which are pre-defined and do not change as a reaction to changed parameters. Surprisingly, the same is true for the research roadmap worked out by the European Technology Platform ETP-EuMaT, concentrating instead on “novel multifunctional materials for multisectorial applications in highly demanding operational conditions”. As a consequence, the preferred basic materials are intermetallics, metal-ceramic composites and functionally graded materials/functional multilayers.

It is concluded that on the European level, materials research programmes do not put particular emphasis on “smart materials” as targeted in the present NRP, where the “smartness” lies in the capability of the materials to react adaptively – and often reversibly – to changed parameters and environmental conditions.

Germany: Several German funding organisations for basic and applied research have addressed the growing need for the development of smart materials in very different applications such as microfluidics, actuators, biosensors, engineering materials, energy technology and med-tech. A comprehensive call similar to NRP 62 combining the entire range of life and materials sciences does not exist yet. The German Research Foundation (DFG) has initiated several priority research programmes where specific smart materials, tailored for special applications, play an important role, among them e.g. smart hydrogels, electro- and magnetorheological microfluidics, and nanostructured thermoelectrica. Both DFG and the Federal Ministry of Education and Research (BMBF) are funding research on adaptronics for engineering applications. Adaptronics and smart materials continue to be a prominent research topic of several Fraunhofer institutes. In 2004, the German Foundation for Industrial Research has initiated funding of “Smart materials for innovative applications” including research on adaptive polymers, cell chips and optical devices. The BMBF-funded priority programme WING „Materials innovations for industry and society” which has started in 2004, has been aimed at combining materials science with chemical engineering and nanotechnology in order to create multifunctional materials. The WING topic “Smart materials – control without electronic control” is listed among the top ten WING research topics. In 2008 BMBF has announced funding of smart materials such as electroactive polymers and thermoelectrica within the framework of WING.

France: The French “Agence Nationale de la Recherche” (ANR) launched 2006, 2007 and 2008 materials science and technology oriented programmes. The 2008 call is entitled “Programme Matériaux Fonctionnels et Procédés Innovants” and includes in the module “Fonctionnalités et matériaux associés” smart materials.

Japan: The New Energy Development Organisation (NEDO) initiated a five year research and development programme on smart materials which was finished in 2005. Several new materials for sensing devices including carbon nanotubes resulted. The experience was made that the generation of a strong response, strong enough not only for sensing, but for actuating, remains the difficult task. The National Institute for Materials Science (NIMS) continues its development efforts.

USA: In contrast to the European framework programmes, both of the two major funding organisations for basic and applied research in the United States – the National Science Foundation (US-NSF) and the Defense Advanced Research Projects Agency (DARPA) – stress the importance of adaptive smart materials. Corresponding research proposals are explicitly encouraged in many of the current research programmes, relating to engineering, chemical, manufacturing, physical, biological and materials sciences, as well as in civil and mechanical engineering. However, the US-NSF has not yet tried to focus interdisciplinary research in smart materials on this particular topic; rather research funding occurs fairly independently in the various directorates.

The situation is different, however, for DARPA: Because of the many potential military applications of smart materials, two important programmes treat this subject as a research theme in its own right, namely the Smart Materials and Structures Demonstration Programme and the Compact Hybrid Actuators Programme. A wide range of applications are being investigated, covering such diverse topics as torpedo quieting, adaptive smart ("morphing") wings, muscle-like materials, smart fluidic valves and electro-active soft polymer actuators. It is acknowledged that "while the efforts so far in smart materials and structures have been impressive, they have just scratched the surface". For this reason, DARPA is continuing its research investment in fields that will have a direct or indirect impact on smart materials.

NRP 62 should clearly benefit from international links and the integration into an international network on project as well as programme level thus is of high importance.

3. Goals of the research programme

The current NRP 62 is a notable and unique cooperation programme between SNSF and CTI; it strives not only for scientific excellence but also for success in the industrial exploitation of smart materials and their applications. Owing to an early involvement of industrial partners, an interactive relationship between scientific insight and practical application will be achieved, replacing the more traditional linear-sequential transfer of projects.

The main focus of NRP 62 is the fostering of original scientific and application ideas, whereas projects envisaging only an incremental improvement of the state of the art, are not supported. The two project types of NRP 62 are i) projects with predictable application potential where already at the beginning a scenario for the industrial exploitation can be established, and ii) exploratory "high risk – high reward" projects (cf. chapter 4.4 and 7.1.).

Once completed, NRP 62 is expected to have achieved the following goals:

- The volume of continued projects, co-financed also by industry, amounts to at least the annual grant budget of NRP 62.
- Based on the results of NRP 62, several start-up companies have been founded or are about to be founded.
- NRP 62 is a successful reference model for future collaborations between SNSF and CTI.
- Research on smart materials in Switzerland will have surpassed a critical size and will be internationally recognised and highly renowned.

To reach these goals the following measures will have to be taken:

- Uncompromising insistence on uppermost scientific quality and high potential for innovative applications, when selecting projects.
- Demand for an industrial exploitation scenario in case of successful project completion, already at the beginning of the research projects.
- Very early integration of industrial partners, who are coaches in a first phase for the evaluation of market potential, specifications and possible "show stoppers"; at a later stage, they become project partners for the industrial exploitation.
- Active support of the researchers by the members of the NRP 62 Steering Committee for finding suitable partners.
- Creation of a particular category of speculative, highly original projects.
- Clear structuring of the programme with stringent selection: After three years, only those projects continue to be funded whose application and exploitation potentials have been confirmed (cf. chapter 6).
- Inclusion of CTI experts for the evaluation of projects, the search for partners and the coaching of the researchers.
- Interdisciplinary operation, both laterally between the various scientific disciplines but also vertically between research and exploitation.

Results of studies on fundamental and application oriented problems will allow prototype materials and structures to be developed that prove the applicability in different industry sectors and identify potential advantages but also problems or risks of these technologies. NRP 62 aims at bundling competences and resources available at several research institutions in Switzerland. Research will provide enabling technologies for (i) smart materials development, and (ii) smart structures and systems application both in sectors that are of strategic importance for the Swiss industry. Process implementations, system's reliability, functional and cost optimisation are among the aspects to be investigated to this end. Furthermore, NRP 62-projects should meet fundamental aspects of health- and environmental protection.

4. Main research topics

The research work of NRP 62 is based on the following definition:

"Smart materials respond to external stimuli with reversible changes of selective properties."

The focus of NRP 62 is on advanced smart materials and low level system integration and includes numerical modelling and simulation as well as processing technologies. Embedded microsystems, high level system integration, signal processing and incremental material improvements are not part of NRP 62.

Materials and materials combinations reach their specific properties in the materials form of bulk, surface/interface, film/membrane, powder, colloids and various other small structures. Several new materials reach particular properties due to nanostructuration and quantum phenomena.

- Examples of novel bulk properties and applications:
  Lead-free piezoelectricity, thermal or magnetic shape memory effect, phase transitions (e.g. magnetic ordering), semiconducting saturable light absorbtion, smart materials for vibrational and acoustic damping, responsive gels, electronic and ionic conductivity.
- Examples of novel smart surface/interface material properties and applications:
  Controllable surface segregation and chemical composition, friction and corrosion, surface magnetism, colour, reflectivity, switchable adsorption, wettability and adhesion (bond and debond on command), hydrophobicity/hydrophilicity.
- Examples of novel smart thin film and membrane material properties and applications:
  Barrier materials and membranes with controllable porosity and permeation, coatings with automatic adaptation of transmission and reflexion or friction, photo-adressable polymers.
- Examples of novel smart powder material properties and applications:
  Novel magneto- und electro-rheological fluids, dissolvable encapsulation, functionalised surface, smart lubricants for controllable friction and tribology.
- Examples of smart systems and applications:
  Combinations of smart materials and passive components which yield enough energy not only for sensors, but also for actuators and adaptive structures; active fibre composites; electro-active polymers; adaptive aero- and hydrodynamic surfaces; interactive safety- and identification systems; adaptive vibration damping and shock absorbing materials systems; self-healing/repairing systems; tactile skin and other smart body material; artificial muscles e.g. for insect-like walking or flying.
- Examples of external stimuli:
  Fields and forces such as static and dynamic electric and magnetic fields including light, mechanical forces (deformation, stress-strain, pressure) as well as environmental, chemical or biological parameters such as, temperature, adsorbants and chemicals, electrochemical potentials, cell communications and biological signals including molecular recognition.

4.1 Module 1: Energy, mobility and environment

Search for and development of smart materials and systems for improved efficient and sustainable generation, transformation, storage, and use of energy

To reach a sustainable equilibrium between the consumption of energy for the needs of our society with respect to transport/mobility, comfort in buildings and process technologies versus the protection of our environment represents a most important and difficult challenge to be addressed in the coming years. It is clear that solutions for some of these most urgent issues will not only be of enormous environmental, political and social relevance, but also provide Swiss industry with a significant competitive advantage. With this module for example the search for and development of smart materials for efficient energy technologies in large and small (e.g. portable) devices is envisaged. Other areas could address the need for novel materials for smart barrier materials and membranes with controllable porosity and permeation properties, the development of switchable mirrors and smart windows with an automatic adaptation of transmission and reflection in a large spectral range, possibly even combined with photovoltaic use of light, or the possibility to achieve controllable friction due to smart lubrication, to name only a few.

4.2 Module 2: Engineering and functional materials

Engineering of structures and devices which reach specific functions based on smart materials and combinations of smart materials with passive components

A particular challenge is the combination of smart materials and passive components into active structures in such a way that they are able to fulfil, without additional external energy supply, not only sensor but also actuator functions. They will enable safe and secure automatic systems control and adaptation to changing environmental conditions. Significant progress has been achieved with respect to materials' specific functional properties, modelling, simulation, control, structural optimisation, and processing technologies. NRP 62 supports interdisciplinary engineering research needed in order to bridge the gap between academic environment and industrial applications in view of multidisciplinary and multi-objective optimisation, optimisation algorithms, design of multi-material structures, fluid-structure interaction, non-linear static and dynamic analysis, design and optimisation of compliant systems as well as for the elaboration of criteria for reliability, mechanical integrity and lifetime evaluation.

4.3 Module 3: Health

Smart materials and systems for health, performance and comfort of the human biomedical and orthopaedic devices, implants and textiles and key components for personalised medicine in diagnostics and therapy, control of heat and humidity

The costs of our health care systems are exploding, due to the current enormous demographic change in our society, a fundamentally changed lifestyle owing to industrialisation and the expectations of the public regarding an ever-increasing quality of life. It is envisaged that only a concerted effort of all stakeholders, the so-called

4P medicine of the future (personalised, predictive, preventative, participatory), can counter this development. The major goals of 4P medicine include diagnosis, treatment and prevention of diseases and traumatic injury; creation, restoration and reinforcement of the human body's structures and defence mechanism; as well as relief from chronic and acute pain. This can only be achieved if a large selection of application-specific materials is accessible, interacting with the body adaptively for precisely targeted long-term use: The availability of smart materials will have a major impact, therefore, on 4P medicine and the future of our society's health. However, this module will not only support projects with a direct pharmaceutical and medical content, but also stimulate development of smart materials and systems including textiles that provide health benefits in a larger context such as for example heat and humidity regulating cloths, responsive and adaptive encapsulation and packaging materials for pharmaceutics and food.

4.4 Module 4: Novel smart materials

Explorative materials research without fixed field of applicability, aiming at the discovery of new smart materials with extraordinary properties

While modules one, two and three concentrate on projects with a predictable application potential in well defined areas that are of strategic importance for Swiss industry and society, and where a scenario for the industrial exploitation can already be established at the beginning of the programme, the fourth module is intended for exploratory and "high risk – high reward" explorative research projects without a fixed field of applicability (see chapters 3 and 7.1). It aims at the discovery of new smart materials with extraordinary properties based on novel concepts and approaches. Materials of particular interest are able to generate respond-energy in amounts which allow not only sensor but also actuator applications.

5. Practical significance and target audience

Smart materials clearly belong to the key technologies of the 21st century. This is due to the interplay between properties, design and form of a material, as well as to its response to changing external influences. Once these relationships are known and understood, it becomes possible to realise materials offering memory, autonomous and deliberate adaptation and application-specific behaviour. Such smart materials are broadly applicable in environmental engineering, in transportation, in safety and security, in energy technology, in civil engineering and construction, in communications technology, as well as in life sciences and health; for these reasons they are of very high economic and societal relevance in the long term.

The necessary know-how exists in the Swiss research community and is distributed in a number of departments and institutes of chemistry, physics, materials science, biology, mechanical engineering and medicine of the different institutions of the ETH domain (ETHZ, EPFL, PSI, EMPA), the Universities of Basel, Bern, Fribourg, Geneva, Neuchâtel and Zurich, in several Universities of Applied Sciences as well as at CSEM. This already illustrates the highly interdisciplinary nature of NRP 62 and the necessary close connection between basic research, applied R&D and technology exploitation. We can thus also expect that the programme will not only promote research in one of the key technology areas, but also foster education in interdisciplinary research and at the interface of basic research and industrial application.

The practical significance of smart materials is conspicuously demonstrated with several commercially available products such as phototropic glasses, smart windows, targeted drug delivery with specific nano-transporters, as well as with a number of companies and industrial associations.

The prospective market potential of high-performance products based on smart materials is huge, and a high visibility of Switzerland is thus of utmost national importance. In addition to the scientific advancement that the programme will result in, it will strengthen Switzerland as a centre for innovation in high technology, further enhance interdisciplinary research and establish new competencies.

It is not to be expected that directly marketable products will result from NRP 62. However, the intense and successful research and development phase in the framework of NRP 62 will form the basis for the continuation of some of the investigated projects in ensuing CTI-projects, in which highly promising products will be developed in close collaborations with industrial partners.

6. Programme flow

The Swiss National Science Foundation (SNSF) will carry out NRP 62 in cooperation with the Innovation Promotion Agency CTI. NRP 62 will be divided in three stages.

At the stages one and two the research projects will be funded by the SNSF. At the first stage, lasting three years, the NRP will be open to the unexpected; higher-risk projects may also be accepted. At the second stage, to last no longer than two years, only those projects with a definite potential for practical application and for follow-up industrial collaboration projects funded by CTI will receive continued support within NRP 62. At the third stage the remaining application-oriented projects will have to change to be funded by CTI and industrial companies according the rules of CTI.

The transfer of a NRP 62-project to an industrial collaboration project funded by CTI can take place at any stage of NRP 62 whenever the progress of a single project is appropriate.

7. Submission procedure

The Implementation Plan as well as forms, rules of procedure and instructions for the submission on the portal *mySNF* can be found on the following website: www.snf.ch.

In order to organise the programme effectively and to define appropriate priorities, a two-stage submission procedure has been set up: pre-proposals are to be submitted first, followed by full proposals. Both the pre- and the full proposals must be written in English for screening and evaluation by a group of recognised international experts.

Pre- and full proposals have to be submitted online on the portal *mySNF*. For the use of *mySNF* prior user-registration on the homepage of https://www.mysnf.ch is required. Previously opened user-accounts are still valid and provide unlimited access to all the funding instruments of the SNSF. For a submission on schedule, a new user account has to be opened two weeks before the submission date at the latest. The submission of the documents by postal delivery is only accepted in exceptional cases after consultation with the Swiss National Science Foundation.

The proposed research projects will have to follow SNSF guidelines and must be limited to a period of no more than 36 months.

Collaboration with research groups in other countries is highly appreciated, if the planned cooperation brings significant added value or substantially enriches Swiss research in respect to content or methodology. For this purpose, the German Research Foundation (DFG), the Austrian Science Fund (FWF) and the SNSF made an agreement offering two options for research partners from Germany or Austria: on the one hand, the "Money follows cooperation line" and, on the other, the "Lead Agency Process". The choice of the suitable funding procedure for the foreign part in a specific research project should be discussed in detail between the SNSF-office and the involved researchers shortly after the decision on the pre-proposal.

SNSF funds awarded are exempted from VAT taxation (Art. 33 Abs.6 Bst. c MWSTG). The SNSF does not issue contracts within the scope of its National Research Programmes, but instead awards grants for the promotion of scientific research in Switzerland.

7.1 Pre-proposals

Interested researchers will first submit a pre-proposal. Deadline for the submission is 30 January 2009. The pre-proposal should give information on the following issues:

To be submitted online on the portal *mySNF:*

- Basic data and abstract,
- National and international co-operation,
- Estimation of financial support required for salaries and running costs (budget).

Project description to be submitted additionally as a PDF:

- Research topic and target of the project,
- State of research,
- Approaches and methods,
- Timeframe and milestones,
- Expected use and possible application of results; specific risks to be considered,
- List of five publications considered relevant as stepping stones for the research envisaged,
- List of the most important publications and/or patents of your own (not more than five).

All the proposals should point out possible scenarios for a successful industrial exploitation and assess the chances of success of the project within the given frame. The Steering Committee will obviously put less emphasis on these issues in the evaluation of "high risk – high reward"-projects (cf. chapter 3 and 4.4).

Furthermore the applicants should outline which kind of cooperation with industrial companies is envisaged in the different phases of the project (e.g. partners for the evaluation of the market opportunity, validation partners, implementation partners for the fabrication of the product).

The project description must be submitted using the template document provided in the *mySNF* portal. The project description must be in English and the final PDF file should not not exceed six A4 pages. In addition a short Curriculum Vitae of a maximum of two pages has to be submitted.

The pre-proposals will be subject to international scientific peer review. Based on the reviewers' reports and its own evaluation, the Steering Committee will decide on which pre-proposals should be developed into full proposals (see the criteria listed below).

7.2 Full proposals

In the second stage of the submission procedure the Steering Committee will invite the authors of the selected pre-proposals to submit detailed full proposals online on the portal *mySNF* (see above) corresponding to standard SNSF rules and guidelines.

All full proposals will be subject to international peer review and the principal investigators will be invited to present their projects to the Steering Committee. This procedure allows the Steering Committee to query specific points and ask detailed questions. Following the presentations, the Steering Committee will convene to select the projects to be recommended for approval or rejection by the National Research Council (Division IV; Presidial Board).

7.3 Selection criteria

Successful investigation and further development of smart materials i.e. of functional high performance materials in which multidimensional response functions are linked up, requires an interdisciplinary approach combining visionary basic research with innovative applied research. The driving force can be a current technical question as well as a creative search for applications of new materials or phenomena.

Pre- and full proposals will be reviewed on the basis of the following criteria:

- **Scientific quality and originality:** pre- and full proposals should fulfil international state-of-the-art criteria with respect to scientific quality and originality as well as methodological standards. Furthermore they have to contain innovative components and to be clearly different from running projects.
- **Feasibility and compliance with the goals of the NRP 62:** proposals should reflect the programme's scientific objectives and comply with its overall framework.
- **Inter- and transdisciplinarity:** Inter- and transdisciplinary projects are strongly encouraged by NRP 62 and will be evaluated accordingly. Disciplinary projects are not excluded if they comply with the programme's goals.
- **Application and implementation:** potential for practical application and implementation of results are key elements of National Research Programmes. Projects of high practical relevance are therefore given high priority.
- **Personnel and infrastructure:** Projects have to be carried out in a setting that provides adequate infrastructure and personnel.

The Secretariat of Division IV checks fulfilment of formal criteria before the proposal is passed on for content review (cf. Grant regulation of SNSF). Applications that do not satisfy these formal criteria will not be processed further.

7.4 Schedule and budget

The following schedule has been set for NRP 62:

Call for pre-proposals	3 November 2008
Submission of pre-proposals	30 January 2009
Invitation to submit full proposals	Mid-May 2009
Submission of full proposals	Mid-August 2009
Final decision on full proposals	December 2009
Start of research	January 2010

NRP 62 will operate with a total funding of CHF 11 million. The provisional allocation of this funding to different types of activities is as follows.

Module 1	CHF 2.3 mill.
Module 2	CHF 2.3 mill.
Module 3	CHF 2.3 mill.
Moduel 4	CHF 2.3 mill.
Implementation and administration	CHF 1.8 mill.

8. Actors

Steering Committee

Prof. Dr. Louis Schlapbach, Director, Swiss Federal Laboratories for Materials Testing and Research (Empa), Dübendorf (President)

Prof. Dr. Martina Hirayama, Institutsleiterin, Institute of Materials and Process Engineering (IMPE), School of Engineering, Zurich University of Applied Sciences, Winterthur, and CTI expert

Dr. Annick Loiseau, Laboratoire d'études des microstructures (LEM), Office national d'études et recherches aérospatiales (ONERA), Châtillon, France

Prof. Dr. Rolf Mülhaupt, Institut für Makromolekulare Chemie, Albert-Ludwigs-Universität Freiburg, Deutschland

Prof. Dr. Peter Seitz, Institut de microtechnique, Université de Neuchâtel, and Centre Suisse d'électronique et de microtechnique SA (CSEM), Zürich

Dr. Hansruedi Zeller, Consenec AG, Dättwil

Delegate of Division IV of the National Research Council

Prof. Dr. Peter Schurtenberger, Adolphe Merkle Institut, Universität Freiburg

Programme Coordinator

Dr. Stefan Husi, Swiss National Science Foundation (SNSF), Berne

Implementation Officer

N.N.

Representative of the Federal Administration

Dr. Vincent Moser, Leiter Ressort „Projektförderung Forschung und Entwicklung", the Innovation Promotion Agency CTI, Federal Office for Professional Education and Technology (OPET), Berne

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