

**An NSF Industry/University Cooperative Research Program**

**CCMC PROSPECTUS**

**May 2005**

**CERAMIC AND COMPOSITE MATERIALS CENTER**

**AT**

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**AND**

**PENNSYLVANIA STATE UNIVERSITY  
249 MATERIALS RESEARCH LABORATORY  
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## **EXECUTIVE SUMMARY**

### **Ceramic and Composite Materials Center NSF Industry/University Cooperative Research Program**

**The University of New Mexico,  
Rutgers, The State University of New Jersey and  
Pennsylvania State University**

The Ceramic and Composite Materials Center (CCMC) is a multiuniversity cooperative research center among The University of New Mexico (UNM), Rutgers, The State University of New Jersey (Rutgers) and Pennsylvania State University (Penn State). It is part of the NSF Industry/University Cooperative Research Centers Program. The CCMC constitutes the amalgamation of three pre-existing I/UCRCs, the UNM Center for Micro-Engineered Materials, the Rutgers Center for Ceramic Research and the Penn State Particulate Materials Center. It is jointly supported by industry, the State of New Mexico, the National Science Foundation (NSF), UNM, Rutgers and Penn State.

The CCMC combines the ceramic processing expertise of the Rutgers researchers, the expertise of the UNM researchers in the chemical synthesis of ceramic and related materials and the Penn State expertise in the synthesis and processing of particulate materials. It functions as a complete ceramic science and engineering center with extreme versatility in developing synthesis and processing systems for powders at all length scales. It has the capability and goal to develop leading edge ceramic, polymer/ceramic composite and nano materials and processes to improve the technical base that is needed by companies to compete successfully in the global marketplace

The mission of the Center is to create and transfer to Center Members the new technologies and relevant technical base to drive development of competitive, reproducible ceramic, polymer/ceramic composites, particulate materials and nanomaterials for advanced, high performance systems.

The Center conducts a cooperative research program that features a highly leveraged, pooled, cooperative research program. The cooperative research program includes the research of approximately 28-33 graduate students, 28 faculty researchers and 6 research scientists. Large industrial firms provide a minimum of \$35,000 per year in research funding for membership in the cooperative program. Small, SBIR-size, firms pay a minimum of \$10,000 per year in research funding for membership. Member firms play a major role in recommending and selecting projects for the cooperative program. Members may designate the program/project areas in the cooperative program to be supported by their funds.

An Industrial Advisory Board (IAB) made up of one member from each voting member firm provides oversight. This committee provides feedback on the state of the research projects at each of the semiannual review meetings. It also recommends projects for the cooperative program, provides feedback on project proposals and makes recommendations to the Center Directors for research direction and Center policies.

The Center's UNM research laboratories are primarily located in laboratories allocated by UNM in the Farris Engineering Center, the Department of Chemistry and the Advanced Materials Laboratory, a joint venture between UNM and Sandia National Laboratories. At Rutgers, the Center's research is primarily conducted in a building constructed to house the CCR, the Rutgers forerunner to the CCMC. This state-of-the art building was made possible by funding provided by the New Jersey Commission on Science and Technology, \$9,000,000 of the \$10,000,000 required for the construction of the Center building and over \$8,000,000 for the purchase of research equipment. The Penn State site is located in approximately 5,000 ft<sup>2</sup> of labs located in the Materials Research laboratory at the University Park campus.

The Center also performs research on individual projects funded by separate research contracts or grants from industry and Government. Work with industry on individual contracts can take several different forms. These include:

- Proprietary, fundamental research projects conducted by the Center in areas of specific interest to a company
- Collaborative research projects between the Center and a company where each conducts a major part of the research,
- Joint projects for Government agencies
- Visiting scientists working in the Center
- Analysis of industrial problems
- Technical services such as scanning and transmission electron microscopy, X-ray photoelectron spectroscopy, X-ray diffraction, small angle X-ray scattering and hot pressing
- Answering technical inquiries.

The IAB meets semiannually. The meetings rotate among Penn State, Rutgers and UNM. Working in concert, the IAB and the CCMC faculty propose new research projects for the cooperative program. Proposed projects are presented at either the spring or fall meeting of the IAB. However most new project proposals will be made at the fall meetings so that graduate students can be recruited on a normal cycle for new projects scheduled to start the next fall semester. The IAB members then specify their level of interest in the current projects and the recommended new projects and provide suggestions for change. Based on the collective results of the IAB project evaluations and anticipated membership funding, the Directors select the new projects for the cooperative program.

Research in the cooperative program concentrates on understanding the factors controlling the properties and behavior of ceramics and the fundamental science associated with the synthesis and processing required to achieve specific properties. The principal research program areas are:

- Porous Materials and Catalysts
- Nanomaterials
- Powder Synthesis and Processing
- Structural Ceramics and Ceramic Armor
- Electrochemical and Energy Related Materials and Processes.

These program areas provide new opportunities for the development of innovative, low-cost, high performance ceramic materials and processes not currently available commercially. A Program Coordinator leads each program area. The Program Coordinators have the responsibility to control the budget allocated to the area and to coordinate the research efforts in the individual projects. Generally, the Program Coordinators are either UNM, Rutgers or Penn State faculty. The research projects are directed by UNM, Rutgers and Penn State professors and carried out primarily by graduate students, assisted by undergraduate students and researchers from Los Alamos National Laboratory and Sandia National Laboratories, New Mexico Institute of Mining and Technology and occasionally Center Member firms. Approximately 25-30 faculty members from the Rutgers Department of Ceramic and Materials Engineering, the UNM Departments of Chemistry, Chemical and Nuclear Engineering, Mechanical Engineering and Physics and Astronomy and the Penn State Department of Materials Science and Engineering and the Department of Chemical Engineering participate in the Center's research program.

Membership in the CCMC Cooperative Research Program provides many benefits to participating companies. These include:

- Opportunity to co-design, co-develop and co-manage the CCMC research program
- A voice in selection of the research projects through membership in the IAB and the direction of a major ceramic science and engineering research program
- An opportunity to allocate their membership funding to support the research program area(s) most relevant to their company interests
- Interaction with the broad knowledge base of participating faculty
- Access to a broad range of ceramic research for a small percentage of the total cost
- An option for a royalty-free, non-exclusive license to patents and other intellectual property resulting from the Center's precompetitive research program
- An opportunity to send a visiting scientist to work at the Center
- Access to the Center for technical questions, occasional technical services and separately funded research projects
- Contact with graduate and undergraduate students for recruiting purposes.

Semiannual meetings are held to review projects, select new projects and conduct the policy-making business of the Center. An annual, comprehensive progress report on the Center's projects is sent to Member Companies prior to the spring IAB meeting. An abbreviated technical report is furnished prior to the fall IAB meeting. These reports are furnished in the form of CDs to facilitate the flow of information throughout the Center member organizations.

Oral project reviews and a poster session are presented at each semiannual meeting. The reports are also furnished as CDs containing a complete Audio/visual record of the technical review talks. IAB members provide written feedback to the project leaders on special evaluation forms. This provides an opportunity for individual companies to have direct input into each project. Publication is encouraged, after review by the Center Members, but can be delayed for a maximum of six-months.

## **INTRODUCTION**

The University of New Mexico Center for Micro-Engineered Materials (CMEM), the Rutgers University Center for Ceramic Research (CCR) and the Penn State Particulate Materials Center (PMC) has had a long history of research with industry. All three centers were part of the National Science Foundation Industry/University Cooperative Research Centers (I/UCRC). The Rutgers CCR was established in 1982. The UNM CMEM was founded in 1988. And the Penn State PMC was founded in 1995. In 1999 the UNM CMEM and the Rutgers CCR joined together to form the CCMC.

The addition of the Penn State PMC to the CCMC increases the critical mass of the CCMC to study the entire spectrum of materials R&D from building blocks at the molecular level to dense ceramics and composite materials with tailored microstructures. The CCMC and the PMC have complimentary strengths. The CCMC's forte has been to apply innovative chemistry to engineer materials starting from preceramic polymers and molecular precursors to world class ceramic powder processing while the PMC has been focusing on the use of colloid chemistry techniques to process nanoscale, inorganic powders as well as spray forming and powder mechanics. Thus, the combined effort will span the scope of particulate material science and technology from particle synthesis and processing through microstructural and property determinations. The breadth and depth of research expertise available to our member companies will be greatly enhanced and expanded with the new intellectual property and synergy provided by bringing together the expertise at Penn State, Rutgers, and UNM

After initial discussions among RU, UNM, and PSU, in the first half of 2002, Professor Adair, Director of the PSU PMC, attended the CCMC/IAB meeting in fall of 2002 at RU and presented an overview of the Penn State center to the CCMC members. After his presentation to the IAB and discussion of the benefits of bringing together the capabilities of the CCMC at RU and UNM with those of the PMC at PSU, the CCMC/IAB voted unanimously in favor of proceeding to merge the two centers.

In spring, 2003, Professor Niesz, the RU site Director of the CCMC, presented an overview of the CCMC to the Penn State PMC/IAB at their spring review meeting. After discussion of the proposed merger, the Penn State PMC/IAB voted unanimously to proceed with the plans to merge with the CCMC.

By pooling the funds from participating companies, their respective universities, NSF and their state governments, the CCMC with the addition of the PMC attains the critical mass of personnel and facilities needed to conduct major research programs to the benefit of their participating companies. Each company provides only a small percentage of the total R&D cost for each resultant new technology.

The three universities provide strong backing and enthusiastic support for the formation of CCMC as a three-university multiuniversity research center. The State of New Mexico supports CCMC through its support of UNM. In addition, beginning in 1996, the State of New Mexico has provided a direct annual allocation, currently about \$80 K, to support the Center's materials science research. This allocation primarily provides salary support for key administrative staff and for the research scientists that maintain and operate the Center's extensive characterization

facilities.

The UNM CMEM provides access for the CCMC researchers to state of the art materials characterization facility including the latest, very high resolution SEM, a one of a kind small angle X-ray scattering facility in conjunction with Sandia National Laboratories and a surface science laboratory featuring a leading edge XPS.

The State of New Jersey provides support for the CCMC through its support of Rutgers University. The State of New Jersey became a major direct sponsor of the CCR in 1984 by providing funding through the New Jersey Commission on Science and Technology in three areas:

1. Baseline and excellence funds for research and technology transfer
2. Capital equipment acquisition (\$8M)
3. Funding for a new building (\$9M out of a total of \$10M)

The State of Pennsylvania provides support for the CCMC through its support of Penn State. The Penn State site is located in approximately 5000 sq. ft. of labs in the Materials Research Laboratory Building at the University Park campus. The PMC includes a state-of-the-art user facility, the Particulate Characterization Laboratory, containing about \$1.5 million in particle characterization equipment. The PCL is a user facility for faculty, staff, students, and visiting scientists to utilize for their particulate materials characterization needs.

### **MISSION AND GOALS**

*The mission of the CCMC is to develop new, interdisciplinary technologies to increase the level of ceramic and particulate science, technology and engineering and to transfer these technologies to its industrial members to foster the development of competitive, reproducible ceramic and composite materials, for advanced, high performance systems*

The CCMC mission inherently recognizes the opportunity afforded by the formation of a multiuniversity science and engineering center that has both a strong chemical synthesis component and an equally strong processing capability. This combination provides the intellectual leadership to meet future ceramic, polymer/ceramic composite and nano science and technology needs of our Member Companies. The focus will be on developing a technology base that will lead to the development of competitive, reproducible ceramic products that:

- Can be manufactured by robust, high-yield and environmentally friendly processes
- Contain chemically and physically tailored microstructures
- Are cost efficient to manufacture
- Can be tailored to specific applications
- Are based on the best innovative science, technology and engineering practices

The following goals were established to accomplish the Center's mission:

- Promote close interaction among the UNM, Rutgers and Penn State researchers to develop an interdisciplinary research program in materials and processing with

- emphasis on developing new areas of ceramic technology such as polymer ceramic composites, control of structure and porosity on small length scales and nanostructured particles and surfaces
- Forge collaborative research alliances with outstanding researchers from other universities to bring in talent and expertise to compliment the Center's Research
  - Develop new science, technology and novel concepts to overcome the underlying problems common to ceramic and related materials, products and processes — these problems include retention of useful electronic and dielectric properties in thin films and lamellar structures, control of nano structure, microstructure and mesostructure in thin films and monolithic materials, improved homogeneity, the achievement of useful ceramic properties at low processing temperatures and the preparation of nanoparticles
  - Serve as an in-depth, expert resource for ceramic science and technology
  - Transfer and exchange knowledge/technology and inventions to the Center's industrial members and Federal Government supporters
  - Contribute to ceramic and materials education, by training and educating students including providing them exposure to industrial technology and industrial research procedures
  - Become a focal point for networking in ceramic and allied areas of science and technology for exchange of ideas and to identify global needs and opportunities.

The CCMC vision, mission statement and goals guide the future direction of the Center's research program.

## **ORGANIZATION**

The organization and management structure provides (1) strong interaction and collaboration among the UNM, Rutgers and Penn State research components and (2) involves each of the Center's combined research faculties and participating members in as much of the decision making process as possible. The policy and research decisions are consistent with the policies of the three parent Universities and the spirit of cooperative research. Within these constraints, the faculty and participants, acting in-concert, determine the research activities, policies, and future directions of the Center.

### **Center Directors**

A Site Director, Rutgers Professor Richard A. Haber, Department of Ceramic and Materials Engineering, Rutgers University, a University of New Mexico Site Director, UNM Professor Abhaya K. Datye, Department of Chemical and Nuclear Engineering and a Penn State Site Director, Professor James H. Adair, Department of Materials Science and Engineering will manage the Center. A Co-Director, UNM Research Professor William J. Kroenke, Department of Chemical and Nuclear Engineering and an Associate Director, Rutgers Professor Emeritus, Dale E. Niesz, Department of Ceramic and Materials Engineering assist the three directors. The Center Directors inform Center Member companies, the National Science Foundation and their respective universities on the conduct and achievements of the Center. The primary responsibilities of the Center Directors are to

- Ensure that the precompetitive research program has intrinsic merit
- Assure communication and knowledge transfer to participating companies
- Ensure and maintain academic excellence and a research program that contributes to the education of students
- Make final decisions on Center policy and operations
- Make final decisions on the selection of research proposals and projects
- Prepare Center budget
- Administer Center funds
- Issue reports on the Center's operation and research
- Recruit new industry participants

### **Industrial Advisory Board**

The Industrial Advisory Board (IAB) advises on matters of Center operation, policy and research. The Committee is the forum through which the ideas, goals and requirements of the industrial participants of the Center are expressed and coordinated. The Chair of the IAB is an IAB member, recommended by the three Directors and approved by vote of the IAB.

The IAB is made up of

- One member from each participating firm with voting rights
- One member from the National Science Foundation
- Additional, non-voting participants as invited by the IAB

The responsibilities of the IAB are to

- Recommend research project areas and projects
- Provide feedback to Center Directors on their interest in recommended projects
- Recommend Center policy including direction of research, member networking, patent and publication policies, etc., consistent with the policies of the participating universities
- Provide feedback on each project at each review meeting to the Center Directors, Program Coordinators and Project Leaders

### **Program Coordinators**

The CCMC technical program consists of four principal thrust areas. Each program thrust area is under the direction of a Program Coordinator(s). The Program Coordinators have the responsibility to administer the budget allocated to each Program Area to assure that the resources are used to the best advantage of the individual technical tasks or projects. The Program Coordinators report directly to the Center Directors and participate in determining the technical strategy of the Center. The Program Coordinators are faculty of Penn State, UNM or Rutgers.

### **Project Leaders**

The Project Leaders are generally university faculty researchers from Penn State, UNM and Rutgers or from other associated universities or Sandia and Los Alamos National laboratories. The responsibilities of the project leaders are to

- Coordinate their research progress with the appropriate Program Coordinator.
- Organize and conduct the research projects
- Direct the students, postdoctoral fellows, visiting scientists, and Center research staff in conducting the research projects
- Interact directly with appropriate research and other technical and business personnel of the industrial member companies particularly interested in their projects.
- Publish research results in accordance with Center policy
- Identify intellectual property and write Invention Disclosures as appropriate
- Advise their Program Coordinators of technical successes as well as problems and resource requirements needed to succeed

### **Communication**

The IAB meets semiannually, in the spring and in the fall. The meeting sites rotate among Penn State, Rutgers and UNM. They consist of a full day technical review and poster session followed by a half-day business meeting. The IAB meetings provide an open forum to discuss research progress, accomplishments, new project selection, technical direction and other Center policies and issues requiring attention.

Annual comprehensive technical progress reports are prepared for each completed calendar year and sent to all Center Members prior to the spring IAB meetings. An abbreviated technical report on all Center Program areas and projects is prepared and distributed to all Center Members prior to the fall meeting. The reports are furnished in the form of CDs to facilitate their dissemination within the member organizations.

The oral technical review talks, which are presented at the semi-annual IAB meetings, are recorded and furnished to the members as audio/visual PowerPoint presentations on a CD.

Center newsletters are sent to all Center Members periodically to report the latest research results and other Center accomplishments and activities. Preprints of publications on completed work and graduate theses from Center projects are available to all members. The Center encourages and provides both formal and informal interactions between industry and faculty as well as student researchers. The Center's Cooperative Research Program relates both the interests and needs of industry with the interests and skills of the Center's faculty. Therefore, close faculty-industry communication concerning research ideas is a necessity. Such research related interactions, while very important, are not intended to supplant the normal faculty consulting services in areas not specifically related to Center projects.

### **Evaluation**

The NSF/IUCRC Program requires that Center activities including industry-university interaction and accomplishments be independently observed and evaluated. The CCMC Evaluators are Dr. James R. Buckmelter and Mr. Steven McGregor. In keeping with NSF/IUCRC guidelines, Dr. Buckmelter, a retired U.S.A.F. Lt. Colonel, and Mr. McGregor, Director of the Ben Franklin Research Institute based at Penn State, attend the IAB meetings and administer the annual satisfaction surveys to the CCMC faculty and members. The Center Evaluators are sensitive and responsive to the needs of the NSF/IUCRC program office, the Center leadership and its constituencies and to the IUCRC Evaluator Guidelines that call for the following:

- Attend, observe and participate in IAB, and semi-annual evaluator meetings
- Administer, analyze and present the findings of Industry/Faculty Outcomes Data to the Center leadership, and the IUCRC program, both as a split run for each site, and as a merged report when appropriate
- Assist in the administration, tabulation and presentation of on-line findings of LIFE forms for new research proposals, and continuing progress reports during IAB meetings
- Perform exit interviews to determine why members leave, and to determine the basis on which they would return
- Prepare annually and at least 90 days before the Center's anniversary an Evaluator Report presenting a history of the Center, including its activities, opportunities, challenges and responses for the previous year, and an indication of the general health, well-being and strategic and tactical direction for the future
- Provide NSF and the Center constituencies with information on Center accomplishments and challenges in a timely fashion, so that corrective action if appropriate can be taken on-line, and thus provide the Center with a basis for continuing improvement

**Level of Interest and Feedback Evaluation (LIFE)** — An important objective of the CCMC IAB meetings is to stimulate interaction among faculty, students and industrial members. The NSF LIFE questionnaire facilitates this interaction. The LIFE questionnaire for each Center Research Project is completed by voting members of the IAB based on the oral presentations, poster presentations and faculty discussions at both the spring and fall Technical Review meetings. The results are presented (in hard copy) and discussed by the IAB, NSF representative and Center faculty during the business meeting that follows the technical review. These open discussions enhance the collaborative spirit of the Center constituencies. They are very important in determining the future technical direction of the Center and fostering significant scientific interaction among researchers and sponsors.

**Study of Organizational Effectiveness** — The organizational effectiveness of the Center is reviewed on an annual basis, generally, just after the spring IAB meeting. The Center Evaluators conduct the review with Center Members and faculty using special forms designed for the IUCRC program. These questionnaires are designed to assess the Center's performance against various effectiveness criteria. The responses to these questionnaires are summarized in report form by the Center Evaluators and presented to the Center Directors to help them identify Center strengths and weaknesses that respectively need to be exploited or corrected. A copy of the

report is also submitted to the NSF.

### **Schedule of Activities**

The Center operates on a fiscal year beginning July 1. However, the membership year for individual members starts on the date they join the program. As already discussed, there are semiannual meetings of the IAB held each spring and fall. Both meetings review the Center's research programs, select new projects, present tutorial lectures, discuss strategic issues and evaluate both the short and long term Center objectives.

### **Project Selection**

The IAB, individual member companies and participating faculty recommend new research projects for the Center's Cooperative Research Program on a semiannual basis. New project proposals can be presented at either the spring or fall IAB meetings although the fall meeting is recommended to provide sufficient time to locate students and resources and assure that the projects start by the following fall semester. These proposals are presented orally during the technical presentation session. Whenever possible, white papers describing the new project proposals will be furnished to the IAB prior to the meeting. The same forms used to evaluate interest in the Center's ongoing research projects are used to evaluate the new project proposals. If a new project proposal is ranked favorably by the IAB compared to existing projects, the Center Directors, in close coordination with Center faculty, can elect to implement the new project. The number of new projects that can be initiated each year depends on the availability of funds and the number of students completing their graduate research.

**Project Selection and Termination** — A key requirement in initiating a new project is the availability of an appropriate student(s). Therefore, we provide a 10-month window from the decision to initiate a new project to allow for student recruitment and to get the project up and running. Conversely, when the decision is made to terminate a Center project, for whatever reason, the Center guarantees funding for at least an additional six-month period if required to enable the student researchers to either complete their graduate research or to enable their faculty advisor to find alternate funding. In a worst-case scenario, the Center provides the necessary funding to enable the students to complete the research requirement for their degrees.

### **Publication Policy**

Publication of research in scientific journals is a requirement of academic research and is encouraged. A disclosure-delay mechanism prevents untimely publication of patentable research. No such publication, which is defined as a presentation at symposia, national or regional professional meetings, submissions of abstracts or proposals, publication in journals or other public disclosure, shall occur before being reviewed by one of the Center Site Directors. Each proposed publication, in the form of the complete publication or an extended abstract, by either a Center Faculty Researcher or a member of a center company, will be submitted to one of the Center Site Directors to be screened for intellectual property content. If the Center Site Director determines that the proposed publication or presentation does not contain patentable material, the Director may authorize publication. If the Center Site Director determines that the proposed

publication may contain patentable material, a copy of the proposed publication or an extended abstract of it shall be sent to each Center Member in good standing for review. Before the end of the 30 day review period, the beginning of which period shall start to run with submittal of a research paper or report to each fully paid member, if a Center Member determines that the proposed publication does contain Center Technology of interest, the member may request a three-month moratorium to allow it to decide if the proposed publication contains patentable Center Technology of interest. The reasons for the three-month moratorium on public disclosure, which may be granted at the discretion of the Center Director, must be clearly stated in the request. During and after the 30-day review period, the Center Member shall keep such disclosures confidential, in accordance with the terms of the Membership Agreement, in order to allow the University or any Center Member to evaluate the research results for patent purposes. The Center will notify the Center Members when a graduate thesis or dissertation, which has been authored by a student supported entirely or in part on a Center project, has been submitted for approval to any faculty member of the participating universities. Center Members have the right to request and receive a copy of said thesis or dissertation prior to any public disclosure of the thesis or dissertation, in accordance with the provisions found in the Membership Agreement. The Center Members will have 30 days from receipt of such copy in which to review the thesis or dissertation to identify intellectual property of interest to the Center Member. In no event shall publication of the thesis or dissertation be delayed more than 60-days after the end of the 30-day thesis/dissertation review period for an appropriate intellectual property filing to be made by the University or any Center Member.

### **Operating Budget**

The operating budget for the CCMC comes from industrial funding, NSF, The State of New Mexico and the cost sharing provided by the three universities. The industrial money is very highly leveraged since UNM, Rutgers and Penn State pay the salaries of their respective faculty. Research funds provided by participating companies are allocated to the costs of the research program. Additional leveraging and funding of individual projects or program areas is provided by Federal grants obtained by Center researchers.

The Universities have established a mechanism for the transfer of membership funds to accommodate the project priorities as determined by the annual vote for fund allocation among research projects.

### **Patent Guidelines**

**General Basis** — The CCMC patent procedures follow the standard UNM, Rutgers University and Penn State patent policies modified to accommodate the goals of cooperative research with industry. The patent policy procedure described herein is subject to the NSF Standard Patent Rights Clause (see NSF Grant Policy Manual 751.3 implementing the Bayh-Dole Act, 35 U.S.C.200 et seq.) including March-in rights.

**Invention Reporting and Ownership** — Inventions made on the Center's Cooperative Research Program shall be promptly reported to the inventing university (or universities in the case of a joint invention) and Center Members. Title to inventions made in the course of this

research on the Center's Cooperative Research Program shall vest in the inventing university(s) or its (their) designee(s). Ownership of Center Inventions shall be determined using the following qualifiers:

1. Ownership shall vest in UNM for Center inventions made solely by one or more Center researchers from UNM.
2. Ownership shall vest in Rutgers for Center inventions made solely by one or more Center researchers from Rutgers.
3. Ownership shall vest in Penn State for Center inventions made solely by one or more Center researchers from Penn State.
4. For inventions made by researchers from any two or each of the three universities, ownership shall vest jointly in the respective universities.

The same protocol holds for inventions involving Center researchers from other universities.

**License Rights** In the event that one university in the case of sole university inventions or multiple universities, in the case of a joint invention, first file for a patent on an invention from the Center's Cooperative Research Program, the Center Members in good standing that are part of the Center's Cooperative Research Program on the date of the Invention Disclosure shall be granted an option to obtain a royalty-free, non-exclusive license to practice such invention.

In the event that one university in the case of sole university inventions or multiple universities, in the case of a joint invention decide to pursue a patent on a Center invention, Center Members in good standing that are part of the Center's Cooperative Research Program on the date of Invention Disclosure will receive an option to obtain a limited, royalty-free, non-exclusive, non-transferable license without the right to sublicense. The Center Members that elect to exercise their license option must agree to share the patent costs in exchange for a royalty-free, non-exclusive license to use such invention for the life of the patent protection that is obtained subject to the Center's formal Patent Procedures.

**Royalties** — Royalties generated from licenses to Center patents and technology will be distributed in accordance with each University's standard royalty distribution policies.

### **Patent Procedure**

1. The University where the invention was made solely by its personnel and first disclosed (hereinafter Principal University) has first opportunity (at the sole discretion of the Principal University) to apply for and pay for the patent. In this case:
  - a) The Principal University owns the patent.
  - b) Non-inventing Universities retain the right to practice for research and educational purposes.
  - c) Center Members retain an option to obtain royalty-free, non-exclusive rights, without the right to sublicense.
2. For joint university inventions, the participating Universities may agree (at the sole discretion of the Universities involved in the patent) to file and share the cost for a patent. In this case:

- a) The participating Universities jointly own the patent.
- b) Center Members retain an option to obtain royalty-free, non-exclusive rights without the right to sublicense.

3. If none of the Universities chooses to file for a U.S. Patent, each Center Member will have thirty (30) days after receipt of the Invention Disclosure from the Center to inform the Center in writing of its intent to exercise its option to have the Principal University or Universities file for a U.S. patent. In this case:

- a) Requesting Center Member(s) agree to pay for the preparation, prosecution and maintenance of the patent (hereinafter “Participating Member(s)”)
- b) All Center Members will be informed of the request to file a patent and will have thirty days to inform the Center of their intent to participate in the patent action and share the patent costs on a pro-rated basis.
- c) Non-participating Members will have waived their rights.
- d) Principal University (or Universities) retains ownership.
- e) Non-inventing Universities retain the right to practice for research and educational purposes.
- f) Participating Members have royalty-free, non-exclusive rights, without the right to sublicense, when they share in the patent costs.
- g) Participating Members may negotiate at any time for an exclusive or field of use exclusive position.
- h) Principal University or Universities may license to third parties but first must give Participating Members the option to negotiate an exclusive or or exclusive fields of use license.

4. Participating Members may request in writing that a foreign patent(s) be filed with the understanding that they will have to pay for the preparation and prosecution of the patent(s) and its (their) maintenance. In this case:

- a) Participating Members, which request that a patent be filed, agree to pay for the preparation prosecution and maintenance of patent.
- b) Principal University or Universities retains ownership.
- c) Non-Participating Members have no rights.
- d) Participating Members have royalty-free, non-exclusive rights, without the right to sublicense, when they share in the patent costs.
- e) Participating Members may negotiate at any time for an exclusive or exclusive field of use position.
- f) Principal University or Universities may license to third parties after first giving the Participating Members the option to negotiate for an exclusive or exclusive field of use position.

5. If no Center Member exercises the option to request that a patent be filed on a Center invention, all Center Members will have forfeited their rights and the Principal University or Universities may exercise its right to file for a patent.

6. If the Principal University or Universities chooses not to exercise its patent filing rights (in Article 5), the Inventors can request the rights to their invention. In this case, it is important to protect the rights of Center Members and the Universities that may already be practicing the technology base of the invention. Therefore, the inventor's request will be evaluated and if approved, will be granted with the understanding that the Center Members on the date of record of the Invention Disclosure and the Universities will retain royalty-free, non-exclusive rights.

### **Center Membership Policy**

The primary objective is the creation of a multi-tiered membership structure that meets the I/UCRC program objective to provide the greatest flexibility to recruit new Center Members from both large and small organizations.

**Eligibility** —Membership is limited to firms that have significant R&D, business or manufacturing operations in the U.S. The categories of membership in the CCMC are listed below:

#### **Tier 1 — Standard Voting Membership**

- a) Full rights to Center Technology
- b) Large company (>500 employees)—\$35K annual membership fee—1 vote
- c) Small company (SBIR eligible size)—\$10K annual membership fee—1/3 vote

#### **Tier 2 — Affiliate Membership**

- a) Approval of Center Directors required
- b) Rights to technology only from specific program/project being supported
- c) Minimum annual program/project support of \$10K
- d) No voting rights

#### **Tier 3 — Associate Membership**

- a) No rights to Center Technology
- b) No voting rights
- c) Access to Center/University facilities under provisions that are established by each university

The standard Large Company Membership Agreement is shown in Attachment 1. The Small Company (SBIR eligible) Membership Agreement is the same except for a smaller annual membership fee and 1/3 of a vote on the CCMC IAB.

### **POTENTIAL BENEFITS TO INDUSTRIAL MEMBERS**

Benefits of membership in the Center's Cooperative Research Program are listed below.

1. Each voting Center Member is entitled to one voting representative on the Center's IAB. This entitlement provides the Center Members a formal opportunity to suggest new projects

for the cooperative research program, select the projects to be funded, and to participate in determining the research direction of the Center.

2. A voting Center Member may allocate its funding to a specific research area(s).
3. A Center Member may send up to five representatives to the semiannual IAB and Technical Review meetings. The presentations by the Center faculty and a poster session provide opportunities for representatives to discuss those projects of particular interest with the involved faculty members and graduate students.
4. A Center Member receives at least one CD copy of the semiannual formal Research Reports. At least one CD copy of the oral technical presentations is provided to each member.
5. A Center Member receives an option for a non-exclusive, royalty-free license to inventions made on the Center's cooperative program if they share patent costs or if one or more of the Universities pays for the cost of a patent.
6. A Center Member through participation in Center Technical Review meetings and progress reports can keep abreast of a wide range of ceramic and materials research results and opportunities. The pooling of membership fees provides base funding for the research of approximately 25-35 graduate students. This provides a cost-effective mechanism for Member Companies to gain detailed access to a broad base research program for a small percentage of the cost of performing research in-house. Funding from NSF, New Mexico and New Jersey and support from Sandia and Los Alamos National Laboratories including participation of National Laboratory researchers in Center research projects provide additional leveraging.
7. A Center Member can choose to send a visiting scientist to the Center. If this person works on one of the research projects in the cooperative program, there is no extra fee required from the Member Company. An extra fee is required in accordance with each university's access to facilities policy if the visiting scientist works on a research project other than a project in the cooperative program.
8. A Center Member has access to the Center and its faculty as a resource for technical questions, occasional technical services, and conducting individual research projects under separate contract.
9. A Center Member gains exposure to graduate students and undergraduate students at the semiannual review meetings to assist in the recruitment of new staff members.

### **RESEARCH PROGRAM**

The Center's cooperative program research projects are integrated into five (5) highly interdisciplinary research areas that cover a broad spectrum of ceramic and related materials science and engineering.

#### **CCMC Research Thrust Areas**

- Catalysts and Porous Materials
- Powder Synthesis and Materials Processing

- Ceramic Armor/Structural Ceramics
- Materials for Energy Conversion and Electrochemical Processes
- Nanomaterials: Particulate Synthesis and Processing

The overall research program of the Center comprises a cooperative research program, individual projects for industry, Government grants and contracts and joint Government projects with industry. The five research areas provide for interaction among researchers in different areas. Research results generated in one research area can be immediately utilized in other areas to contribute to their technical progress. This highly interdisciplinary research program emphasizes the interaction among the main research areas as shown below:

### **CCMC Research Projects**

#### **Catalysts and Porous Materials**

Development of Super-Hydrophobic and Self-Assembled Materials by Sol-Gel Routes — Jeff Brinker

Sintering of Heterogeneous Catalysts — Abhaya Datye

Synthesis of Mesoporous Oxide Powders — Abhaya Datye, Tim Ward and Jeff Brinker

Characterization of Heteroepitaxial Growth on Patterned Silicon Surfaces — Abhaya Datye

#### **Powder Synthesis and Materials Processing**

Low Cost Scalable Synthesis of Dispersed Single and Multicomponent Metal Oxides — Richard Riman

In Situ Analysis of Nucleation and Growth during Atomic Layer Deposition of Copper Barrier & Seed Films — Steve George

Conformal Plasma Coating of Particles for Polymer Composites — Don Weinkauf

Chemical Uniformity in Ceramic Powder Processing — Richard Riman

The Determination and Control of Water Content in Ceramic Powders — Richard Riman

Experimental and FE Modeling Study of Co-sintering Multilayer, Multifunctional Ceramic Structures — M. John Matthewson and W. Roger Cannon

Additive Removal from Consolidated Ceramics — Richard Haber

Particle Orientation in Green Microstructures — Richard Haber

Densification Stresses and Distortions Produced by Density Gradients — David Green, Gary Messing and Al Segall

Uniformity of Simultaneous Powder Deposition in Multiple Dies Tester Design and Development, Measurement, and Modeling — Virenda Puri and Abraham Grader

**Materials for Energy Conversion and Electrochemical Processes**

Nano-Electrode Arrays based on Anodized Aluminum Oxide — Dmitri Brevnov and Plamen Atanassov

Oxidation Resistance of Carbonaceous Materials — Plamen Atanassov

Fabrication of Pd Based Hydrogen Separation and Storage Membranes — Tim Ward

Enzymatic Bio-Fuel Cells — Plamen Atanassov

Non-Platinum Electrocatalysts for Direct Methanol Fuel Cells — Plamen Atanassov

Amorphous Electroactive Materials — John Xu

### **Structural Ceramics/Ceramic Armor**

Determination of the Root Cause of the Poor Ballistic Performance of Boron Carbide — Manish Chhawolla and Dale Niesz

Non-Destructive Evaluation of Ceramic Armor — Richard Haber and Dale Niesz

Property Measurements as Estimators of Ballistic Performance — Roger Cannon

Effect of Gas Phase Composition in Pores During Densification — M. John Matthewson and Dale Niesz

Defining Microstructural Tolerance Limits of Defects for SiC Armor — Richard Haber

### **Nanomaterials: Particulate Synthesis and Processing**

Dispersion of Nanoscale  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> as a Function of Phase and Degree of Hydration — James Adair

Electrophoretic Deposition Studies of Nanoparticles for Thin Films and Coatings — James Adair and Clive Randall