MRS

Materials
Research
Society

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August 13, 2010

Mr. Aneesh P. Chopra
Associate Director and Chief Technology Officer
Office of Science and Technology Policy
New Executive Office Building
725 Seventeenth Street, NW
Washington, DC 20502

Dear Mr. Chopra:

The Materials Research Society (MRS) applauds your efforts to reach out to the science and technology community and ask for individual comments from researchers in the field of nanotechnology as you develop the next phase of this very important federal program.

MRS has encouraged our membership to submit their personal input to the NNI Strategic Plan 2010 RFI as outlined in the Tuesday, July 6 Federal Register. In addition, our Materials Research Society leadership proposed that we consider providing some overall comments for your consideration. To that end, we asked a number of recognized experts in the field who have served as nanotechnology symposium organizers at MRS meetings to come together as a short-term task force and provide input to the RFI for transmittal to OSTP.

While we have chosen to not comment on every single area of the Request for Information, we have summarized the ideas of this task group in the attached document. The specific questions which were addressed by the group and the recommendations by section are clearly identified. In addition, we have included a list of the participants, by name and institution, who were involved in the review.

As you develop the final version of the NNI Strategic Plan in the coming months, we welcome any suggestions you might have as to how our professional society might be helpful in the future. The National Nanotechnology Initiative is an important contributor to the work of many in the interdisciplinary materials research field and MRS is most grateful for the support that the federal government has provided to our community.

If you should have any questions, or if we can be of any further assistance, please feel free to contact me at 505-844-6385 or contact Ron Kelley our Washington, DC representative at 202 256-5211.

Sincerely yours,

Dr. Duane B. Dimos

Chair, MRS Government Affairs Committee

Materials Research Society

MRS Task Force on NNI Submission to Request for Information – NNI Strategic Plan Input - August 13, 2010

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B. Research Priorities

B.1

“Important Gaps”

“Bionanomaterials”

In the next decade the medical and biological interest in nanomaterials and nanostructures should increase dramatically. Nanomaterials are capable of adhering to a cell’s surface or the ability to penetrate within the cell and to impact new physical interactions and chemical reactions. Recommend adding a priority “Materials and Systems for Biology and Medicine at the Nanoscale”.

“Nanocomposites”

There is a range of properties and associated research from nanoparticles to nanocomposites to integration of nanomaterials into systems. The entire range requires exploration and further research to better understand the impact on nanomaterials in a system environment.

“Relativistic Quantum Mechanics of Nanomaterials and Nanostructures”

The nanoscience revolution can be fuelled by advances in theoretical physics. Most of our theoretical approaches are based on non-relativistic equations and empirical approaches to add spins (which are intrinsically a relativistic effect). Funds for progress within the relativistic quantum theory of few bodies, modeling, and simulations are required. We need to train our best young scientists in this incompletely explored field of quantum mechanics.

B.2

“Nanomanufacturing”

Nanoscience is based on a structural scale ranging from 1 to 100 nm, while the manufacturing process for commercialization typically has a requirement for materials and their structural integration and uniformity at the macro scales. This gap in scale for assimilation into the manufacturing process is an obstacle for realizing the commercialization in applications geared toward nanoscience. As an example, a single carbon nanotube (CNT) exhibits superior mechanical properties at the nanoscale, however, the challenge still remains to obtain a uniformly dispersed CNT/polymer matrix at the macro-scale to form strong composites, even after a decade of research.

We recommend that NNI identify and target research programs on nanomaterials with structural integrations to “multi-scales”, ranging from the nanometer to micron and even larger scales. Such nanomaterials are likely to be successful for applications due to their ease of inserting into the manufacturing process. The graphene/SiC nano-structure is an example of a success story in the making. Graphene grown by SiC surface decomposition exhibits an atomic thick graphitic layer on SiC with a good uniformity on the scale of 10’s of mm. Having just been realized as novel electronic materials in

2004, a prototype ultra-high speed transistor has been recently demonstrated in 2010 with promising applications for next generation electronics.

"Electronics"

The challenges to next generation electronics include: higher speed, lower cost, and greener methods for their production. Si-based electronics are close to the theoretical limits in all these aspects. However, no materials are thought to be candidate to replace Silicon. Several new electronic materials, including nanomaterials, have been widely investigated for next generation electronic materials. Carbon nanotubes (CNTs) exhibit superior electronic properties in higher mobility for high speed, potential low cost and less production pollutions. However, CNTs based electronic devices with high reliability for large scale manufacturing have not been achieved. Due to lack of understanding of the fundamental CNT growth mechanisms, techniques in atomic-scale structural control of CNTs are not available.

Electronic properties are controlled at the atomic level. In addition, the bottom-up synthesis of nanomaterials requires a full understanding of the growth mechanisms and/or chemistry at the atomic scale. Thus, we recommend that NNI increases the support of fundamental issues in growth mechanism from the atomic to nanoscales as well as in nanochemistry.

One of the technological and scientific challenges to achieve NNI goals: combining the conventional and unconventional technologies to grow nanomaterials and nanocomposites: for example, growth of embedded quantum dots in semiconductors while maintaining the crystal quality and purity.

B.3

"Responsible development of nanotechnology"

Nanomaterials and the environment (Goal 4) still needs to be better understood from both the impact of nanomaterials on the environment and the impact of environmental conditions and effects on nanomaterials. Additional focus on nanotoxicity will be required as a part of the next stage of the NNI program.

"Purity of nanomaterials"

Purity of nanomaterials in a broader way requires NNI to address "characterization" issue further. There is a lack of full characterization and batch to batch consistency (or inconsistency) and there is a need for more accurate characterization of nanomaterials including instrumentation and the need for new characterization methods.

Purity of nanomaterials needs to be well defined, which is extremely important for applications and toxicity studies. For example, some toxic properties may not come from nanomaterials, instead, they may come from the byproducts during the treatment of the nanomaterials.

Minimum progress can be made under the current funding. Well-developed definition for the purity of nanomaterials (in addition to their sizes) is needed, including sources of materials prepared, functionalization materials applied, and purification methods adopted, etc.

"Instrumentation"

Instrumentation development for nanomaterials analysis and for studying the interactions of nanomaterials and biomaterials should have high priority as well. The electronic and optical properties of nanomaterials are extremely sensitive to the environment, making them excellent probes for sensing many variables, possibly at the single molecule level. There will be a growth point here if we integrate the unique nanostructures with other existing methods.

"Education"

Goal 3 is specifically directed at developing a skilled workforce who will continue to revolution in nanomaterials. Dissemination of nanoscience and nanotechnology progress is essential to success. One of the challenges to meet NNI goals would be to bridge the gap at the grass roots level, for example, relationship between grade schools and universities. Introducing the concepts of nanotechnology to all high/middle school students would accelerate their preparation to this important area as they reach college and beyond. Training of teachers and the fostering of a broader understanding of nanoscience within the science curriculum can be encouraged by NNI.

C. Investment

C.1

"Types of Investments"

The current R&D investment is well distributed for individual investigators, small teams, centers, research infrastructure etc. However, there are no quantitative data showing the relative investment distribution for these categories, as well as comparing the productivity and performances between these investments. These quantitative data are important for evaluation of future R&D investments.

Creativity is a major component of Nanotechnology. It is important to enhance support for individual investigators and small teams to study promising new ideas. In comparison, centers should be funded to work on a focused theme for various approaches. Relative support for individual investigator and centers needs to be carefully balanced to enable exploration of untested ideas from individual investigators and small teams and the research synergy resulting from larger teams or centers.

Investment in research infrastructure is also important. However, a lot of key infrastructure has been established, so there is probably an opportunity to focus more future investment on investigators and students.

More investment in academic-industry collaboration is needed to transform ideas to business. However, measures should be taken to ensure that these investments are well distributed between academic and industry sectors in a cost effective manner. Care should be taken to avoid excessive spending in supporting administrative personnel.

C.2

"Relative Distribution Among The PCAs"

Program Component Areas (PCAs):
1. Fundamental Nanoscale Phenomena and Processes
2. Nanomaterials
3. Nanoscale Devices and Systems
4. Instrumentation Research, Metrology, and Standards for Nanotechnology
5. Nanomanufacturing
6. Major Research Facilities and Instrumentation Acquisition
7. Environment, Health, and Safety
8. Education and Societal Dimensions

PCAs 1, 2, 3, should continue to be the dominant focus of NNI investment. In particular, the investment on PCA 2 should be enhanced as nanomaterials are the fundamental basis for nanotechnology.

As a comparison, investment on PCA 5 (nanomanufacturing) should not be further increased for two major reasons: i) there are very few commercial products that will require mass production of certain nanomaterials, ii) the environmental and health impacts of large quantity nanomaterials are still not well understood. More investment should be channeled to PCA 3 that will promote the creation of novel devices and systems. Academic-industry partnership on PCA 3 should be emphasized.

Investments PCAs 7 and 8 should be enhanced as these are important as more nanomaterials and products are being created.

C.3

"Balance Between Public and Private"

The relative investment between private and public entities should be different for each of the R&D projects. Government should take more responsibility on basic research, the study of environmental and health impacts, and other educational and societal topics.

Corporate investment should be dominant for projects that involve devices and product development as these projects become closer to commercial and business implementation.

The overall status of nanotechnology is still far away from mass commercialization. To further accelerate the transformation of basic science into real products, both public and private investments are equally important to promote academic-industry partnerships. Government should take the lead to enhance academic-industry partnership and funding for these partnerships for both universities and industry will be required in the early stages of these NNI programs.

D. Coordination and Partnerships

D.1

"Interagency interactions"

Additional logical interagency initiatives/partnerships that make use of complementary strengths would be very worthwhile. What often prevents this from happening on a regular basis is the fact that individual agencies need to respect their congressionally mandated missions which are by definition mutually exclusive. Nevertheless, joint interactions would have merit.

D.3

"Partnership and collaborations - roles of professional society"

NNI and several federal agencies have actively explored the effective mechanism for commercialization of nanomaterials. This is an ongoing issue and challenges remain. The current policy of the NNI and other federal agencies is vague.

Professional societies have the advantage of involving researchers and administrators from academics, industry, and government at their annual meeting and special topic workshops. They frequently support the interaction with researchers working on nanotechnology projects and in doing so are supporting Goal 1 of the NNI program. We recommend that professional societies play active roles in organizing symposium and workshops which will support Goal 2 by presenting specific successful stories in partnerships and collaborations. From these workshops they could provide specific suggestions and recommendations to federal agencies and the NNI program.

D.4, D.5, and D.8

"Successful technology transfer examples"

NNI investments will produce a lot of successful research results. Tech transfer stories which have been successful in transferring NNI research should be captured and referenced for the benefit of all. There are some examples that could be pointed to where the method of transfer has been particularly successful. e.g. A123 (battery company spun out of MIT). The current program on Soldier of the Future at MIT has produced new sensors in Iraq today from this joint program with Army Research Office.   We believe there are many other examples in the materials community which could be used as models and this awareness would enhance the chance of achieving Goal 2.

Encourage universities and government laboratories to conduct R&D that will systematically build an understanding of nanoscale fundamentals to enable application based problem solving.

Invest in standards development. Increase participation of government agencies and increase government funding of organizations such as ISO that are promoting science based standards that will accelerate commercialization.

D4, D.5

"Accelerating transition to useful products"

Look at the experience of MMRS – multi organization effort with the major pharmaceutical companies where universities can contribute in a rather complex business model to accelerate the time to market for drugs. It has been very successful – e.g. new drugs produced within 3 years from the research discovery. Use this as an example of successful lessons learned.

New mechanisms should be considered for investments in research which dramatically improve the chance that the research results in market success. A consortium or collaborative effort that works in this way is found in the semiconductor industry – nanoelectronics. Semiconductor Research Corporation (SRC) which is financed by industry and supports works at many universities.

Energy Frontier Research Centers' (EFRC) are focused on a partner's best practice – e.g. universities for the most part are doing the fundamental basic research and companies are doing the translational R&D.

For some proportion of government funding, prioritize R&D initiatives based on an assessment of potential for enabling commercial value.

D.6

"Industry component for NNI"

NSF has a program for industry called Goalie – industry and academia work together – establish a specific program within NNI that encouraged something similar. Currently the financial benefit goes primarily to the university not the company directly. Ensuring shared benefits would be important for any new program under NNI direction. e.g. establish a mechanism that might work better to support industry rather than just sitting on advisory boards.

Provide mechanisms for federally funded research projects to be led by industry. ARPA-E, EFRC and DARPA are good models.

Give industry more voice - include industry experts in an advisory capacity, having a committee of scientists in addition to PCAST that advises the NNI. Include more industrial participants in grant reviews. Establish forums with representatives of the materials and chemical industry.

Using the EFRC as a model, develop consortia using government funding to address critical US needs. Have industry lead these efforts since they are the most proficient in translating invention into innovation.

Provide both large and small companies increased access to US government funding for fundamentals as well as applications R&D

Provide industry access to national user facilities with equitable fees and ownership of intellectual property.

For user facilities, canvas the industrial community to ensure that they are meeting their needs. For example, most of the nanomanufacturing facilities are focusing on fabrication techniques (e.g. semiconductor processes). Research that would enable materials development, such as on line real time measurements during chemical and material processing would be welcome.

D.7

"Intellectual Property"

Establish intellectual property policies at universities and government labs that create a more favorable climate for partnering with companies and for accelerating commercialization.

D. "Other Considerations"

A roadmap for nanomaterials was developed by the Vision2020 group and can be found at www.chemicalvision2020.org. There were a number of recommendations that have not yet been implemented that would foster collaboration, and accelerate commercialization.

Create a position with OSTP that develops strategies for fixing the tech transfer issue. Quantify what has made it to the marketplace both from a basic research perspective (i.e., the fundamental physics) and an applied research perspective (a new method for storing energy based on the fundamental physics).

Think about the reward structure at universities. Is patenting the right output? Were we better off when the role of universities was educating students and fundamental science? Did more things wind up in the open literature and later were commercialized by industry? Is there some middle ground between rewards based on publishing vs. patent applications?

Through the NNI program office, host technical workshops and symposia for industry, university, and government researchers and allow for large amounts of interactions. Provide funding mechanisms for collaborations between these groups.

Environmental Health and Safety policy support appropriate agencies such as NIST, NIOSH, NCI to conduct studies.

Create a searchable national database for nanotechnology based on federally funded research.

E. Evaluation

E.1

"Criteria for NNI Evaluations"

Goal 1: Advance a world-class nanotechnology research and development program.

Generally speaking, criteria should include increase in university research programs, significant discoveries or advances, publications, patents, and licenses. In addition, the number of individuals (including students, technicians, and postdocs) trained and number of jobs directly created by NNI should be quantified. Within this subset, it would also be beneficial if data on participation of minorities and members of underrepresented groups could be collected. In addition, granting agencies might require reviewers to evaluate/comment on the previous grant-supported research of the proposers.

Consider specifying criteria for each PCA to account for the differences in appropriate metrics (i.e. research, manufacturing and education will require very different evaluation criteria).

Clearly state the criteria and desired output with respect to evaluation in order to facilitate reporting at the end of a grant.

It is also necessary to recognize the challenges associated with some of the potential evaluation criteria such as university or employer influence on the publication and patenting processes. Universities do not provide the same level of support for patent filing from a policy and/or a financial resource standpoint. Many companies, on the other hand, do not permit publication of research results in the interest of delaying disclosure and protecting intellectual property for future patent plans.

Goal 2: Foster the transfer of new technologies into products for commercial and public benefit.

A metric of innovation that should be considered is the number of licenses that have been made to corporations.

Goal 3: Develop and sustain educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology.

(As stated under Goal 1) – The numbers of individuals (including students, technicians, and postdocs) trained and numbers of jobs directly created by NNI should be quantified. Within this subset, it would also be helpful if data on participation of minorities and members of underrepresented groups could be collected.

E.3

"Balancing Fundamental and Applied Research"

As introduced in C-Investment, – fundamental and applied research should be the primary focus areas to achieve the NNI goals.

Specific to fundamental research, PCAs 1 and 2 should be the dominant focus of NNI investment. Applied research, addressed in part by PCA 3, should also be emphasized. (It should be noted that increased investment in PCA 2 – nanomaterials will lead to advances in PCA 3 – devices and systems).

At this time, increased investment in PCA 5 – nanomanufacturing – would be premature as we do not have many commercial products that require mass production of nanomaterials, and the environmental and health impacts of large-scale production of nanomaterials require additional attention to understood.

It is necessary at this time to continue to invest in PCAs 7 and 8 in order to develop a fundamental understanding of environmental, health and safety impacts of nanotechnology development. At the same time, education to increase awareness, understanding and interest in this field is required. This applies to the general public, K-12 and post-secondary students and educators, as well as our technical workforce.

F. Policy

F.1

"New Policies"

NNI is a coordinating body within the federal government and does a very good job in maintaining an awareness of programs and expenditures by program component areas. What additional authority could be given to the NSTC organization to ensure that strategic plans are implemented year to year by the agencies which have the responsibility for executing NNI goals? This recommendation attempts to move beyond being aware of activities in each of the agencies to ensuring they achieve the four goals of the NNI program and the next strategic plan for the initiative.

"Education"

As nanotechnology spreads throughout industrial and societal sectors with new technologies, products, and jobs. Goal 3 calls for a more competent workforce with the nanoscience knowledge and skills.

The performance of American students in sciences and mathematics at middle and high schools are below the average of the industrial countries. The enrollments of undergraduate students who major in science and engineering in US universities have declined in the past decades. Nanosciences have been recognized as a part of science and science teachers need new tools to promote science learning. NSF has several programs studying the integration of nanosciences in science curricula in middle and high schools, and the studies have demonstrated that nanosciences can be integrated in the current curricula.

NNI should develop a strategic plan to integrate the nanosciences into the curricula of science courses at middle and high schools in the coming years. It will be a societal and generation wide impact. Since the curricular reform involves many organizations, standard test revision, teacher training, and text book updates, and evaluation, NNI could be in a position to play a major leadership role.

Professional societies are in a unique position to support nanoscience and nanotechnology education by working with their members to develop educational materials, activities and programs that increase awareness, understanding and appreciation. These educational resources can be used to increase awareness and understanding of the general public, promote curiosity and excitement in K-12 students and educators, and interest among university students.

In additional to resources for students and educators, professional development workshops for practicing scientists are needed to train and support these professionals in their endeavor to educate lay audiences about their research.

These activities should be encouraged and supported by federal programs such as NNI as they result in collaboration across many disciplines that involve research at the nanoscale and widespread dissemination of educational resources.

"Visa and Permanent Residency Requirements"

If a foreign student studies a technology discipline in US and has high-achieved research credentials, he/she might get a permanent residency by applying for the category of 'National Interest Waiver

(NIW)'. Unfortunately, the process can take nearly three years under current practices. Foreign graduates from accredited US institutions should be able to have a more expedited process for consideration. We recommend that the NNI program should have sufficient experience to consider how individuals working in NNI funded programs are currently impacted by student visa, scholar visa, and permanent residency requirements and procedures.

"Prizes"

X-prizes with very ambitious but well-defined objectives can be a tool for more rapidly fostering innovation and potential nanotech commercialization. The use of prizes is primarily oriented towards NNI investments that have reached the stage of applied research or nano processing.

F.2

"Best Practices"

Refer to previous recommendations made in Section D on best practices including D.4, D.5, and D.8.

"International"

An additional focus on strengthening international collaborations should also be emphasized. Science is a global enterprise, so encouraging foreign collaboration would be positive step for the program. The most effective initial action could be to attempt some level of awareness and even coordination with government sponsored programs in other countries. Select foreign countries where they have NNI equivalent organizations that might mutually benefit from this collaboration.