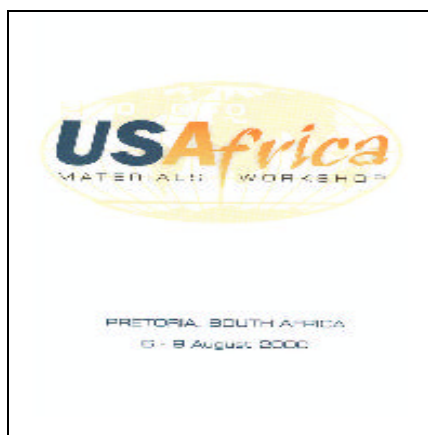
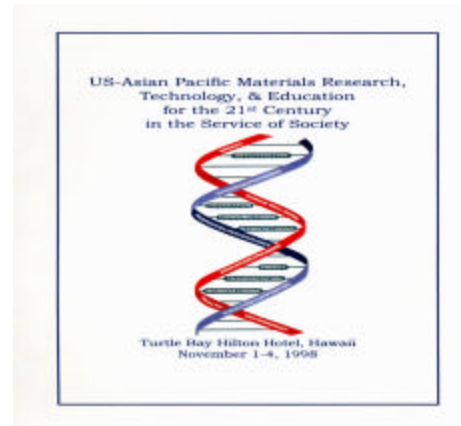
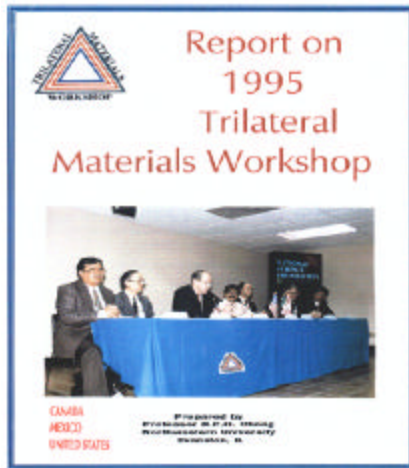


TOWARD AN INTERNATIONAL MATERIALS RESEARCH NETWORK

Status Report, January 2002



**US-Middle East
Materials Workshop**

**Planned
For
2002**

Background

Materials are more than mere components of modern tools - the basic properties of materials frequently define the capabilities, potential, reliability, and limitations of technology itself. Materials and processes will play an ever increasing role in improving energy efficiency, promoting environmental protection, lowering health-care costs, developing an information infrastructure, providing modern and reliable transportation and civil infrastructure systems, and strengthening security worldwide. Advances in materials science and engineering, therefore, enable progress across a broad range of scientific disciplines and technological areas with dramatic impacts on society.

Continued progress in materials science and engineering is increasingly dependent upon collaborative efforts among several different disciplines, as well as closer coordination among funding agencies and effective partnerships involving universities, industry, and national laboratories. Because of the interdependence of countries' national priorities, partnerships are not only important at the national level but from an international point of view as well.

With this in mind, the National Science Foundation has co-sponsored a series of five international workshops in materials research designed to stimulate enhanced collaboration among materials researchers and create networks linking the participating countries.

The first workshop, held in May 1995 in Saltillo, Mexico, involved scientists and engineers from the U.S., Canada, and Mexico. The workshop was organized by Dr. Leonel Cota Araiza, Instituto de Fisica, UNAM, Ensenada, Mexico; Prof. R.P.H. Chang, Northwestern University, Evanston, IL, USA; Dr. Manuel Mendez Nonell, CINVESTAV, Saltillo, Mexico; and Prof. Juan Sanchez, University of Texas, Austin, TX, USA, and was attended by 57 participants and observers from the three principal countries as well as Brazil, Chile, and Columbia. NSF was represented by William Harris, Adriaan de Graaf, Harold Stolberg, and Robert Wellek.

The second workshop, a joint National Science Foundation-European Commission venture, took place in December 1996 in Leuven, Belgium. The workshop was organized and chaired by Prof. Horst Czichos, President, BAM, Federal Institute for Materials Research and Testing, Berlin, Germany; Prof. Bertrand Escaig, Laboratoire de Structures et Proprietes de l'Etat Solide, Universite des Sciences et Technologies de Lille, France; Prof. Jean-Pierre Celis, Faculty of Applied Sciences, Catholic University, Leuven, Belgium; Dr. Praveen Chaudhari and Dr. Mark Ketchen, IBM T.J. Watson Research Center; Prof. Venkatesh Narayanamurti, Dean, Division of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA; and Dr. James Williams, Dean, College of Engineering, Ohio State University. The workshop was attended by 72 scientists and engineers from EU member states. NSF representatives included Adriaan de Graaf, Lance Haworth, Jeanne Hudson, John Hunt, John Hurt, Elbert Marsh, and Thomas Weber.

The third workshop, involving participants from the U.S. and Pan American countries including Brazil, Argentina, Chile, Uruguay, and Venezuela, took place in Rio de Janeiro, Brazil in June 1998. The workshop was organized by Dr. Miguel Blesa, Comision Nacional de Energia Atomica, Buenos Aires, Argentina; Prof. Guillermo Solorzano, PUC, Rio de Janeiro, Brazil; Prof. Edgar Zanotto, Universidade Federal de Sao Carlos, Brazil; Prof. Guillermo Gonzalez -Moraga, Universidad de Chile, Santiago, Chile; Prof. R.P.H. Chang, Northwestern University, USA, and Dr. Kathleen Taylor, General Motors, USA and was attended by 79 participants from Argentina, Brazil, Chile, the United States, and observers from Colombia, Honduras, Mexico, Uruguay, and Venezuela. The NSF was represented by Adriaan de Graaf, Robert Eisenstein, Raul Miranda, Harold Stolberg, Thomas Weber, and Robert Wellek.

The fourth workshop focused on the U.S. and Asian Pacific countries and was held in Hawaii in November 1998. The workshop was organized by Prof. Masao Doyama, Teikyo University of Science and Technology, Japan; Prof. Minhua Jiang, Shandong University, China, Prof. Hyeong Joon Kim, Seoul National University, Korea; Prof. Jim Williams, The Australian National University, Australia; Dr. Nikolai Lyakhov, Siberian Materials Research Association, Russia; Prof. Lih J. Chen, National Tsing Hua University, Taiwan; and Prof. R.P.H. Chang, Northwestern University, USA. The 81 participants and observers were from Australia, China, Japan, Korea, Malaysia, Singapore, Taiwan, the United States, and South Africa. NSF representatives included Adriaan de Graaf, Lance Haworth, Alice Hogan, George Strawn, Thomas Weber, and Robert Wellek.

A fifth workshop involving the U.S. and African countries took place in Pretoria, South Africa in August 2000. The workshop organizers were Prof. Ababacar Chedikh Beye, UCAD, Dakar, Senegal; Prof. Arthur Every, University of Witwatersrand, South Africa; Dr. Joseph Gogo, STEPRI, CSIR, Ghana; Prof. Kavishe, Moi University, Kenya, Nairobi, Kenya; Prof. Marjorie Mujaji, University of Zimbabwe, Zimbabwe; Prof. E.R. Sadiku (representing Nigeria), University of Stellenbosch, South Africa; Prof. Ron Sanderson, University of Stellenbosch, South Africa; Prof. Joseph Tesha, University of Dar es Salaam, Tanzania; Prof. A.J. Varkey, University of Swaziland, Kwaluseri, Swaziland; Prof. R.P.H. Chang, Northwestern University, USA; and Prof. Isiah Warner, Louisiana State University, USA. The number of participants and observers was 81 from Botswana, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Morocco, Namibia, Nigeria, Senegal, South Africa, Swaziland, Tanzania, United States, Zambia, and Zimbabwe. NSF representatives included Joseph Bordogna, Adriaan de Graaf, Robert Eisenstein, Lance Haworth, Elbert Marsh, Wanda Ward, and Thomas Weber.

These workshops have involved close to 400 people from many countries, from government, from industry, and from universities. Their ideas, contributions, and support resulted in a set of high-quality workshop reports. The executive summaries of these reports are attached to this status report. The full reports of the workshops are available at <http://www.iumrs.org>.

The idea for the workshops was conceived by the author and by Prof. R.P.H. Chang, Director of the Northwestern University Materials Research Center. Prof. Chang, who was the co-organizer of and the brains behind 4 of the 5 workshops, i.e., those held in Saltillo, Rio de Janeiro, Hawaii, and Pretoria, received support from NSF for this activity. The Leuven workshop was organized directly by the NSF and the EC. NSF staff who played significant roles in making the workshops the successes they were, include Alex DeAngelis, Lance Haworth, Alice Hogan, Jeanne Hudson, John Hunt, John Hurt, Harold Stolberg, Pat Tsuchitani, Thomas Weber, and Robert Wellek. The encouragement by NSF Director Neal Lane during the initial stages of this effort and the constant support by NSF Deputy Director Joseph Bordogna and NSF Assistant Director for Mathematical and Physical Sciences Robert Eisenstein, have provided valuable stimuli to continue this important project, despite inevitable administrative and political obstacles. This effort has brought us closer to the ultimate goal of achieving an international materials network that facilitates the development of future technologies and provides future generations of young scientists and engineers throughout the world with greater opportunities.

Conclusions

The workshops identified possible areas for mutually beneficial collaborations. They also led to a number of major recommendations including:

1. Promoting *virtual institutes* via the internet with video capabilities for distance conferencing and learning;
2. Organizing and coordinating *exchange science and education programs* at all professional levels;
3. Developing a *materials world net* that will act as a resource for research and education (e.g., a searchable database containing materials properties, publications, facilities, instruments, experts);

4. Establishing *mechanisms for long-term collaborations* among academia, industrial, and government laboratories; and

5. Enhancing *public awareness* of the contributions of materials science and technology.

Ongoing and Future Activities

A sixth workshop involving Middle East countries is being explored. Lance Haworth and David Nelson from NSF visited counterpart funding agencies and materials research institutions in Egypt, Jordan, and Turkey in the fall of 2000, and Robert Eisenstein and David Nelson met with agency officials, researchers and educators in Israel in 2001. A planning meeting for the US-Middle East materials workshop is tentatively scheduled for 2002 in Ankara, Turkey.

As a result of the joint National Science Foundation-European Commission workshop, an implementing arrangement between the European Commission and the National Science Foundation for cooperative activities in the field of materials sciences is now in effect (see <http://www.nsf.gov/pubs/2000/nsf0018/nsf0018.htm>). The first awards were made in 2000 and 2001 following open competitions which involved coordinated review by the NSF and the EC. In two of the new collaborations, for example, inter-university US teams are partnering with multinational European research groups to fabricate novel nanostructured materials and to elucidate their behavior. A joint NSF-EC workshop to identify research opportunities in nanotechnology was held in Toulouse in October 2000; a series of four topical workshops in 'nano' planned for the US and Europe in 2002 will build on the findings of the Toulouse workshop.

Efforts to develop additional US-European interactions that complement and extend the NSF-EC cooperation are also bearing fruit. With the help of the NSF Office of International Science and Engineering, MPS staff organized a series of meetings with staff from European funding agencies beginning in 1998 to exchange information about national funding programs in materials, and to explore interest in supporting bilateral and multilateral research and education cooperation. The NSF is now preparing an announcement to the research community, better known as "Dear Colleague Letter" to initiate joint activities in cooperation with several European agencies including the Deutsche Forschungsgemeinschaft (DFG) in Germany; the Consiglio Nazionale delle Ricerche (CNR), the Consorzio Interuniversitario per la Scienza e la Tecnologia dei Materiali (INSTM), and L'istituto Nazionale per la Fisica della Materia (INFN) in Italy; the Swedish Foundation for Strategic Research; Science Foundation of Ireland; and others. A workshop to identify opportunities for US-Italy cooperation in materials and nanotechnology is planned for March 2002 at the NSF.

"Dear Colleague Letters" are also being prepared by science funding agencies in Canada, Mexico, Argentina, Brazil, and Chile, as well as by NSF to initiate joint activities involving scientists and engineers from these countries in response to the recommendations of the workshops held in Saltillo and in Rio de Janeiro.

In order to explore ways to implement the recommendations of the Pretoria workshop, a meeting of government officials from thirteen African countries and the NSF was held on August 13, 2001 in Nairobi, Kenya. The minutes of this meeting are attached. A second meeting of this kind will be held in Dakar, Senegal, in 2002.

With respect to Asian Pacific countries, implementation of the Hawaii workshop recommendations is being discussed with various science funding agencies in these countries. A meeting in Moscow is planned for 2002 to explore ways to enhance scientific collaborations between materials researchers in Russia and their counterparts in the US. The Russian Foundation for Basic Research will host this meeting. Similar meetings are expected to take place with agencies in other major Asian Pacific regions (e.g., Australia, China, India, Japan, Taiwan, Singapore, South Korea) over the next few years.

The NSF is preparing an "International Materials Institutes (IMIs)" competition in early CY 2002. It is expected that this competition will lead to the establishment of up to 3 IMIs that would address

recommendations 1-5 mentioned above, serving as the initial US nodes of a world-wide network for international cooperation in materials research and education. This is a joint activity involving several directorates, including Engineering; Computer and Information Science and Engineering; Social, Behavioral, and Economic Sciences (Office of International Science Engineering); and Mathematical and Physical Sciences.

The countries mentioned in this report that contributed to the organization of the workshops will form the core of the envisioned world-wide materials network. Countries that sent observers to the workshops or those that were not represented may, of course, join the network at any time by forming partnerships with appropriate government and private organizations in other countries and issuing their own announcements to their respective research communities.

The materials network, once it is fully operational in a few years, should serve as an example for the other sciences and engineering fields to follow. We believe that international networks connecting scientists and engineers around the world are increasingly important as the new millennium unfolds, and as the demands of economic and global security test our scientific, engineering and technological capabilities more than ever.

Adriaan de Graaf
Directorate for Mathematical and Physical Sciences
National Science Foundation

January 2002



Report on 1995 Trilateral Materials Workshop



CANADA
MEXICO
UNITED STATES

Prepared by
Professor R.P.H. Chang
Northwestern University
Evanston, IL

Report on 1995 Trilateral Materials Workshop by Professor R.P.H. Chang

I. Introduction

With the approval of the North American Free Trade Agreement (NAFTA) by Mexico, the United States, and Canada in 1993, a major step was taken towards economic integration and deeper understanding and acceptance of each country's cultural diversity.

The North American Free Trade Agreement is unique. It is the first trade agreement between an industrialized and a developing nation, and the first to include intellectual property, labor rights, and the environment. Traditionally, free trade agreements do not create common markets since they do not permit the free movement of people, but they do allow for the free trade of goods.¹

However, NAFTA is more than a trade agreement; it is an investment agreement. It establishes the principle of "national treatment," which gives people in these countries the right to invest and provide services as if they were nationals. The principles of nondiscriminatory treatment also allow for such things as the transfer of capital for investment purposes, freedom from performance requirements, limited exercise of the sovereign right of expropriation, and finally the use of international arbitration rather than a nation's courts to settle trade disputes.¹

NAFTA presents the three signatory nations with great opportunities for creating an integrated economic system in which the comparative advantages of each are given full opportunity to develop within a larger trading bloc than had previously existed. It is understood that in today's economy, sustained growth and profitability depend on active and broad-based international operations. The challenge and the opportunities of NAFTA are significant. It remains for the Canadians, Americans, and Mexicans to work together over the long term as partners for their mutual benefit.

The closer economic ties afforded by NAFTA will inevitably have cultural and educational implications, but without a new level of cultural comprehension and engagement between the American peoples, trade and capital opportunities will be lost. To illuminate some of the differences, demographics and import and export information of the three countries are given in Table 1.

Table 1. 1991 Trade Figures (in billions of U.S. dollars)¹

	Canada	Mexico	United States
Mexico			
Exports	2.3	--	31.9
Imports	0.4	--	33.3
United States		--	
Exports	82.5	33.3	--

	Imports	95.6	31.9	--
Canada				
	Exports	--	0.4	95.6
	Imports	--	2.3	82.5

II. The First Trilateral Materials Workshop

NAFTA has provided a challenging opportunity, for professionals in the universities and national laboratories of all three countries may play an important role in shaping a future in which there is not only a better understanding of three diverse cultures but the skills necessary for economic integration.

A first step was taken towards this goal in May 1995 when the National Science Foundation in the United States, CONACYT (Consejo Nacional de Ciencia y Tecnologia or National Council for Science and Technology) in Mexico, and Natural Sciences and Engineering Research Council in Canada jointly sponsored an important scientific workshop. The workshop, entitled the first Trilateral Materials Workshop (TMW-95) brought educators and research scientists from all three countries together at Saltillo, Mexico for an unprecedented intellectual summit. The workshop concentrated on the engineered materials which have played a crucial role in recent technological advancements in areas such as electronics, automotive, biomaterials, metals, and telecommunications. However, the purposes of the workshop went beyond technical discussions and are expected to have far-reaching significance.

The purposes of the workshop were to provide opportunities for educators and scientists in all three countries to:

- * Exchange information on materials research, education, and technology,
- * Establish joint programs among the three countries,
- * Discuss and plan for electronic information linkages and databases,
- * Discuss participation and usage of "central" facilities.

A total of 59 educators and scientists attended the two-day workshop including not only participants from Canada, Mexico, and the United States, but also from South America.

III. Panel Findings and Recommendations

Participants were organized into discussion groups based on their scientific interests including optoelectronics, polymers/advanced cement, and metals.

Participants were committed to finding ways to promote economic growth for mutual societal benefit through pre-competitive or generic research in the fields of materials science and engineering and to promote knowledge and acceptance of our cultural diversity. These goals are considered to be of crucial significance to the NAFTA trading partners in light of similar agreements among the member countries of other international

trading blocks such as the European Union (EU).

Each panel provided written reports of their findings and recommendations, which are consolidated below.

A. Issue - Information Dissemination

The participants found that there was little knowledge of the scope of research, the scientists involved, or the facilities available among these countries. Meaningful scientific interactions can not exist in a vacuum. The need for some means of widespread and rapid dissemination of scientific information is of vital importance.

Recommendation #1 - Electronic Links

It is recommended that a U.S. Network be established. The function of this network would be to first serve as an electronic link among scientists within the United States, providing them with vital information in the area of materials research, education, and technology.

The network would be designed to grow with available technologies, eventually providing remote real-time research collaborations, educational programs, research publications, etc. Users and information providers would include researchers from universities, industry, scientific organizations, and government laboratories.

It is also recommended that steps be taken to encourage the formation of similar electronic networks in other North and South American countries. These networks could then be linked together and expanded to form an international materials network capable of linking countries, continents, and hemispheres.

Recommendation #2 - On-going Trilateral Workshops

In addition to electronic links, meaningful scientific interactions require personal contacts among scientists. The Trilateral Materials Workshop provided an important first step towards forging scientific relationships and promoting cooperation and collaboration among researchers in the academic and industrial communities of the NAFTA countries.

Ongoing workshops along this line will improve the educational, scientific and technological development of advanced materials of strategic importance.

Using the Trilateral Materials Workshop as a model, these future workshops will be designed to bring together people from different disciplines who have an interest in the same problem. Each workshop would be organized by a trilateral committee and the location of each workshop would rotate.

The objectives of these workshops would include the following:

- * Promote the exchange of scientific information and latest research progress
- * Foster new and enhance existing collaborations
- * Encourage new research areas
- * Facilitate the training, education, and exchange of undergraduate and graduate students
- * Generate specific plans of action

The majority of the funding should come from the umbrella of a NAFTA initiative supplemented by cosponsorships from other funding sources. Industrial funding and participation would be actively sought.

B. Issue - Limited Research in Mexico

Although some interactions exist between scientists in Canada and the United States, there are few collaborations between scientists in either of these two countries and scientists in Mexico. Mexico's limited tradition of research has resulted in diminishing numbers of active scientists and graduating PhDs. In 1992, approximately 1,500 students received their postgraduate degrees in science and technology of which there were only about 20 PhDs in physics. In Mexico, 65% of the total government expenditure in research and development goes to education, while only half a percent goes to CONACYT (National Council of Science and Technology) and 6.7% goes to health. In contrast, 48% of the U.S. federal expenditure goes to health, about 12% goes to the NSF and 1.7% to education. In addition, Mexican industry accounts for only a small percentage of research funding (government funds 99%).²

NAFTA makes research and development in hi-tech areas an imperative for Mexico. Mexico needs trained workers for manufacturing plants which are being established by U.S. and Canadian corporations in Mexico, even though most of the design and development work is presently done in the United States and Canada. To participate effectively within the NAFTA community, Mexico must increase its capability in science and engineering and build its academic infrastructure in technology.

Panel members found that there are strong indications that Mexico recognizes the need to increase their research and development in high-tech areas. For example, Mexico has recently expended large sums to improve the infrastructure for scientific research. Mexican scientists would like to use their new facilities for collaborative research activities which could be expanded into full cooperative projects.

Recommendation - Providing Educational Opportunities

In order to increase the number and scope of trained scientists working in Mexico, an increase is needed in the number of students from Mexico who receive graduate training in the United States or Canada and who then return to Mexico. The objective is to promote a better capability to interact with the industrial establishment, and to generate highly qualified human resources.

The participation of U.S. corporations which have established factories in Mexico should also be pursued in order to leverage government programs in this area.

C. Issue - Paper Collaborations vs. People to People Collaborations

Exchanging personnel among NAFTA countries is key to the education and training of students, the transfer of skills and/or technology, the expansion of opportunities for cross-border research collaboration, and the expanded use of large federally funded facilities. The ultimate goal would be to promote "people to people" collaborations rather than collaborations which exist only on paper. For example, in 1993 Mexico had 132 cooperative projects with Cuba, 23 cooperative projects with the United States, and none with Canada.

Recommendation #1 - Support for NAFTA Personnel Exchanges

While numerous opportunities for personnel exchange already exist some of this effort needs to be focused specifically on interactions between NAFTA countries. These programs could be used to achieve the additional goal of further strengthening the NAFTA alliance.

For example, Canada has funds for visiting graduate students and for sending people to visit other universities. Mexico has the CONACYT program which provided limited funding to researchers for travel and living expenses, but no funding for research supplies.

The United States has a variety of programs for international cooperation, for visiting scientists and for planning research activities, but they are dispersed throughout various programs and directorates.

It is recommended that existing programs be better publicized and expanded to include exchanges that focus on strengthening ties between the NAFTA countries. Some suggestions include:

1. NAFTA Postdoctoral Fellowships at research institutions, including universities and government or industrial laboratories for a period of two years. Initially, each country would support a minimum of two post docs per year in another NAFTA country.
2. NAFTA Visiting Scientist or Visiting Professor positions at universities or government or industrial laboratories, which are jointly funded by the two governments involved for a minimum of one semester and a maximum of two years.
3. NAFTA Travel Grants to allow scientists to do short term work at a large federally funded facility, plan joint research proposals, or attend NAFTA workshops.

Recommendation #2 - Increased Support for Cooperative Projects

Recommendation #2 - Increased Support for Cooperative Projects

Identifying and supporting specific cooperative research projects which leverage the strengths of each country's scientific community was established as an important goal. It is felt that to optimize success, cooperative research areas should fulfill the following criteria:

- * Be of scientific and industrial importance to all three countries, with particular emphasis on product improvement, new developments, recycling and other environmental issues,
- * Make use of established infrastructure, including basic facilities,
- * Have practical achievable objectives and use modeling techniques wherever possible.

Cooperative research projects between Canada, Mexico, and the United States would also encourage personnel exchanges at all levels (e.g., technicians, post-docs, and senior scientists). These exchanges would accommodate the differing needs of the scientific communities within these three countries, such as Mexico's need for industry-targeted research, Canada's need for technicians, and the continuing need for high quality graduate students in the United States.

D. Final Recommendation - The Virtual Institute

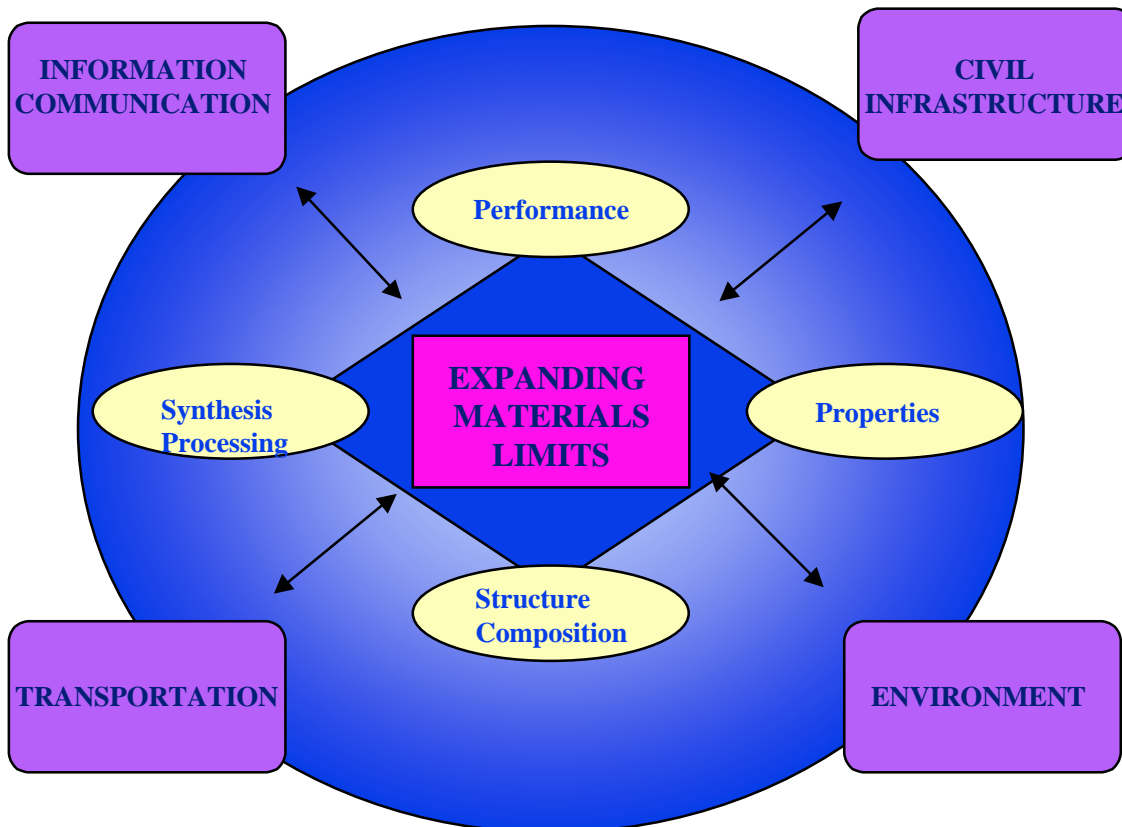
Panel members deliberated how to achieve the above recommendations. It was concluded that the most efficient and effective course of action would be to establish a overseeing body -- a Virtual Institute -- to organize and coordinate programs and services such as:

- * Maintain databases of information vital to this NAFTA initiative, and make this information readily available to researchers,
- * Organize, coordinate and publicize workshops which promote cooperation and collaboration among researchers in the academic and industrial communities of the NAFTA countries,
- * Establish and maintain a U.S. Materials Network, and encourage the development of similar networks in the NAFTA countries and elsewhere,
- * Provide advice and counsel on funding opportunities and proposal preparation,
- * Act as a central clearinghouse for proposal applications, either forwarding proposal to the appropriate agency or providing funding from federal NAFTA Initiative funds.

The Virtual Institute will centralize efforts and not only ensure the success of the programs described above but provide the impetus for new incentives. The establishment of a central coordinating office -- a Virtual Institute -- will bring us further to reaching our goal to increase scientific interaction among Mexico, Canada, and the United States, not only in the spirit of NAFTA, but with the understanding that this effort will have a meaningful industrial, economic, and cultural impact.

1. NAFTA - Managing the Cultural Differences, Robert T. Moran and Jeffrey Abbott, Gulf Publishing Company, 1994.
2. Indicadores de Actividades Cientificas Y Technologicas, Secretaria de Educacion Publica, CONACYT (National Council of Science and Technology), 1993.

REPORT OF THE WORKSHOP ON MATERIALS FOR FUTURE TECHNOLOGIES



EUROPEAN COMMISSION - US NATIONAL SCIENCE
FOUNDATION

LEUVEN - BELGIUM
DECEMBER 12-14, 1996

PREFACE

TOWARD GREATER INTERNATIONAL COOPERATION IN MATERIALS RESEARCH


Materials are more than mere components in technology; rather, the basic properties of materials frequently define the capabilities, potential, reliability, and limitations of technology itself. Improved materials and processes will play an ever increasing role in efforts to improve energy efficiency, promote environmental protection, develop an information infrastructure, and provide modern and reliable transportation and civil infrastructure systems. Advances in materials science and engineering, therefore, enable progress across a broad range of scientific disciplines and technological areas with dramatic impacts on society.

Continued progress in materials science and engineering is increasingly dependent upon collaborative efforts between several different disciplines, as well as closer coordination among funding agencies and effective partnerships involving universities, industry, and national laboratories. In addition, because of the rapidly growing interdependence of the world's economies, partnerships are not only important at the national level but from an international point of view as well.

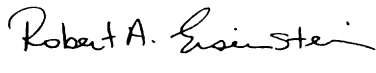
With this in mind, the European Commission and the US National Science Foundation co-sponsored a workshop in the area of materials research designed to help stimulate enhanced collaboration among materials researchers and create networks linking the participating countries. The workshop was held on December 12-14, 1996 in Leuven, Belgium and was attended by eminent scientists and engineers from the European Union countries and the United States. Their excellent report is attached. We would like to thank all the workshop participants and in particular the workshop co-chairs Prof. Dr. Dr. h.c. Horst Czichos, Prof. Bertrand Escaig, Prof. dr. ir. Jean Pierre Celis, Dr. Praveen Chaudhari, Dr. Mark Ketchen, Prof. Venkatesh Narayanamurti, and Dr. James C. Williams for the considerable effort that went into the preparation of the report.

Since the workshop took place, the European Community and the United States signed on December 5, 1997 a draft agreement for scientific and technological cooperation in the materials sciences among several other areas of cooperative activities. Thus, the workshop report comes at a highly opportune time.


From time to time we expect to communicate with the materials research communities in the European Union countries and in the United States as we jointly work toward implementation of the recommendations contained in the workshop report.




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**European Commission–National Science Foundation
Workshop on Materials for Future Technologies
December 12-14, 1996
Leuven, Belgium**

Executive Summary

Scientific research is complex and expensive. Technology can be advanced by collaborative research, in which expertise in a number of fields is brought together to solve a particular problem. Institutions are now reaching out to expand that collaboration between researchers in the United States and the European Union, spurred by the increasing globalization of the economy and the concomitant challenges that this poses for technology and economic progress.

To that end, staff members of the European Commission (EC) and the US National Science Foundation (NSF) hosted a meeting December 12-14 in Leuven, Belgium. Workshop participants were eminent researchers in the field of materials science and engineering, charged with identifying specific areas for fruitful US-European cooperation in the interdisciplinary field.

There are benefits to be gained from such international cooperation. The key is to exploit the complementary aspects of the systems and cultures on both sides of the Atlantic Ocean to produce a result that cannot easily be accomplished by either side alone. There is now a strong will to cooperate, which increases the likelihood that the objective can be achieved. Materials research is a logical area for some of the earliest interactions because of its inherent interdisciplinarity and crossing of traditional boundaries, as well as the significant amount of funding devoted to the area by both partners.

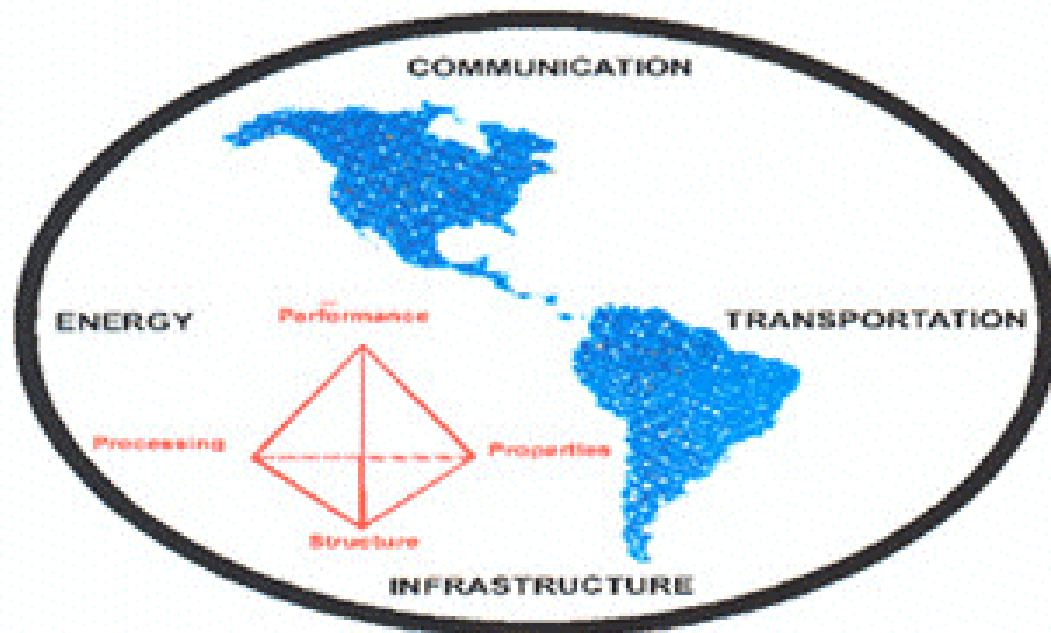
Several mechanisms were identified that could promote long-term international cooperation:

- The EC and the NSF should encourage and develop means for the collection and dissemination of information on materials research enterprises.

- The EC and the NSF should conduct a pilot for international cooperation in materials research consisting of several coupled projects.

- The European and US materials research communities should be more proactive in strengthening existing and finding new ways for cooperation, such as virtual centers. They should also document those ways that work well as a blueprint to others.

Frontiers in Materials Research, Technology and Education



A Workshop to Advance Pan-American Collaboration

RIO DE JANEIRO, BRAZIL
JUNE 7-10, 1998

Preface

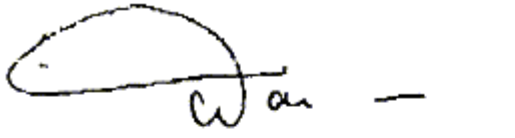
Toward Greater International Cooperation in Materials Research

Materials are more than mere components in technology; rather, the basic properties of materials frequently define the capabilities, potential, reliability, and limitations of technology itself. Improved materials and processes will play an ever increasing role in efforts to improve energy efficiency, promote environmental protection, develop an information infrastructure, and provide modern and reliable transportation and civil infrastructure systems. Advances in materials science and engineering, therefore, enable progress across and broad range of scientific disciplines and technological areas with dramatic impacts on society.


Continued progress in materials science and engineering is increasingly dependent upon collaborative efforts between several different disciplines, as well as closer coordination among funding agencies and effective partnerships involving universities, industry, and national laboratories. In addition, because of the rapidly growing interdependence of the world's economies, partnerships are not only important at the national level but from an international point of view as well.

With this in mind, the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), the Financiadora de Estudos e Projetos (FINEP), the Brazilian Ministry of Science and Technology (MCT), and the Catholic University of Rio de Janeiro of Brazil (PUC-Rio); the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), the Argentinean Secretary of Science and Technology (SECYT), the Argentinean Atomic Energy Commission (CNEA) of Argentina; the Comisión Nacional de Investigación Científica y Tecnológica (CONICYT) of Chile; and the US National Science Foundation (NSF) co-sponsored a workshop in the area of materials research designed to help stimulate enhanced collaboration among materials researchers and create networks linking the participating countries. The workshop was held on June 7-10, 1998 in Rio de Janeiro, Brazil, and was attended by eminent scientists and engineers from Brazil, Argentina, Chile, Uruguay, Venezuela, and the United States. Their excellent report is attached. We would like to thank all the workshop participants and in particular the workshop co-chairs Miguel Blesa, R.P.H. Chang, Guillermo Gonzalez, Guillermo Solórzano, Kathleen C. Taylor, and Edgar Dutra Zanotto for the considerable effort that went into organizing the workshop and preparing the report.

From time to time we expect to communicate with the materials research communities in the Pan American countries as we jointly work toward implementation of the recommendations contained in the workshop report.



Carlos Roberto de Faria e Souza, CNPq



Adriaan M. de Graaf, NSF



Joel Weisz, FINEP



Arturo Alvarez, CONICET



Ximena Gomez de la Torre, CONICYT

Workshop Summary

Background

A Workshop on Frontiers in Materials Research, Technology, and Education sponsored by the Brazilian National Council for Scientific and Technological Development (CNPq), the Brazilian Granting Agency for Scientific and Technological Projects (FINEP), the Brazilian Ministry of Science and Technology (MCT), the Catholic University of Rio de Janeiro (PUC-Rio), the National Science Foundation (NSF) of the United States, the Argentinean Council for Science and Technology (CONICET), the Argentinian Secretary of Science and Technology (SECYT), the Argentinian Atomic Energy Commission (CNEA), and the Chilean Council for Science and Technology (CONICYT) was held June 7-10, 1998 in Rio de Janeiro, Brazil. The workshop participants were charged with identifying areas for fruitful cooperation among the individual research groups, centers, institutions and funding agencies of the Pan American countries, in the interdisciplinary field of materials research. Other goals of the Workshop were to identify means to stimulate collaboration, to foster future technologies, and to promote and enhance the exchange of materials information. A final goal was to identify mechanisms for optimizing the effectiveness of materials education, and for assuring its relevance to current and future needs. Workshop invitations went out to all North, Central, and South American countries. Workshop participants were from Argentina, Brazil, Chile, United States, Uruguay, and Venezuela.

The workshop chairs were:

Miguel Blesa (CNEA, Argentina)
R.P.H. Chang, (Northwestern University, U.S.)
Guillermo Gonzalez (U. de Chile, Chile)
Guillermo Solorzano (PUC-Rio, Brazil)
Kathleen C. Taylor (General Motors, U.S.)
Edgar Dutra Zanotto (UFSCAR, Brazil)

As the outcome of the meeting, the workshop participants made recommendations to the group of sponsoring agencies about steps to be taken to develop increased Pan American collaboration in materials research, technology, and education. Hopefully, the sponsoring agencies will view the workshop as the model for growing cooperation in these areas throughout the Pan American region. This initiative arises from the increasing globalization of the scientific enterprise and the wish to enhance the mutual resources and considerable strengths of the Pan American community.

Workshop Format

The Workshop explored opportunities for enhancing materials research and education for the purpose of contributing to the development of new technologies. Focus groups addressed the following especially pressing topics: materials for transportation/energy, materials for communications, materials for infrastructure, and materials education. The agenda for the meeting is shown in Appendix 1.

The Workshop began on June 7 with brief speeches from representatives of the participating sponsoring organizations:

Dr. José Galizia Tundisi,
President of the National Council for Scientific and Technological Development (CNPq) and also representing Dr. Jose Israel Vargas,
the Brazilian Minister for Science and Technology

Dr. Lourival Carmo Monaco,
President of the Brazilian Granting Agency for Scientific and Technological Projects (FINEP)

Ambassador Carlos Alberto de Azevedo Pimentel,
Head of the Department for Scientific and Technological Cooperation of the Brazilian Ministry of Foreign Affairs

Dr. Alvaro Albuquerque Júnior,
Special Secretary for Economic Development, Science and Technology of the City of Rio de Janeiro

Pe. Jesus Hortal Sanchez, S.J.,
Rector of the Catholic University of Rio de Janeiro

Dr. Robert Eisenstein,
NSF and representing Dr. Neal Lane, the Director of the National Science Foundation, Washington, D.C.

Dr. Miguel A. Blesa,
Argentinean Commission for Nuclear Energy and also representing the Argentinean Secretary of Science and Technology (SECYT) and the Argentinean Council for Science and Technology (CONICET)

Dr. Guillermo González,
University of Chile and also representing the Chilean Council for Science and Technology (CONICYT)

The second day of the Workshop featured plenary lectures representing the topical areas of the Workshop. These talks set the tone for the discussions of the following day.

On the third day of the Workshop seven groups met in parallel to address each of the topical areas, building upon the information of the plenary talks. Each group was asked to identify links between the topics of research and technology and current materials needs, resource issues, manufacturing technology issues and materials education. The groups identified joint materials research topics offering potential long term benefit and utility from a global perspective. Human resource issues were addressed, as well as conditions needed for successful collaboration (e.g., effective modes of communication). The groups considered regional research strengths, infrastructure issues, and educational needs and opportunities. They also discussed the benefits of involving National Laboratories and industry in the collaborations.

On day 4, the groups gave reports in a plenary session, which allowed all workshop participants to contribute to the workshop report.

Strategic Conclusions

The Workshop participants identified many promising and practical avenues for fruitful cooperation in the interdisciplinary areas of materials research and education within the Workshop focus areas. These suggestions appear in full in the appended group reports. The groups looked especially for actions that are global in nature and address long term societal needs.

Finding effective means to stimulate collaboration was a cross cutting theme for the focus groups. The need to have face to face interaction among researchers is seen as a necessary starting point for collaboration. A theme raised by every focus group was the importance of establishing and funding (a) substantive international academic residencies for faculty, post-docs and students, and (b) strong series of focused Pan American conferences, workshops or summer schools. It was clearly felt that successful exchange programs and conference activities of this kind will automatically catalyze the type of research interactions that are so eloquently called for in other parts of this Report. For example, small invitational workshops focused on a narrow topic, representing areas of overlapping interests and deliberately involving Pan American representation, should be given special consideration by the sponsoring organizations. Funding for joint work should be long-term and formally structured to achieve substantive collaboration.

Another concern common to all groups is the prevailing isolation of industry in general from the research and training activities of universities and government laboratories within the South American countries. A participatory linkage that goes well beyond Aetechnology transfer@ will be important in order to maximize the benefits of materials research and training. Hence, it is recommended that means should be identified to engage industry in cooperative programs with universities and government research institutions, so that the needs of industry will be better comprehended and addressed. Such cooperative programs should be enabled and encouraged to use the existing materials research infrastructure and facilities across institutions and national borders. Remote access for use of specialized experimental facilities in real time, for example, would facilitate cooperation of this kind while providing the additional benefit of bringing researchers together.

Another common theme was the development and establishment of robust mechanisms to enhance the exchange of, and access to, technical and educational information. The Pan American professional societies that represent materials research might take on a greater role in this area, and could also help to identify mutual technical interests and educational opportunities.

Finally, in order to meet the demands in the arena of Materials Research, Technology and Education at the Pan American level, a long-term, well-structured program should be established by the supporting agencies (CNPq, CONICET, CONICYT, NSF) jointly with the leading scientists of the countries involved.

Topical Priorities

The breakout session topics were selected to explore broadly based materials issues and thereby to identify productive directions for future planning. Nonetheless, these topics should be taken only as examples, since other important materials areas are also deserving of attention. Discussions of needs and opportunities during the Workshop breakout sessions revealed both similarities and differences among various countries. Proposed research topics should be selected according to common themes and needs, in order to promote their maximum impact.

Two of the breakout sessions addressed transportation/energy concerns. While energy infrastructure of the Pan American countries differs regionally, ranging from hydroelectric to nuclear to fossil fuels, issues of materials durability and longevity were identified as common to all. New alloy development, environmental degradation of materials, and tribology were among the many topics proposed for collaborative research. New transportation energy sources, possibly including hydrogen for fuel cells, will require new catalysts, sensors, and gas purification and storage techniques. Environmental mandates and fuel efficiency are global issues that create needs for both novel concepts and a total systems approach. Clean materials processing, power generation with clean technologies, recycling and materials lifecycle strategy are all topics that require creative materials research.

The breakout sessions on infrastructure identified many common and emerging themes. Construction materials must be designed more durably in order to resist natural disasters like earthquakes. Examples of such materials include reinforced concrete as well as damping and fracture-resistant materials. Environmental concerns include air and groundwater pollution, purification of water and desalination of seawater, synthesis of waste management materials such as solidification materials, and materials designed for recycling/disposal. Service life prediction and life-cycle costing, including better understanding of deterioration processes and application of modeling tools, were specifically mentioned as applied to a broad range of infrastructure. Research on polymeric materials and new synthesis methods was another cross-cutting theme. Materials for mining and ore processing / purification and for the pulp and paper industries were also cited.

Materials related to the advancement of communication and information technologies were considered by both of the groups on Communications to be very important for collaborative research. The groups identified and provided examples of areas for joint activities, including: nano-electronic devices, novel photonic devices, advanced magnetic recording systems, and the next generation of displays. While the capabilities and infrastructures in each country differ substantially and vary in terms of degrees of sophistication, strong collaborative research teams can nevertheless be formed by carefully choosing partners from the participant countries whose special backgrounds and resources complement each other. Examples of such joint Pan American groups are given in the reports. In addition, the need for improved human resources, i.e. a population of highly trained professionals, was identified as crucial to advancement in this technological area. Therefore, the joint establishment of new materials educational programs, starting at the pre-college level, is strongly encouraged.

The working group on Education highlighted the expected value of developing strong programs for international exchange visits for university faculty and for students; of supporting instructional workshops for materials educators; and of promoting shared development of advanced teaching resources and modern materials curricula. The group also noted the importance of outreach projects aimed at developing a basic awareness of materials issues in the non-specialist community.

Workshop Recommendations

- § *Establish a Pan American interactive communication network to accelerate collaborative research and educational programs and to enhance the exchange, management, and dissemination of information.*

- § *Establish within the sponsoring organizations a Pan American Amanagement council== for the purpose of promoting, coordinatng, and funding joint programs in materials research and education, and*
 - 1) *to foster collaboration among industry, university, and government laboratories in innovative ways*
 - 2) *to establish mechanisms for long term and substantive collaborations involving academia and industrial and government laboratories*

- 3) *to promote and monitor exchange programs at all professional levels*
 - 4) *to provide program quality assessment and to assure that joint research and educational programs will have societal and technological impact*
 - 5) *to identify areas of important and innovative research for joint collaborative programs*
 - 6) *to ensure that all joint programs are competitive in nature and to assist in the reviews of funded programs*
 - 7) *to promote and assist in the organization of workshops, symposia, and focused meetings*
 - 8) *to enhance public awareness of the contribution of materials science and technology*
- § *Funding agencies, professional societies and other institutions should be solicited and encouraged to act as brokers for multi-national collaborations at all levels, e. g. to facilitate communication among interested international collaborators and organizations.*
- § *The participants strongly recommend that the agencies who supported the workshop (CNPq, FINEP, MCT, PUC- Rio, SECYT, CNEA, CONICET, CONICYT, and NSF) take the lead in developing effective mechanisms to advance Pan American collaboration in materials research and education.*

Acknowledgments

The workshop organizers would like to acknowledge the assistance of the representatives of the supporting agencies:

- Brazil: Carlos Roberto de Faria e Souza (CNPq)
Joel Weisz (FINEP)
Patricia Morganti (CNPq)
Carmen Negraes (CNPq)
- Argentina: Miguel Blesa (SECYT, CONICET, CNEA)
- Chile: Guillermo Gonzalez (U. de Chile)
- USA: Adriaan de Graaf (NSF)
Robert Eisenstein (NSF)
Lance Haworth (NSF)
Raul Miranda (NSF)
Harold Stolberg (NSF)
Thomas Weber (NSF)
Robert Wellek (NSF)
Elisabeth Jacobs (Northwestern University)

US-Asian Pacific Materials Research,
Technology, & Education
for the 21st Century
in the Service of Society



Turtle Bay Hilton Hotel, Hawaii
November 1-4, 1998

PREFACE

TOWARD GREATER INTERNATIONAL COOPERATION IN MATERIALS RESEARCH

Materials are more than mere components in technology; rather, the basic properties of materials frequently define the capabilities, potential, reliability, and limitations of technology itself. Improved materials and processes will play an ever increasing role in efforts to improve energy efficiency, promote environmental protection, develop an information infrastructure, and provide modern and reliable transportation and civil infrastructure systems. Advances in materials science and engineering, therefore, enable progress across a broad range of scientific disciplines and technological areas, with dramatic impact on society.

Continued progress in materials science and engineering is increasingly dependent upon collaborative efforts between several different disciplines, as well as closer coordination among funding agencies and effective partnerships involving universities, industry, and national laboratories. In addition, because of the rapidly growing interdependence of the world's economies, international partnerships are as important as those at the national level.

With this in mind, the Department of Industry, Science and Tourism of Australia, the Natural Science Foundation of China (NSFC), Representatives from Japan, the Korea Science and Engineering Foundation (KOSEF), the Russian Academy of Sciences, the National Science Council of Taiwan (NSC), and the US National Science Foundation (NSF) co-sponsored a workshop in the area of materials research designed to help stimulate and enhance collaboration among materials researchers and create electronic communication networks in the Asian-Pacific region. The workshop was held on November 1-4, 1998 in Hawaii, and was attended by eminent scientists and engineers from Australia, China, Japan, Malaysia, Singapore, South Korea, Taiwan, and the United States. Their excellent report is attached. The workshop organizers - R.P.H. Chang, Lih J. Chen, Masao Doyama, Minhua Jiang, Hyeong Joon Kim, Nikolai Lyakhov, and Jim Williams - would like to thank the workshop participants for their significant contributions at the workshop as well as to the report. They also would like to thank the sponsoring agencies for their support, which made the workshop possible. We very much hope that the materials research communities and the sponsoring agencies in the Asian-Pacific region will strive toward implementation of the recommendations contained in the report.



For the Workshop Organizers
R.P.H. Chang

Background

The first US-Asian workshop in Materials Research, Technology and Education was held at the Turtle Bay Hilton in Turtle Bay, Hawaii, from Sunday, November 1 to Wednesday, November 4, 1998. The event was sponsored by the National Science Foundation (NSF) and supported by the scientific agencies of the participating countries. A planning meeting, attended by the workshop organizers and representatives from the NSF, was held in Turtle Bay, Hawaii on February 17-18, 1998. During this meeting, the organizers identified goals for the workshop. These goals were:

- To identify possible areas of joint research, networking, and cooperation among individual research groups, centers, and institutions in the Pan Pacific countries
- To stimulate collaboration and investigate the possibility of exchange programs
- To foster future technologies
- To identify mechanisms for making materials education relevant for future needs
- To promote and enhance the exchange of materials information
- To identify funding opportunities for cooperation

Workshop participants, who numbered 72 total, were from Australia, China, Japan, Korea, Malaysia, Singapore, Taiwan, and the United States. Observers from South Africa and the United States, along with representatives from the National Science Foundation and other national agencies, also attended. A total of 81 people attended the workshop. The workshop organizers were:

R.P.H. Chang, Northwestern University, US
Lih J. Chen, National Tsing Hua University, Taiwan
Masao Doyama, Teikyo University of Science and Technology, Japan
Minhua Jiang, Shandong University, China
Hyeong Joon Kim, Seoul National University, Korea
Nikolai Lyakhov, Siberian Materials Research Association, Russia
Jim Williams, The Australian National University, Australia

Workshop Topics

The Workshop explored research opportunities directed towards expanding materials research and education for the purpose of contributing to the development of new technologies. Focus groups addressed the following topics: materials for energy and transportation, materials for communication and information, biomaterials, materials for the environment, materials education and policy, materials resources management, and infrastructure and materials characterization. The agenda for the meeting is shown in appendix 1.

The opening ceremony of the Workshop was held on November 1, 1998. The following speakers welcomed the participants:

Rene Monsho
Council member of the city of Honolulu

Dr. Frank Perkins
Assistant Vice President of Research
University of Hawaii

Dr. Masatoshi Okada
National Research Institute for Metals
Science and Technology Agency, Japan

Dr. Hyeong Joon Kim
Inter-university Semiconductor Research Center
Seoul National University, Korea

Dr. Minhua Jiang
Institute of Crystal Materials
Shandong University, China

Dr. Lih J. Chen
Department of Materials Science and Engineering
National Tsing Hua University, Taiwan

Dr. Brian Delroy
Manager, International Science and Technology Branch
Department of Industry, Science and Tourism, Australia

Dr. Thomas Weber
Director, Division of Materials Research
National Science Foundation, US

The first day of the workshop featured plenary lectures representing the topical areas of the Workshop. The Workshop also featured two panel discussions during the plenary session: one on materials education, the other on materials networking. The talks and panel discussions set the tone for the discussions of the following day.

On the second day of the Workshop, nine parallel groups met in each of the topical areas, building upon the plenary talks. The group discussions sought to identify links between the research and technology topics and materials needs, resource issues, manufacturing technology issues and materials education. The groups identified potential joint materials research topics with long-term benefits and utility from a global perspective. Human resource issues were addressed, as were factors for successful collaboration, such as communication modes. The groups identified regional research strengths, infrastructure issues, and educational issues. Benefits for involving national

laboratories and industry in the collaborations were also discussed.

On day 3, the groups gave reports in a plenary session, which allowed all workshop participants to contribute to the workshop report.

Workshop Conclusions

The Workshop participants identified many possible areas for fruitful cooperation in the interdisciplinary areas of materials research and education within the Workshop focus areas. These suggestions appear in full in the appended reports. The groups looked for topics that were global and addressed long-term societal needs. All groups considered potential barriers and aids to effective collaboration. One recurring theme was the need for attention to Intellectual Property issues, which often impede or prohibit effective collaboration among nations. Many groups expressed the desire to establish virtual centers or databases on the Internet, where information and expertise could be shared, catalogued, and exchanged. In addition to electronic networking, participants agreed upon the importance of international student exchange. Several of the groups in the topical areas recommended the creation of accessible materials science curricular materials for pre-college and undergraduate students in order to promote greater interest in and awareness of the importance of materials science in everyday life and for national and global technological and economic growth.

Technical Recommendations

The breakout session topics were selected to explore broadly-based materials issues to identify meaningful directions for future programs. Discussions during the Workshop breakout sessions identified both similarities and differences in needs and opportunities in the topical areas. Proposed research topics should be aimed at maximizing overlap by identifying common themes/needs.

The breakout session on biomaterials aimed to address research and collaboration opportunities pertaining to bio-improvements, biomolecules, and bio-inspired materials. The group identified technical needs common to all aspects of biomaterials research. These included the need to develop novel instrumentation for characterizing biomaterials, which would improve the capacity for predictive modeling of materials, and the need for better systems integration. The group expressed particular enthusiasm about investigating how and to what extent self-assembling materials could be used to direct the repair of the human body. Along with human repair, biomaterials for energy, environment and population control were discussed, as was the ideal of collecting specimens around the world in order to catalogue and ultimately exploit biodiversity.

Two of the breakout sessions addressed materials related to information and communication technologies. One of the groups identified the two most crucial research areas for communication and information materials as Ecological Processing of Electronic Materials and IT-Information Technology Infrastructure. Other research topics that these groups discussed were atomic scale properties of materials, molecular and nanoscale materials, mesoscale materials, interfaces and

defects, complex materials (e.g. ferroelectric and piezoelectric thin films, superconducting materials), and materials with extreme properties (e.g. high K, low K).

The breakout session on energy and transportation reported that this subject greatly overlaps all the other research topics and was therefore impossible to comprehensively discuss in such a limited time. One advantage of the scope of energy and transportation materials is the extent to which collaboration might (and should) be used in this area to encourage research that is novel, or that falls outside of the established areas. Among the research topics the group did discuss were the sequestration of greenhouse gases (CO₂), hydrogen generation and storage, immobilization of nuclear wastes, superconductors, and round robin testing of novel materials.

The Environmental breakout group identified three specific research areas as the most serious and influential: waste disposal and management, alternative materials development (e.g. plastic), and a life cycle assessment database. Ideally, this database would be international, allowing all countries to compare life cycle inventory and assessment. The group discussed a number of research topics in ecomaterials, i.e. materials developed with consciousness of the environmental impact, among them materials flow analysis, life cycle analysis, and assessment for new materials. In the area of design and manufacture, the group identified topics including DFE (Design for environment), CT (Clean processing), and "Creation" of resources, i.e. reuse of industrial byproducts. Under Fundamental Materials Research, the group listed renewable materials, alternative materials, biodegradable materials, functional materials for remediation and restoration, and functional materials for energy.

Two breakout groups were devoted to materials characterization and infrastructure. Because materials characterization enables the discovery and development of new materials, as well as analysis of structure in established materials, it is essential to all other areas of materials science and to economic development worldwide. The first group suggested the creation of an international network of "Materials Characterization Centers" (MC²) that would provide access to users on a fee-for-service basis and/or collaborative basis. An MC² would represent a cluster of related instruments, necessary sample preparation facilities, data analysis capabilities and professional staff. The second group identified areas of expertise in characterization for each participating country: steel in Japan, concrete in China, interfaces/surfaces in Korea, sensors in Taiwan, modeling in the US, and raw materials processing in Australia. Moreover, they discussed each country's particular needs, which are detailed in their report. This group also pointed out that students will not select study in structural materials until they see a global commitment to such work.

The breakout group discussing Materials Education and Policy emphasized that education enhances the human resources that provide the basis for advancing technology and future economic growth. Rather than trying to establish one recommended international curriculum for materials science, the group suggested that a mechanism for sharing curricular information be developed. The group discussed exchange programs, fellowships and awards, outreach programs for K-12 students (e.g. Northwestern's Materials World Modules program), and educational workshops that might be offered through an international Network.

The breakout group dealing with Materials Resources and Management identified three areas of research that are common to all countries, involve the “public good” as opposed to commercial enterprise, and can be addressed most effectively through joint research. These broad categories were Environment, Health, and Critical Resources. The first two categories overlapped with discussions in the Environment and Biomaterials group, respectively, while the last involved the discussion of a) more efficient use of existing resources and b) the substitution of critical, or energy-intensive, materials with others that are either in greater (potential) abundance or that are more energy-benign.

Workshop Recommendations

Education and Training

- Establish a mechanism to enhance and coordinate education for all levels: K-12, undergraduate, graduate, postdoctoral, and technical.
- Implement short courses for “lifelong learning,” which feature hands-on experience with materials characterization. Create a network of these courses and students, or a “virtual university,” which makes distance learning possible.
- Coordinate across countries to recognize students who will attend the virtual university.
- Use materials in K-12 to teach fundamental concepts of physics, chemistry, and biology.
- Enhance students’ awareness of materials and the environment, as well as natural resource management.
- Include environmental aspects of materials engineering with solid technical grounding in environmental life cycle impacts.
- Coordinate across chemistry, physics, chemical engineering, and other materials-related disciplines.
- Begin process of defining where undergraduate curriculum in materials science should go.

Networking

- I. Communication among researchers
 - A. Establish searchable database containing materials properties, publications, instruments, experts
 - B. Conference via Internet (e.g., interactive video link between Canada, US, and Mexico in process now, following the 1995 meeting)
 - C. Promote society’s access to information about regional activities pertaining to materials
 - D. Establish an Ecomaterials center on the Web
- II. Access to facilities
 - A. Locating facilities
 - B. Determining cost and timing
 - C. Making arrangements
- III. Control of instruments across the Internet
 - A. Central management of databases to achieve quality control of standards
- IV. Education
 - A. Use Internet to publicize and administer short courses

- B. Use Internet to create and facilitate the “virtual university”
- C. Create a Web site of interest to the general public

Identify the path forward

- Establish a steering committee made up of leaders from each country represented at this Workshop
- Strive for early successes, which are needed

Identify centers for concentration and link them together now

- Materials characterization
- Materials education
- Addressing a global problem with global impact—environmental impact and materials; Sematech is going international; they have identified environmental impact of electronic materials processing as a focus.

Intellectual Property

- Identify model for IP agreements and set standard practices

Environment as a unifying focus

- Education
- Research centers addressing this major problem
- Substitution of natural resources

VI. Acknowledgments

The Workshop organizers gratefully acknowledge the government agencies that provided support for participants. The Workshop would like to acknowledge the assistance of Dr. Murli H. Manghnani, of the University of Hawaii, for his help as an on-site contact prior to and during the Workshop.



PRETORIA, SOUTH AFRICA

6 - 9 August 2000

Preface

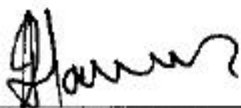
Toward Greater International Cooperation in Materials Research

Materials are more than mere components in technology; rather, the basic properties of materials frequently define the capabilities, potential, reliability, and limitations of technology itself. Improved materials and processes will play an ever increasing role in efforts to improve energy efficiency, promote environmental protection, develop an information infrastructure, and provide modern and reliable transportation and civil infrastructure systems. Advances in materials science and engineering, therefore, enable progress across a broad range of scientific disciplines and technological areas. Indeed, effective and sustainable use of materials is critical for the well-being of society.

Continued progress in materials science and engineering is increasingly dependent upon collaborative efforts between several different disciplines, as well as closer coordination among funding agencies and effective partnerships involving universities, industry, national laboratories, and other research organizations. In addition, because of the rapidly growing interdependence of the world's economies, partnerships are not only important at the national level but from an international point of view as well.

With this in mind the National Research Foundation of South Africa, the Ministry of Environment, Science, and Technology of Ghana, the Commission of Higher Education of Kenya, the Raw Materials Research and Development Council of Nigeria, the Ministry of Higher Education and Scientific Research of Senegal, the Tanzania Commission for Science and Technology of Tanzania, the Ministry of Higher Education and Technology of Zimbabwe, and the National Science Foundation of the United States co-sponsored a workshop in the area of Material research designed to help stimulate enhanced collaboration among materials researchers and create networks linking the participating countries. The workshop was held on August 6 - 9, 2000 in Pretoria, South Africa, and was attended by eminent scientists and engineers from Botswana, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Morocco, Namibia, Nigeria, Senegal South Africa, Swaziland, Tanzania, United States, Zambia, Zimbabwe. Their excellent report is attached. We would like to thank all workshop participants and in particular the workshop coordinators Aboubaker Chédikh Beye, Senegal; Robert P. H. Chang, United States; Arthur Every, South Africa; Joseph O. Gogo, Ghana; Frank P. L. Kavishe, Kenya; Marjorie Mujaji, Zimbabwe; E. r. Sadiku, Nigeria; Ron Sanderson, South Africa; Joseph V. Tesha, Tanzania; A. J. Varkey, Swaziland; and Isiah M. Warner, United States for the Considerable effort that went into organizing the workshop and preparing the report.

From time to time we expect to communicate with the materials research communities in the African countries as we jointly work toward implementation of the recommendations contained in the workshop report.



Jill Sawers, South Africa



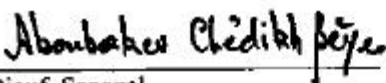
Edwin Barnes, Ghana



Justin Iriga, Kenya



Ademola. Ajibade, Nigeria

for 
Madior Diouf, Senegal



Yadon M. Kohi, Tanzania



Michael Ngoni Mambo, Zimbabwe



Adriaan M. de Graaf, United States

Background

The first U.S.-Africa Materials Workshop was held at the Farm Inn in Pretoria, South Africa from Sunday, August 6, to Wednesday, August 9, 2000. The event was sponsored by the National Science Foundation (NSF) and the National Research Foundation (NRF) and supported by the scientific agencies of the participating countries. A planning meeting, attended by the workshop organizers and representatives from the NSF and NRF, was held at the National Research Foundation in Pretoria, South Africa on July 27 and 28, 1999. During this meeting, the organizers identified the following goals for the workshop:

- To identify specific areas and future directions for fruitful U.S.-Africa cooperation in the interdisciplinary field of materials research and education
- To establish an electronic network on materials science and engineering for these regions
- To recommend how the supporting U.S. and African government agencies can help in the development of increased cooperation in the international research community, especially between the United States and Africa

The 68 workshop participants were from Botswana, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Morocco, Namibia, Nigeria, Senegal, South Africa, Swaziland, Tanzania, the United States, Zambia, and Zimbabwe. An observer from the United States, along with representatives from the National Science Foundation and the National Research Foundation, brought the total number of people attending the workshop to 81. The workshop organizers were:

A.C. Beye	Senegal
Robert P.H. Chang	United States
Arthur Every	South Africa
Joseph O. Gogo	Ghana
Frank P.L. Kavishe	Kenya
Marjorie Mujaji	Zimbabwe
Emmanuel R. Sadiku	Nigeria
Ron Sanderson	South Africa
Joseph V. Tesha	Tanzania
A. Joseph Varkey	Swaziland
Isiah M. Warner	United States

Workshop Topics

The workshop explored research opportunities directed towards expanding materials research and education for the purpose of contributing to the development of new technologies as well as promoting collaboration among U.S. and African universities and industries. Focus groups addressed the following topics:

- Education and training
- Civil infrastructural materials (e.g., construction, concrete)
- Materials characterization (modeling, low-cost instrumentation, NDT)
 - Materials value chain (raw materials to processed products)
 - Biomass/natural products
 - Minerals/ores/metals
 - Indigenous materials

- Affordable health care
- Advanced and emerging materials (niche opportunities for Africa)
 - Advanced polymer synthesis
 - Photonic and electronic materials
 - Nanomaterials
 - Advanced ceramics

The agenda for the meeting is shown in Appendix 1.

The opening ceremony of the workshop was held on August 6, 2000. The following speakers welcomed the participants:

- Alhaji Abubaker Abdullahi, Director-General/Chief Executive, Raw Materials RandD Council, Nigeria
- Edwin P.D.Barnes, Chief Director, MEST, Ghana
- Joseph Bordogna, Deputy Director, NSF, U.S.
- Gerhard von Gruenewaldt, Vice President, NRF, South Africa
- Justin Irina, Secretary, Commission for Higher Education, Kenya
- Yadoni Kohi, Director General, Tanzania Commission for Science and Technology, Tanzania
- Michael Ngoni Mambo, Permanent Secretary, Ministry of Higher Education and Technology, Zimbabwe
- Moustapha Sourang, Rector of UCAD, Senegal

The first day of the workshop featured plenary lectures representing the topical areas of the workshop. The workshop also featured a panel discussion on applications of polymers and composites. The talks and the panel discussion set the tone for the discussions of the following day.

On the second day of the workshop, seven groups in each of the topical areas met in parallel sessions to discuss in detail some of the issues and questions that were introduced during the plenary talks. Specifically, the groups sought to identify links between the research and technology topics and materials needs, resource issues, manufacturing technology issues and materials education. The groups identified potential joint materials research topics with long-term, global benefits, addressed human resource issues, and discussed the central role of communication in collaborative efforts. In addition to identifying regional research strengths, infrastructure issues, and educational issues, the groups considered how existing relationships and potential connections among universities, national laboratories, industries, and funding agencies might promote collaborative initiatives.

On day 3, the groups presented their reports in a plenary session, which allowed all workshop participants to contribute to the workshop report.

Workshop Conclusions

Working within the topical areas, the workshop participants collectively offered many suggestions for launching collaborative ventures that would promote materials research and education in the U.S. and in Africa. Records of their discussions, along with their recommendations, appear in full in the appended reports. One common thread throughout all of the topical groups' discussions was the need to establish one or more organizations to ensure

the continuation of the conversations and initiatives that began at this workshop. The current fragmentation of the African materials research community is a serious obstacle to African progress in the area of materials. A continent possessed of tremendous potential wealth in the form of its natural resources, Africa too often finds itself without the necessary funds and human resources to enjoy its own riches. The formation of an African Materials Research Center and/or other materials-related consortia or centers would help to foster and coordinate efforts to obtain funding and to retain expertise within Africa while simultaneously attracting high-powered scientific and industrial collaborators from abroad. Given the barriers of time and distance that separate African nations from each other and the rest of the world, greater use of the Internet was also encouraged by all of the discussion groups. Whether it is used simply for communication or for sophisticated research projects involving the remote control of instrumentation, all groups agreed that the World Wide Web ought to be exploited in the service of improved collaboration among materials scientists working in academe, industry, and government. Similarly, many groups recommended the establishment of databases that would provide all materials scientist with a base from which to network with colleagues in their region, nation, and around the world.

Technical Recommendations

The recommendations made by the topical group in Materials Education and Training included the formation of consortia—at the regional, national, and continental levels—that could set international benchmarks for quality in research, teaching, and facilities. These consortia would also establish a common core curriculum in materials science. The group cited the need for the development of courses and curricular modules emphasizing industrial applications, which could be used at the precollege, undergraduate, and graduate levels. Graduate fellowships from industry would be more prevalent, the group reasoned, if industry had greater representation on departmental committees. In order to maximize the use of available education and training resources in materials, the group recommended the creation of a website. This website could be part of a larger initiative, such as the proposed U.S. Africa Institute of Materials Research and Education, which would strengthen the relationship of materials scientists and engineers working in the U.S. and throughout Africa. An institute such as this one would utilize existing resources, both government-owned and within the private sector, to set up partnerships between the U.S. and different regions of Africa. This institute would help U.S. academics to become involved in research and education in Africa, and vice versa. Ultimately, such a venture would prove mutually beneficial to the U.S. and to Africa.

The group for Civil Infrastructural Materials agreed that focused materials research and development efforts are needed in the design and construction of the following: durable infrastructural materials, energy efficient housing, and materials for road and transportation infrastructure development. Most crucial for Africa is the need for research into ways to create aesthetically appealing and socially acceptable low-cost housing materials. The recognition of this goal will require integrated, multidisciplinary research and development that is informed by the expertise of civil and mechanical engineers, architects, and materials scientists and engineers. Obstacles to the creation of decent, low-cost housing include a lack of funding and a dearth of high-level materials science personnel within many regions of Africa. One way to remedy this latter problem, the group suggested, would be to form a database, possibly under the auspices of the nascent Africa MRS, of all available human resources within Africa in the area of materials science and engineering. Similarly, some members of the group proposed the publication of a journal (perhaps only on the web, in order to minimize costs) of the Africa MRS, which would encourage still more collaborative ventures. This topical group plans to continue communicating with one another via the web in order to complete some or all of the following

tasks: joint proposal development, collaborative research and code development, and joint organization of symposia or workshops that will be part of future Africa MRS meetings or other, similar meetings.

The materials characterization group proposed the formation of an African Materials Characterization Consortium in order to integrate existing and future characterization techniques and facilities and to provide a permanent staff for their efficient utilization. They also recommended the establishment of an African Materials Research Society, which would facilitate the use of advanced information technology and promote materials education at all levels, from K-post graduate. This organization might also be able to reverse the industry's tendency to perform research outside of Africa and to deliver turnkey processes and factories. The group also recommended that international offset agreements be reached in order to change this trend.

Two topical groups met on the subject of the Materials Value Chain. The groups acknowledged the great variety of value chains abounding on the African continent, noting that opportunities for economic growth, job creation, and global competitiveness inhere within the varied materials industries. In order to recognize these improvements, one group proposed a dual focus for research: first, into the identification and development of better materials and second, into alternate manufacturing processes that will impart added value to materials. Greater use of the Internet, including cross-linked web pages among institutions with an African focus, as well as the formation of an Africa MRS, were recommended as means by which to achieve these goals. The other group recommended the establishment of value chain subcommittees that would systematically work a) to enhance middle level technical training that was focused on specific value chains and b) to promote the targeted education of workers in the areas of emergent technologies.

Two groups discussed Advanced and Emerging Materials. The development of products such as photovoltaics, photoconcentrators, optical materials, biomaterials for medical applications, polymer fibers and ultrahard materials can best be facilitated in a number of ways. Specifically, African institutions need to acquire laboratory equipment that they can also repair and to develop foundations that will fund collaborative research. If these recommendations can be implemented, they may stop the "brain drain" out of Africa. The groups recommended internet-accessible libraries with electronic journal subscriptions and the establishment of an African Materials Research Society. One group's recommendation for the establishment of regional centers of excellence dedicated to particular areas of research was echoed by the other group's fully-fleshed-out plan to create regional Centers for Advanced Technology and Entrepreneurial Development (CATED). As envisioned, these centers will act as hubs for collaboration, attracting renowned scientists who will be able to work together using state-of-the-art equipment located on site. These centers would allow young African scientists to flourish in their fields rather than to feel compelled to leave Africa in order to advance their research efforts.

Acknowledgments

The workshop organizers gratefully acknowledge the government agencies that supported the participants. The representatives of Reynolds Travel Agency—Lydia Norval, Mary Reynolds, and especially Jenny Hutchinson—worked tirelessly to assist the participants with all of their travel and lodging arrangements. Ron Sanderson of the University of Stellenbosch procured tote bags for all of the participants at no cost. Yunus Ballim of the University of the Witwatersrand prepared the report of Thursday's technical meeting, which is included in appendix 4. Christine Belden compiled the final report and served as the primary workshop coordinator for the U.S. and African participants. Finally, Jill Sawers' staff at the NRF—especially Nicoli Thomas, Jenny Hale, and Francisca Howie—provided invaluable organizational assistance during, before, and after the workshop.



MINUTES

USAfrica MATERIALS IMPLEMENTATION MEETING

August 13, 2001

NAIROBI, KENYA

TOWARD A *USAfrica* MATERIALS RESEARCH AND EDUCATION NETWORK

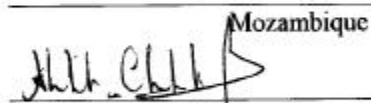
Engineering materials are more than mere components in technology; rather, the basic properties of materials frequently define the capabilities, potential, reliability, and limitations of technology itself. Improved materials and processes will play an ever increasing role in efforts to improve energy efficiency, promote environmental protection, lower health-care costs, develop an information infrastructure, and provide modern and reliable transportation and civil infrastructure systems. Advances in Materials Science and Engineering, therefore, enable progress across a broad range of scientific disciplines and technological areas with dramatic impacts on society.

Continued progress in Materials Science and Engineering is increasingly dependent upon collaborative efforts among several different disciplines, as well as closer coordination among funding agencies and effective partnerships involving universities, industry and national laboratories. In addition, because of the rapidly growing interdependence of the world's economies, partnerships are not only important at the national level but from an international point of view as well.

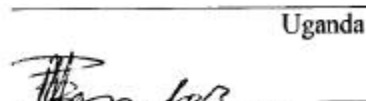
With this in mind, the US National Science Foundation and Agencies in several African countries co-sponsored a workshop in the area of materials research designed to help stimulate enhanced collaboration among materials researchers and create networks linking the participating countries. The workshop took place in Pretoria, South Africa in August 2000 and identified possible areas for mutually beneficial collaborations. The report of the workshop is available at <http://www.iamrs.org/>.

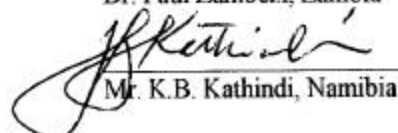
The first *USAfrica* Materials Implementation Meeting was held in Nairobi, Kenya on August 13th, 2001. The undersigned who attended the Nairobi meeting agreed to work toward the creation of the *USAfrica* Materials Research and Education Network and to hold the next meeting within a year in Senegal and report on progress made.


Abebe Mekuriauw, Ethiopia

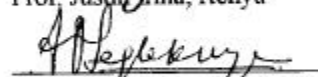

Prof. Aboubaker C. Beyc, Senegal

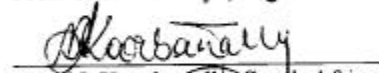

Mr. Bethuel Ndlovu, Swaziland

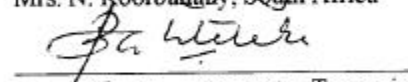

Dr. Paul Zambzi, Zambia

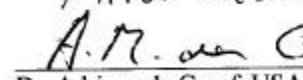

Mr. K.B. Kathindi, Namibia



Prof. Justin Jina, Kenya

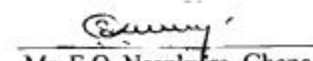

Prof. O.O. Adewoye, Nigeria


Mrs. N. Koorbanally, South Africa


TITUS MTELEGA, Tanzania


Dr. Adriaan de Graaf, USA


Dr. Michael N. Mambo, Zimbabwe


Mr. E.O. Nsenkyire, Ghana

US Africa MATERIALS IMPLEMENTATION MEETING

Silver Springs Hotel

Nairobi, Kenya

August 13, 2001

MINUTES

The US National Science Foundation, SA National Research Foundation and Agencies of several African countries co-sponsored a workshop in the area of materials research in Pretoria, South Africa in August 2000. This workshop was designed to stimulate collaboration among materials researchers and to create an electronic network that would facilitate such collaborations. The government representatives present at this workshop agreed to "...communicate with the materials research communities in the African countries as we jointly work toward implementation of the recommendations in the workshop report." (See <http://www.iumrs.org>). The first US Africa Materials Implementation Meeting was held on August 13, 2001 in Nairobi, Kenya. This meeting was attended by African government representatives from 14 countries and scientific observers. The government representatives described the ways science, technology, and education are supported in the respective countries.

Registration started at 8:15 a.m. There were 32 representatives in attendance.

Dr. Frank Kavishe (Kenya), the Workshop host and one of its organizers, introduced Professor Justin Irina, (Kenya) the host.

Professor Irina asked the group to introduce themselves. He then briefed the group on how the meeting would be run and invited Dr. Robert Eisenstein (NSF) to make welcoming remarks

Dr. Eisenstein thanked everybody for coming and passed on good wishes from Dr. Rita Colwell, the Director, National Science Foundation (NSF). He spoke briefly about the work being done in Materials Research by NSF. He recognized all the NSF staff that have been instrumental in putting together these workshops.

Since the Kenyan Minister for Science and Technology was delayed in arriving, the meeting continued with country presentations. Copies of these presentations are attached.

Kenya

Professor Justin Irina presented a paper on Kenya. He emphasized the need for closer collaboration between Kenya and USA. He talked about the work in progress to form the East African Materials Research Society (EAMRS) Chapter. He said that there was a need to maximize the impact of development by forming closer relationships between the academic institutions, governments, and private industry. He concluded that full industrialization of Africa should be slated for Year 2020 (as a goal). He assured the group of his government's full support.

Namibia

Mr. Kathindi presented a paper explaining the situation of Namibia in the field of Materials Research. Some asked, "How is Namibia keeping up with the education challenges facing it?" Mr. Kathindi answered, "Great challenge. Graduates go to South Africa and do not come back to Namibia. It is a great challenge". Mr. Kathindi indicated that Namibia is a huge country geographically with a population of only 1.7 million people. He said that the country is very rich in natural resources but these resources are too remote from academic institutions and therefore it is difficult for young researchers to have access in order to carry out any research. He expressed a need for Namibia to invest in its young people. He said that Namibia lacks the expertise among its own people and it has become very urgent for the Ministry of Education to take care of this situation.

Nigeria

Professor Adewoye presented for Nigeria. He informed the group that Nigeria has more than 50 universities and polytechnics and therefore education is viewed very seriously. He emphasized the importance of the role of the private sector in collaboration with academic institutions. He said that economic growth of any developing country cannot be dependent only on raw materials but rather on industrial development. He expressed the urgent need for developing countries to turn to education and scientific research to realize the technological know how that will equip these nations for the future. "Materials research would be the way to go", he said. He continued to say that Nigeria and Africa as a whole must resort to science education in order to develop. He said that his government will fully participate in this initiative.

Kenya

Mr. Peter Okaka represented the Minister of Education. Mr. Okaka was introduced by Professor Irina. Mr. Okaka, Director of the Kenya Commission for High Education read the message from the Minister of Education. The speech is abstracted here.

He thanked the participants for choosing to have this meeting in Kenya. He elaborated on where Kenya is going with science and technology. He welcomed the idea of collaboration between African institutions and U.S. research scientists. Mr. Okaka vowed that his government would do all that is in its power to enhance the development of better collaboration among African scientific bodies. He invited the group to visit with some of the institutions around Nairobi to see what is being done in Kenya in the way of scientific research.

Dr. Eisenstein introduced himself again and reiterated the message from Dr. Colwell, Director of NSF.

Later this morning, Professor King'oriah, Executive Secretary, National Council for Science and Technology, Kenya addressed the group. He emphasized the need for international collaboration through materials research. He stressed the fact that African governments do not

have adequate funding for scientific research and that international support of various kinds of research is very much needed.

Mozambique

Mr. Magaia introduced himself and read a message from the Minister of Education, Mozambique. He described the problems of his country that stem from a total lack of education and poverty. He said that 60% of Mozambique can hardly read or write. "This is mainly a result of long civil wars and natural disasters that have plagued Mozambique for a long time", he said. "In Mozambique, education is basically theory. Technical education is non-existent. Scientific research is far removed from the normal day-to-day activities of the Mozambican government. However, the Ministry of Education has now approved a strategic plan for the next 10 years", he reported. Mr. Magaia was confident that given the sure but slow progress socially and otherwise, Mozambique will be able to forge ahead in the right direction. Mr. Magaia expressed his profound gratitude for having been invited to this forum and promised to take back to his country the important message of fostering Africa-wide and eventually international collaboration in materials research and education.

Senegal

Professor Beye introduced himself and apologized for his Minister of Education who was unable to attend the meeting. He told the group that Senegal is looking at new approaches to education and training. Senegal is creating new universities around the country. His country has 10 million people and a budget of \$2 billion. Only a small portion of this budget goes towards science and technology education. Education and training of civil servants and high-school teachers have been for a while, the main task of universities in Senegal to enable the country to take over the education and administration system from the French government. He explained to the group that even though Senegal's university syllabus is similar to that of France, a lot has been done to break away from this "one-way" traffic and now they have collaboration with U.S. institutions, i.e. the University of California at Los Angeles (UCLA). At UCLA, they are working with Dr. Jane Chang, a professor in the Chemical Engineering department. They hope to expand to other fields.

A question was asked whether other Francophone countries were interested in joining the USAfrica Materials Research Society. The answer was a strong "yes".

Ethiopia

Professor Abebe Mekurian presented for his country. He informed the group that Ethiopia has many social problems stemming from previous wars, drought, soil erosion and lack of funding. Education is a highly desirable goal for all Ethiopians. He stated that Ethiopia depends almost totally on imported goods and subsistence farming. "The government of Ethiopia annually earmarks funds for scientific research but records show very little financial support for Ethiopian scientists and therefore scientists mainly resort to foreign donor agencies", he said. Professor Mekurian expressed the need for African scientists to work together to build and maintain a steady flow of young scientist. He suggested that this type of collaboration as is being created in

Nairobi would go a long way in enhancing economic growth among African nations. He also introduced the idea of an “exchange program” among African institutions to enable continuity not only in one nation but also in the whole of Africa. He assured the group that Ethiopia will do all that is in its power to implement the recommendations of the Nairobi meeting.

The National Council for Science and Technology, Kenya

Professor King’oriah presented a paper to emphasize the work already underway in Kenya. He stated that the Council has very limited resources to support this very important, but expensive, materials research. He said that Kenya has put in place teacher training facilities to encourage scientific knowledge at the lower levels of education. He emphasized the need to integrate science and technology with industry. He said that the collaboration between scientists and the private sector would go a long way in solving the immediate social problems in Africa. He pleaded with his government to make more funds available for scientific research. A question was asked, "what is the role of multi-nationals in Africa?" The answer was that "in sub-Saharan Africa, the emphasis is NOT on human resources development but more on industrial production. This creates a vacuum in Africa." he told the group.

South Africa

Mrs. Nicoli Koorbonally of the National Research Foundation (NRF) presented a paper for her country, South Africa. “South Africa is well established in materials research and a number of scientists benefit from the various funding mechanisms of the NRF. The NRF’s mission is to be a dynamic, quality-driven organization, and to provide leadership in the support and promotion of research and research capacity development. We aim to uphold research excellence by promoting innovation and supporting basic and applied scientific research. We are very interested in creating meaningful networks across Africa and abroad” she told the group. She talked about the collaboration that already existed between South Africa and the SADC countries and other inter-governmental agreements. She talked about the role the NRF played both locally and internationally and said that South Africa still needed to improve its international competitiveness in order to become a major player in the global market. “This and other national challenges can only be achieved by, inter alia, investing in scientific knowledge, human resources and good infrastructure,” she said.

Swaziland

Dr. Varkey of the University of Swaziland introduced himself and apologized for Mr. Ndlovu, the government representative who was unable to attend. He then delivered a paper on behalf of Mr. Ndlovu on Materials Research in Swaziland. “Swaziland is a land-locked small country and there is significant scientific research currently going on but not much on materials at this time,” he told the group. Professor Varkey welcomed the idea of an Africa-wide collaboration group. Even though he was not the government representative, Professor Varkey assured the group that Swaziland would fully participate in all the recommendations of the Nairobi meeting.

Uganda

Dr. John Fred Kakule represented Uganda. Dr. Kakule started off by giving "special thanks" to Margaret-Anne Wampamba who was instrumental in getting Uganda to this meeting. "Uganda must move from an agrarian to an industrialized economy," he told the group. He said that funding for scientific research is very low in his country and that it is very difficult to get reliable data on either funding levels or participations. He told the group that there is a need to solicit private sector support for scientific research funding which will eventually enable the transfer of technology to various industries. He said that his country is moving towards the enhancement of scientific and technological research by promoting human resources development through advanced training both locally and abroad. "Uganda welcomes continuous collaboration among other institutions within Africa and other countries", he said. He said that Makerere University has a very active Physics Department and that the only thing missing is funding. "The university lacks good infrastructure to advance materials research," he concluded.

Zambia

Zambia was represented by Dr. Zambezi. "Zambia is one of the countries in Africa that have been engaged in materials research for a long time. The National Institute for Scientific and Industrial Research (NISIR) is manned by a good group of materials research scientists", Dr. Zambezi explained. Dr. Zambezi told the group that even though materials science is taught as a minor course at the University of Zambia, it plans to offer a full undergraduate degree program. He said, "most of the research has been industrially based and there is an urgent need to do research within our universities". "Zambia welcomes the idea of an all-Africa collaboration initiative and we will do our best to contribute as much as we can," Mr. Zambezi concluded.

Zimbabwe

Dr. Mambo presented the paper on what Zimbabwe is doing in materials research. "Zimbabwe is on track and on target with regard to science and technology. Zimbabwe is poised to realize its dreams through on-going research." He said that in Zimbabwe, materials research is supported by the state through universities and the private sector through parastatal bodies. He expressed the need for Zimbabwe to promote awareness of science and technology among the people of Zimbabwe. That Zimbabwe should invest more in science and technology. Also, he told the group that Zimbabwe is faced with the challenge of global competitiveness. Dr. Mambo told the group that the only way for Africa to forge ahead was through collaborations such as those being discussed here today.

USA (NSF)

Dr. Adriaan de Graaf made a presentation on behalf of NSF. He talked about what NSF has done so far in attempting to enhance collaborations in materials research around the world. He talked of how NSF can help the African countries represented at this meeting to realize their dream of a materials research network across Africa. Dr. de Graaf encouraged the group to forge ahead in all aspects of materials research because that is one way Africa can join the industrialized world. "Materials research can enhance the development of your countries at a

level never envisaged before," he told the group. "NSF is ready to extend a helping hand but Africa has to show initiative and that is your job. NSF can point you in the right direction for collaborations but we cannot initiate the research activities for you," Dr. de Graaf went on to explain. "We are all very excited to be here. We are very grateful to our Kenya colleagues that agreed to host this meeting. We are looking forward to working with each one of you in the future," Dr. de Graaf concluded.

The Africa Virtual University

Dr. Akidiva presented a brief paper on this university and what they can do to help the scientists in Africa. "This is a World Bank project. There is a liaison office at the World Bank, a facilitating office in Washington, D.C. and the headquarters in Nairobi", he told the group. Dr. Eisenstein visited the Africa Virtual University in the afternoon to see what is being done there. A brochure about the AVU is attached.