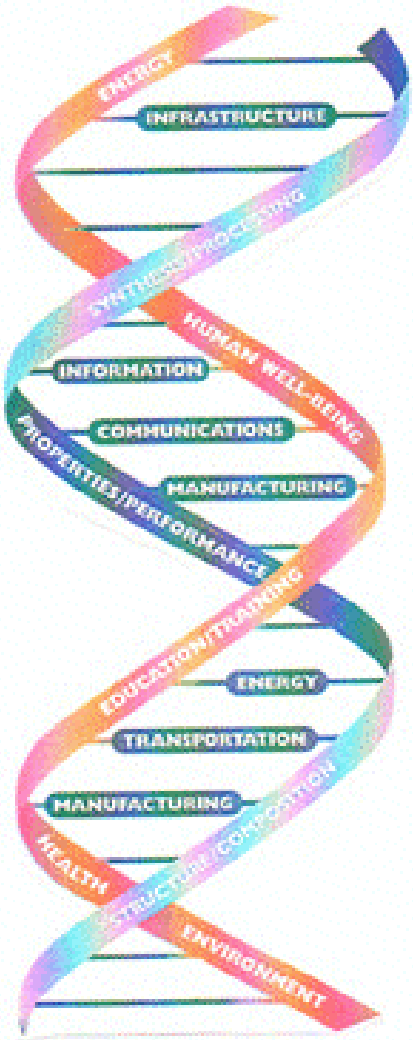
US-Asian Pacific Materials Research, Technology, & Education for the 21st Century in the Service of Society



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 (CO_2), 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" (MC^2) that would provide access to users on a fee-for-service basis and/or collaborative basis. An MC^2 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.