MRS International Meeting on Advanced Materials—Tokyo Report

The following reports summarize symposia featured at the MRS International Meeting on Advanced Materials held May 30-June 3, 1988 in Tokyo, Japan. For an overview of this meeting, plus several other major materials meetings held in Asia about the same time, see the September issue of the MRS BULLETIN, p. 29.

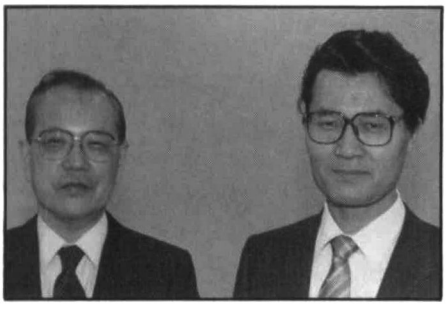
The summaries published here only describe the symposium highlights. Readers interested in detailed technical content can order the symposium proceedings being published by the Materials Research Society. (See the proceedings list elsewhere in this issue.)

Serving as Meeting Chairs for the MRS International Meeting on Advanced Materials were Prof. Masao Doyama (left) of Nagoya University and Shigeyuki Somiya of the Nishi Tokyo University and also the most recent recipient of the Japan Prize.

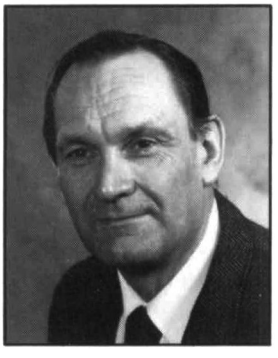
Superconductivity—D

Organizers: K. Tachikawa (Tokai University) and K. Kitazawa (University of Tokyo).

Symposium D on Superconductivity was by far the largest of the 21 symposia at the MRS International Meeting on Advanced Materials. All the sessions were packed, the average attendance being 300 persons. The program consisted of 12 sessions with a total of 169 papers. Topics included the processing and characterization of both oxide and metal superconductors. In particular, oxide superconductors in the form of fibers, wires, thin films, thick films, single crystals and composite materials were addressed. Also covered were theory, structure, phase transformations, chemical stability, physical properties, and superconducting properties.



Symposium D organizers (left to right): K. Tachikawa and K. Kitazawa.



E.W. Collings, research leader, Battelle Columbus, and a representative of the International Cryogenic Materials Conference, which co-sponsored Symposium D on Superconductivity with MRS at the International Meeting on Advanced Materials.

A number of experimental techniques were shown to be able to form thin films of oxide superconductors. These included magnetron sputtering, activated reactive sputtering, activated reactive evaporation, electron beam co-evaporation, laser beam evaporation, chemical methods, and fine particle deposition. Techniques used for making oxide superconductors in various forms included suspension spinning, sol-gel processing, gas phase reaction, aerosol flow reactor processing, hot extrusion, liquid quenching, spray decomposition, thermal spray, electrophoretic deposition, etc. Moreover, techniques used for making composite forms of oxide superconductors included diffusion, lamination, hot isostatic pressing, oxidation of metallic precursors, paste processing, etc.

Structural studies covered crystal structure, phase transformations, oxygen ordering, microstructure and interface structure. Properties covered included superconducting, electrical, magnetic, electrochemical, electromechanical, elastic, thermal and other aspects.

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Superplasticity—E

Organizers: M. Kobayashi (Technological University of Nagaoka) and F. Wakai (Government Industrial Research Institute, Nagoya)

This symposium was devoted to new developments of superplasticity in advanced materials—metals, intermetallic compounds, composites, and ceramics. It brought together scientists and engineers from academic institutions, industry and government with backgrounds ranging from metallurgy to ceramic engineering. Thirty-six oral contributed and invited pa-

pers were presented, and were subject to lively discussions for two days. Of these papers, 23 were devoted to the superplasticity of metals and alloys, and the remainder to the superplasticity of ceramics.

On the superplasticity of metals and alloys, Zn-Al eutectoid alloys have been used as the model materials to investigate the mechanism of superplastic phenomena as in previous years and also utilized for a base metal for composite materials. The state of the art and prospects on superplasticity of duplex Ti alloy, mainly on superplasticity of Ti-6Al-4V alloy, were reviewed by C.H. Hamilton.

The current interest in Al alloys, especially 7475 Al alloy and Al-Li alloy, is increasing. The analysis of cavitation during the superplastic deformation of these alloys was presented by N. Ridley and by T.G. Langdon. Novel processing methods, grain refinement, and Zr addition were developed to suppress cavitation by M. Kobayashi, K. Matsuki, T.G. Nieh, and D.J. Chellman. The mechanical performance of superplastically formed products at cryogenic temperatures was evaluated by J. Glazer. Also discussed were improvements in superplastic elongation of duplex stainless steel (25Cr-6.5Ni-3Mo).

An important feature of this symposium was the emergence of new field—the superplasticity of advanced ceramic materials. The session on superplasticity of ceramics was highlighted by C. Carry's invited review talk. The great interest centered on TZP and ZrO_2-toughened ceramics, such as ZrO_2/Al_2O_3 composites by a Japanese MITI group and ZrO_2/mullite composites by I.W. Chen. The deformation mechanisms of Y-TZP, effects of second phase dispersion on superplasticity of ZrO_2-containing composites and diffusion bonding of composites were subject to a lively discussion. T.G. Nieh, J. Wadsworth and O.D. Sherby presented late-news results on extraordinary elongation of TZP. The deformation of liquid containing ceramics was discussed by Y. Okamoto. Other novel materials discussed included fine-grained SiC by T. Nose and Si_2Mo/boride composites by T. Watanabe. This session provided a forum for exciting interdisciplinary discussions on the new developments in superplasticity and high ductilities of oxide and non-oxide ceramics.

Shape Memory Materials—H

Organizers: K. Shimizu (Institute of Scientific and Industrial Research, Osaka Univ.) and K. Otsuka (Institute of Materials Science, University of Tsukuba).

Papers presented at this symposium included 43 from Japan and 53 from 11 other countries. Among the unique aspects of this symposium was the introduction of new shape memory materials or those exhibiting martensitic transformations, such as ceramics, antiferroelectrics, superconductors, Fe-base alloys and polymers, in addition to well-known shape memory alloys such as Ti-Ni based and Cu-based alloys. Emphasis was also placed on the fabrication and applications of shape memory alloys, considering the practical importance of shape memory alloys. Also discussed were lattice instability and the mechanism of martensitic transformations. Another significant aspect was the provision of comprehensive up-to-date review articles by experts in this field. The articles will serve as an excellent and timely guide in this field.

In the session on the mechanism of martensitic transformations and lattice instability, G. Shirane presented an invited paper on soft modes in condensed matter physics, especially considering high T_c superconductors La_2CuO_4 and NiAl. T. Suzuki explained a new theory on the mechanism of martensitic transformation and nonlinear lattice vibration. Papers by several physicists threw new light into the field of martensitic transformation.

In the session on martensitic transformations and shape memory effects in Ti-Ni alloys, C.M. Wayman's invited paper presented a unified view on transformation, self-accommodation, deformation and shape memory behavior of Ti-Ni alloys. Another invited speaker, T. Saburi, gave an excellent comprehensive up-to-date review on the structure and mechanical behavior of Ti-Ni shape memory alloys.

Two invited papers were presented during the session on martensitic transformation and shape memory effects in Cu-based and noble metal-based alloys. L. Delaey et al. reported new research on the hysteresis effect in shape memory alloys from the viewpoint of thermodynamics and mechanical effect. T. Tadaki and K. Shimizu gave an up-to-date review on aging, thermal cycling and deformation cycling effects in β phase shape memory alloys.

Invited speakers in the session on shape memory effects in Fe-based alloys included T. Maki and A. Sato. Maki explained how his group developed Fe-Ni-Co-Ti shape memory alloys. Sato discussed the shape memory effect and physical properties of Fe-Mn-Si alloy.

The session on martensitic transformations and shape memory effects in ceramics and superconductors was remarkable in its coverage of new areas such as antiferroelectrics, ceramics, and superconductors. K. Uchino, T. Sakuma and Y. Wang were the invited speakers. Uchino reviewed the shape memory effect associated with the forced phase transition in ferroelectrics based on his own research. Sakuma discussed the diffusionless cubic-tetragonal transition in partially stabilized zirconia. In an exciting, timely review, Wang discussed martensite-like transition in high temperature oxide superconductors.

In the session on fabrication and application of shape memory alloys, Y. Suzuki presented an invited paper on fabrication, characterization and applications of shape

Symposium E organizers (left to right): M. Kobayashi and K.F. Wakai.

Symposium H organizers (left to right): K. Shimizu and K. Otsuka.

Symposium J organizers (left to right): Y. Hamano and O. Kamigaito.

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memory alloys, concentrating on those of Ti-Ni alloys. Y. Chu also presented an invited paper on research and applications of shape memory alloys in China, showing a video on the medical applications of Ti-Ni alloys in China. The invited paper by T.W. Duerig and K.N. Melton focused on designing with the shape memory effect and showed some examples developed in their company.

Structural Ceramics—J

Organizers: Y. Hamano (Kyocera Corporation) and O. Kamigaito (Toyota Central Research and Development Laboratories)

This symposium drew a large and enthusiastic audience during its two days with approximately 40 invited and contributed oral and poster presentations. Speakers reported on new approaches to fabricate more reliable, more precise, and cheaper ceramic components through refined or newly developed processes. Other reports covered approaches to more heat resistant material above 1,300°C through controlling microstructure and composition, and recent experiences with applying structural ceramics.

Invited speakers covered diverse aspects of structural ceramics: T. Nakagawa described a highly efficient and precise grinding technology that applies a tough diamond grinding wheel made of powder metallurgical cast iron, high rigidity cutting machine tools, an electro-discharging process, and ultrasonic vibration. Realization of cheap as well as precise ceramic components looks possible. M. Mizukane reviewed fabrication processes, advantageous properties and application of large size ceramic construction to measuring tools, guide rails, machining beds, and more.

M.D. Meiser and R. Kamo gave an overview of silicon nitride and silicon nitride based composites for heat engine applications in relation to the fabrication process. High temperature properties of these and other materials were also discussed, as were design concepts for heat engines, thermal barriers, and heat efficiency. H. Kawamura reported on the actual application of silicon nitride in a turbo compound type passenger car engine. Besides describing experience with the engine, he mentioned a successful running of over 5,000 hours, and a thick barrier made by precious ceramic engine components.

Y. Hamano described ceramic components for high-temperature gas turbines in relation to fabrication technology and evaluation technology. Test-runs of the gas turbine were reviewed in connection with the AGT project.

E.M. Lenoe evaluated the current status and future possibilities of ceramic components. Design concept, design allowables, required properties for engine components, and data analysis techniques were discussed in relation to the properties of the actual ceramics.

Other topics covered were: improvement of the mechanical properties of some structural ceramics (silicon nitride, silicon carbide, borides, zirconia-based ceramics, and some composites) through refinement of powder preparation, sintering and forming processes, etc.; lengthy fatigue tests; morphological and phase changes in the sintering process; machining and its influence on mechanical properties; newly developed machining methods; designing precision components for structural and high temperature use; and applications to heat engine and static structure.

Taking CeO_2 and Y_2O_3 as an example of dopants, K. Matsuhiro and T. Takahashi emphasized the importance of dopants to the morphology and mechanical property of sintered silicon nitride. Their influence on the alpha-to-beta transformation rate in sintered silicon nitride was also considered. The possibility of compositional design of $0' + \beta$ sialon composite and sialon with refractory grain boundary phase was discussed by T.S. Yen, W.Y. Sun, Z.K. Huang, and Y.R. Xu. The possibility for the ceramics to retain mechanical strength up to 1,300°C or higher was discussed affirmatively. The crack propagation paths in CVD SiC (parallel to the closed packed plane) and in HIP SiC (intergranular) were described by G. Sasaki, K. Hiraga, M. Hirabayashi, T. Hirai, and K. Niihara, as was the correlation between the microstructure and mechanical properties. The influence of CIP-ing pressure on mechanical properties was studied in relation to the structural homogenity of CIP-ed compacts by O. Abe, S. Kanzaki, and H. Tabata. Mechanical properties were much improved by removing the inhomogenity by selecting suitable CIP-ing pressure. Y. Matsuo, T. Nishimura, K. Yasuda, K. Jinbo, and S. Kimura studied ways to improve the uniformity of each specimen's mechanical properties by using the newly developed forming method, cyclic CIP, in which CIP pressure is applied cyclically. More uniform microstructure of green compacts was shown to be responsible for the improved Weibull modulus of the specimen.

Improvement of the mechanical properties of silicon nitride through gas pressure sintering was discussed by M. Mitomo in relation to its microstructure. His study emphasized the importance of developing a high aspect ratio silicon nitride rod in achieving high fracture toughness. The possibility of getting higher fracture toughness in the material by using gas pressure sintering was suggested. Improvement of TZP/Al_2O_3 by doping CeO_2 and Y_2O_3 was discussed by T. Sato, T. Endo, and M. Shimada. Improvement of thermal stability through doping $Y\text{-}TZP/Al_2O_3$ with CeO_2, suppression of grain growth by addition of Al_2O_3 to (Y,Ce)-TZP, and the possible presence of an unallowable region in a bending strength-fracture toughness diagram were shown.

Fabrication of high density SiC/C composite was discussed by K. Kijima, T. Uetsuki, and K. Tanaka in relation to fabricating process. The remarkable enhancement of densification of the composite by applying plasma was shown.

An advantageous application of amorphous Si-C-N powder to Si_3N_4/SiC composite, which has high fracture toughness (6 to 8 $MPa/m^{1/2}$ at the composition of 90 vol% Si_3N_4/10 vol% SiC) and high fracture stress, was studied by K. Niihara, T. Hirano, A. Nakahira, K. Ojima, K. Izaki, and T. Kawakami. The possibility of high fracture toughness and fracture stress at high temperature was also discussed.

Lengthy rotary bending fatigue tests on sintered silicon nitride and sintered alumina were carried out by H.N. Ko, up to 10^9 cycles. The S-N curve showed little saturation for alumina rods, but it indicated the occurrence of saturation beyond 10^8 cycles for silicon nitride rods, proving the material to be advantageous for rotary components.

The presence of unexpectedly high residual surface stress on machined silicon nitride specimen was discussed by H. Kishimoto, A. Ueno, and H. Kawamoto. Elimination of the residual stress was also discussed.

SLAM application to NDI was discussed by M. Oishi, K. Noguchi, T. Masaki, and M. Mizushima, showing the possible characterization of defects down to 30 μm.

Microstructure-Property Relationships in Magnetic Materials—L

Organizers: M. Homma (Tohoku University), Y. Imaoka (TDK Corporation) and M. Okada (Tohoku University).

Many magnetic properties are sensitive to microstructures, which are extremely varied, depending on the fabrication of materials. It is technologically important to understand the microstructural evolutions during processing, in conjunction with their properties. This symposium covered topics of microstructure-property relationships in hard magnetic materials, soft magnetic materials, magnetic recording media, and magnetic-optical recording media, ranging from fundamental aspects such as

Symposium L organizers (left to right): M. Homma and Y. Imaoka.

Symposium M organizers (left to right): M. Sakai and T. Kishi.

Symposium O organizer: Y Moro-oka.

theoretical considerations, microstructural characterizations, through technological issues such as material fabrications.

Sixteen invited papers and 10 contributed papers were presented in seven sessions at the symposium. Invited speakers covered the following current topics:

For permanent magnets, the greatest interest centered on the microstructure-property relationships in the Nd-Fe-B permanent magnets. Theoretical aspects of the relationships were reviewed by Kronmuller and experimental ones were covered by Hirosawa. Microstructural features of Nd-Fe-B magnets were discussed by Thomas and Tokunaga in conjunction with their magnetic properties. Single-domain size of the Nd-Fe-B compound was estimated with the magnetic domain observations by Goto. Umeda established the phase diagram of the Sm_2Co_{17} magnet system. Okada reviewed the relationships in Fe-Cr-Co ductile magnets; Sakamoto, in Mn-Al-C magnets.

For soft magnetic materials, developments of grain-oriented silicon steels were reviewed by Nozawa, in correlation with the domain structures and magnetic properties. Arai reported the developments of (110)[001] textures in 4.5% Si-steels. Takada presented the successful developments of Fe-6.5wt% Si sheets. Their fabrication had been deemed difficult, with their magnetic properties. Takahashi reviewed the relationships in Fe-Al-Si (Sendust) alloys using single crystals. Nomura discussed the relationship between the power loss at high frequencies and the microstructure of MnZn Ferrites.

For magnetic recording media, Fujiwara demonstrated the effects of particle factors on media properties utilizing the barium ferrite media. For magneto-optical recording media, Marinero presented the structural properties of rare-earth transition metal alloys, in conjunction with their magnetic properties. Fukamichi reviewed the magnetic properties of amorphous and crystalline states of Fe-based alloys.

Fracture Mechanics—M

Organizers: M. Sakai (Toyohashi University of Technology) and T. Kishi (University of Tokyo).

The symposium's main objective was to provide an interdisciplinary forum for theoretical and experimental scientists in the fracture mechanics fields of advanced materials involving metals, ceramics, polymers, concretes, and their composites. Major topics included toughening mechanics and mechanisms, fatigue and subcritical crack growth, failure of composite materials, and dynamic fracture. Because of recent intensive interest in advanced ceramic materials, there were several fracture mechanics studies on the fracture behavior of ceramics and their composites. The symposium consistently drew a large audience throughout its two days with approximately 45 invited and contributed oral and poster presentations.

The session on toughness and toughening mechanisms was highlighted by two excellent talks by R.M. McMeeking and Y-W. Mai. In particular, the rising R-curve behavior associated with various types of toughening mechanisms both in frontal process zone and its following wake region was demonstrated and discussed.

H. Horii guided the session on fracture of rocks and concretes with an invited talk by V.C. Li. The micromechanics studies of "stress-induced microcracking" and "grain bridging" along fracture surfaces in rocks and concrete materials was recognized to be very similar to those in ceramics through interdisciplinary discussions among the participants from civil engineering and materials science.

An excellent review talk by D.B. Marshall focused on the micromechanics of ceramic composites failure. He addressed the details of fiber pull-out mechanism in the toughening process of fiber-reinforced ceramic composites.

The symposium featured a joint session with Symposium J (Structural Ceramics) on "Fatigue and Life Time Prediction for Ceramics." The session began with an interesting review by D. Munz and included seven excellent papers. It was difficult to find vacant seats during the session, an indication of the strong interest in applying ceramic components to practical engineering uses.

Catalytic Materials—O

Organizer: Y. Moro-oka (Tokyo Institute of Technology).

This symposium focused on recent developments of advanced materials for catalysis, including 30 invited and contributed presentations. Major topics included zeolites and layered compounds, catalytic combustion, multicomponent metal oxide catalysts, supported metals and sensors. This was a modest but compact symposium which highlighted work in new materials systems and approaches to the effective catalysts.

A significant feature of the symposium was increasing interest in high temperature combustion catalysts, highlighted by invited talks by H. Arai (Kyushu University) and K. Kato (Hitachi Ltd.). Cation-substituted hexaaluminates ($BaO{\bullet}6Al_2O_3$ et al.) and lanthanide β-alumina ($Ln_2O_3{\bullet}11\text{-}14Al_2O_3$) were introduced as excellent catalysts and supports for high temperature combustion above 1200°C. It was reported that cation-substituted barium hexaaluminates retained large surface areas above 10 m^2/g even after calcination at 1300°C. $BaMnAl_{11}O_{19-\alpha}$ and its related compounds showed the surface area of 23 m^2/g after calcination at 1300°C and superior combustion activity which exceeds those of conventional combustion catalysts, such as Pt/Al_2O_3 and perovskite-type oxides. Another novel development included talks

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by K. Saito's (Nippon Shokubai Kagaku Kogyo) description of a catalytic trap oxidizer for reducing particulates from heavy-duty diesel engines. It was suggested that noble-metal-promoted catalytic trap oxidizers show sufficient durability for practical use at 600°C using low sulfur fuel and ashless lubricating oil.

New directions in the zeolites crystallized from templated low silica aluminosilicate gels were reviewed by D.E.W. Vaughan (Exxon Research & Engineering). Catalytic behavior of cation-exchanged zeolites, CVD zeolites with controlled pore-openings, and smectite clays pillared by alumina for the shape selective reaction of trimethylbenzene were also discussed. E. Kikuchi (Waseda University) gave beautiful results on the shape-selective catalysis of pillared sponite, where pseudocumene or 1,2,4-trimethylbenzene was converted selectively to 1,2,4,5-tetramethylbenzene without any deactivation of the catalyst.

A novel process to produce maleic anhydride from n-butane using V/P/O catalyst was introduced by A.W. Sleight (E.I. du Pont de Nemours and Co.). Other topics covered were catalytic behaviors of mixed oxide catalysts having perovskite structure, MgO modified with metal cations, and multicomponent metal oxide catalysts prepared by various new methods.

Advanced Cements and Chemically Bonded Ceramics—S

Organizers: M. Daimon (Tokyo Institute of Technology), G. Sudoh (Chichibu Cement Company), S. Sōmiya (Nishi Tokyo University), and K. Takemoto (Onoda Cement Co.).

Symposium S served as a focus for reporting new research findings and potential applications, bringing together reports on advancements in structural concrete materials made with cement and also those achieved with special cements. It further helped define the boundaries of a newly developing focus, chemically bonded ceramics, formed through the utilization of the thermodynamics of chemical reactions in contrast to the thermal energy involved in usual ceramic forming through sintering, fusion, casting, or other high temperature processes. The various approaches to the Symposium S topic were well represented by the co-chairs: Masaki-Daimon (inorganic materials), Shigeyuki Sōmiya (advanced ceramics and hydrothermal synthesis), and Giichi Sudoh and Kunihiro Takemoto (representing the cement and concrete industry). The symposium included some 30 invited and contributed papers. Participants were treated to an elegant dinner hosted by the Cement Association of Japan.

Invited speakers in the first session discussed new advancements and applications in concrete-polymer composites including fiber-reinforced materials (Y. Ohama, Nihon University) and in polymer-impregnated concretes (M. Kawakami, Akita University). A later session dealt specifically with fiber composites (including carbon-fiber-reinforced materials): mechanical properties and applications (S. Akihama, Kajima Institute of Construction). Recent advancements in phosphate chemically bonded ceramics were described by D.M. Roy (Pennsylvania State University), while the characteristics of hydraulic calcium phosphates having potential biomaterial applications, were elaborated by H. Monma (NIRIM, Japan). Macro-defect free cements were discussed in several contributed papers, followed by a session on materials incorporating fine particles. S. Nagataki (Tokyo Institute of Technology) reviewed the status of high strength concrete, and J.D. Birchall (ICI, United Kingdom) reviewed principles of chemically bonded ceramics. In the final session, special cements were discussed, including ettringite cements, low energy, and hydrothermal cements. The concluding paper by F.P. Glasser (University of Aberdeen) discussed special calcium aluminate cements.

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Symposium S organizers (left to right): M. Daimon, G. Sudoh, S. Sōmiya, and K Takemoto.

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