

## AUTHORS — JULY 1991

### CARBON MATERIALS SPECIAL

#### PROPERTIES AND PERFORMANCE OF BERYLLIUM AND CARBON FOR PLASMA-FACING COMPONENTS

**Karl Jürgen Dietz** (PhD, applied physics, University of Göttingen, Federal Republic of Germany, 1967) worked at the Institute of Plasmaphysics of the Kernforschungsanlage Jülich from 1969 until 1979. His main areas of research were low-density, high-beta theta pinches and aspects of plasma/wall interaction (hydrogen recycling and chemical erosion). He joined the Joint European Torus (JET) project in 1979, working on plasma limiters and wall conditioning. In 1986, he was appointed head of the First-Wall Division with responsibilities for material development, plasma-facing components, and pellet injection as well as for the vacuum, gas introduction, and wall conditioning systems.

*Karl Jürgen Dietz  
The JET Team*



#### PERFORMANCE OF BRAZED GRAPHITE, CARBON-FIBER COMPOSITE, AND TZM MATERIALS FOR ACTIVELY COOLED STRUCTURES: QUALIFICATION TESTS

**Ivica Šmid** (top right) (Dr. rer. nat., physical chemistry, University of Vienna, Austria, 1987) is a member of the staff of Österreichisches Forschungszentrum working on the characterization and testing of refractories and carbon materials. **Charles D. Croessmann** (top left) (BS, nuclear engineering, University of Missouri-Rolla, 1981; MS, 1983, and PhD, 1986, nuclear engineering, University of Wisconsin) is a member of the technical staff at Sandia National Laboratories (SNL). He is currently responsible for coordination of experiments in the Plasma Materials Test Facility and for the operation of the Electron Beam Test System. His current interests include high heat flux testing of plasma-facing components and materials response to intense energy deposition. **Robert D. Watson** (bottom right) (PhD, nuclear engineering, University of Wisconsin) is a member of the SNL staff. His research interests include finite element thermal stress analysis and design of high heat flux components. **Jochen Linke** (bottom left) [Dr. rer. nat., physicist, Technical University of Aachen, Federal Republic of Germany (FRG), 1977] joined the Institut für Reaktorwerkstoffe at Forschungszentrum Jülich in 1974. His first research was on the deposition of pyrolytic carbon.

*Ivica Šmid  
Charles D. Croessmann  
Robert D. Watson  
Jochen Linke  
Antonino Cardella  
Harald Bolt  
Nikolaus Reheis  
Erich Kny*



He is currently working on material characterization and the development and testing of plasma-facing components for fusion devices. **Antonino Cardella** (top right) (Dr.-Ing., nuclear engineering, University of Palermo, Italy, 1977) joined the Next European Torus (NET) Team in 1984 and is now a member of the International Thermonuclear Experimental Reactor (ITER) Team. He is responsible for divertor design and technological research and development. **Harald Bolt** (top left) (Dr.-Ing., Technical University of Aachen, FRG, 1988; Dr. Eng., Nagoya University, Japan, 1990) worked with the NET Team on the development of plasma-facing components. Since 1990, he has been an associate professor of nuclear engineering at the University of Tokyo. His current work concerns plasma/material interaction and plasma-facing components. **Nikolaus Reheis** (bottom right) (Ing. Chemotechnik, Graz, Austria, 1981) is head of the joining techniques department of Metallwerk Plansee. He has been involved in manufacturing and testing first-wall and divertor components. **Erich Kny** (bottom left) (PhD, chemistry and physics, University of Vienna, Austria, 1975) has been with Metallwerk Plansee since 1981, where he became the deputy director of research and development. He is now head of the Engineering Division at Österreichisches Forschungszentrum.



#### BRAZED GRAPHITE FOR ACTIVELY COOLED PLASMA-FACING COMPONENTS IN TORE SUPRA – DESCRIPTION, TESTS, AND PERFORMANCE

**Manfred Lipa** (top) is a former member of Max-Planck-Institut für Plasmaphysik. Since 1974, he has worked for Euratom at the Commissariat à l’Energie Atomique (CEA) Department of Controlled Fusion. He has been involved in the development and fabrication of plasma-facing components and the design of the divertor for the Tore Supra tokamak. His current interest is the development of a first-wall concept for the Next European Torus (NET)/International Thermonuclear Experimental Reactor (ITER). **Phillippe Chappuis** (bottom) has been involved in the development and fabrication of plasma-facing components for Tore Supra in which he specialized in the design of high heat flux elements. His current interest is the development of a divertor concept for NET/ITER and plasma/wall interactions in Tore Supra. **Pierre Deschamps** (no photograph available) is head of the plasma-facing components group at the CEA Department of Controlled Fusion.

*Manfred Lipa  
Phillippe Chappuis  
Pierre Deschamps*



#### THICK CARBON DEPOSITION BY CASCADED ARCS

**Ad J. M. Buuron** (top) [MS, physics, Eindhoven University of Technology (EUT), Netherlands, 1983] has been a member of the plasma physics group at EUT since 1989. His primary research is in the fast deposition of crystalline carbon layers by an expanding cascaded arc plasma, particularly the relationship between plasma parameters and the properties of the deposited material. **Sjaak J. Beulens** (center) (MS, physics, EUT, Netherlands, 1987) has worked in the plasma physics group at EUT since 1987. He is currently working on his PhD. His primary interests are two-dimensional modeling of the flow behavior and the parameters of the expanding cascaded arc plasma, as well as absorption and emission spectroscopy for determining plasma densities and temperatures. **Ries J. F. van de Sande** (bottom) (technical engineering, MTS Tilburg, Netherlands, 1968) joined the plasma physics

*Ad J. M. Buuron  
Sjaak J. Beulens  
Ries J. F. van de Sande  
Daniel C. Schram  
Jaap G. van der Laan*



group at EUT in 1968. He has been involved in the stationary cascaded arc, the pulsed arc, and the high-pressure arc. He recently worked on the development and optimization of the expanding cascaded arc. **Daniel C. Schram** (top) (PhD, FOM Rijnhuizen, Netherlands, 1969) leads the plasma physics group at EUT. He is working on the fundamentals of plasma physics, including transport phenomena, excitation, radiation, and turbulence. **Jaap G. van der Laan** (bottom) (Ingenieurs diploma, applied physics, Rijksuniversiteit Groningen, Netherlands, 1986) joined the Netherlands Energy Research Foundation in 1986. He worked on the development of mechanical characterization methods for technical ceramics and plasma-sprayed ceramic coatings. His main interests are the analysis and experimental simulation of off-normal high heat loads on plasma-facing materials. He was assigned to the Next European Torus (NET) Team in 1990, where his work concentrates on off-normal operating conditions for plasma-facing materials, high heat flux testing, and materials development.



#### INTERACTIONS OF BULK-BORONIZED GRAPHITES WITH DEUTERIUM PLASMAS IN THE PISCES-B FACILITY

**Yoshi Hirooka** (top right) (PhD, nuclear engineering, Osaka University, Japan, 1981) is the principal investigator leading experimental efforts and manager of the PISCES program at the University of California-Los Angeles (UCLA). He worked in the Nuclear Materials Division of the Japan Atomic Energy Research Institute from 1981 to 1984. His interests include plasma/surface interactions, fundamental surface science, and development of new materials for plasma-facing components for magnetic fusion devices. **Robert W. Conn** (top left) (PhD, California Institute of Technology, 1968) is a professor of nuclear engineering at UCLA and director of UCLA's Institute of Plasma and Fusion Research. He was a member of the nuclear engineering faculty at the University of Wisconsin for 10 years before going to UCLA in 1980. His primary research interests include plasma physics, plasma/surface interactions, fusion reactor design, and reactor plasma analysis. **Monali J. Khandagle** (second from top right) (PhD, physics, University of Poona, India, 1991) worked on plasma-assisted thin film deposition for her PhD dissertation. She joined the PISCES program in 1989. She is responsible for the operation of electron microprobe facilities to characterize plasma-bombarded materials. **Gaetan Chevalier** (center left) (PhD, engineering physics, Ecole Polytechnique de Montreal, Canada, 1988) worked as a postdoctoral fellow at the Tokamak de Varennes at the Centre Canadien de Fusion Magnetique from 1988 to 1989. He joined the PISCES program in 1989 and is in charge of spectroscopic diagnostics for plasma/surface interaction experiments. **Toshiaki Sogabe** (third from top right) (BS, materials science, Toyohashi University of Technology, Japan, 1981) is a senior engineer at Toyo Tanso Company, where he is responsible for the production of bulk-boronized graphites. He participated in the plasma/surface interaction experiments in the PISCES program in 1989 as of the U.S.-Japan collaboration program. **Teruo Matsuda** (bottom left) (BS, synthetic chemistry, Okayama University, Japan, 1988) is a staff engineer at Toyo Tanso Company. He is currently visiting the PISCES Team for joint experiments on bulk-boronized graphites using the PISCES-B facility. **Hiroaki Ogura** (bottom right) (BS, synthetic chemistry, Gunma University, Japan) is a chief engineer and the manager of the Research and Development Division of Toyo Tanso Company. He supervises the development of new materials such

*Yoshi Hirooka  
Robert W. Conn  
Monali J. Khandagle  
Gaetan Chevalier  
Toshiaki Sogabe  
Teruo Matsuda  
Hiroaki Ogura  
Hirotaka Toyoda  
Hideo Sugai*



as bulk-boronized graphites. **Hirota Toyoda** (right) (PhD, Nagoya University, Japan, 1988) is a member of the research staff of the Department of Electrical Engineering at Nagoya University. His main interests are the fundamentals and applications of plasma-assisted thin film deposition and etching processes. **Hideo Sugai** (left) (PhD, Tohoku University, Japan, 1971) is a professor of engineering in the Department of Electrical Engineering at Nagoya University. He has worked on plasma-assisted low-Z coatings and plasma/surface interactions.



### SIMULATION AND ANALYSIS OF THE RESPONSE OF CARBON-FIBER COMPOSITES AND PYROLYTIC GRAPHITES TO OFF-NORMAL HIGH HEAT LOADS

**Jaap G. van der Laan** (top right) (Ingenieurs diploma, applied physics, Rijksuniversiteit Groningen, Netherlands, 1986) joined the Netherlands Energy Research Foundation (ECN) Petten in 1986. He worked on the development of mechanical characterization methods for technical ceramics and plasma-sprayed ceramic coatings. His main interests are the analysis and experimental simulation of off-normal high heat loads on plasma-facing materials. He was assigned to the Next European Torus (NET) Team in 1990, where his work concentrates on off-normal operation conditions for plasma-facing materials, high heat flux testing, and material development. **Henk Th. Klippel** (top left) (nuclear engineering, Technical University Eindhoven, Netherlands, 1967) joined ECN Petten in 1967. He has worked on reactor physics for light water reactors, fast breeder reactors, and fusion reactors. He has been involved in a number of reactor studies in Europe. He is a project leader of system and safety studies for fusion reactors. He is also coordinator of the ECN fusion technology program. **Rob C. L. van der Stad** (bottom right) (Dr., physics, University of Amsterdam, Netherlands, 1988) joined ECN Petten in 1989 as a nuclear reactor physicist, where he contributes to nuclear cross-section processing, numerical thermal analysis of plasma/wall interactions, and fusion reactor safety analysis. **Co Bakker** (bottom left) (mechanical engineering, Technical High School Amsterdam, Netherlands, 1985) worked at ECN Petten on the investigation of microwelding techniques in 1986. He joined the Technical University Twente in 1987 for research on laser welding. He rejoined ECN Petten in 1988, where he has been working in the field of laser/material interaction and plasma disruption simulation experiments.

*Jaap G. van der Laan  
Henk Th. Klippel  
Rob C. L. van der Stad  
Co Bakker*



### PHYSICAL AND CHEMICAL SPUTTERING OF MULTICOMPONENT SOLIDS

**Wolfgang Eckstein** (top) [Diploma, physics, University of Frankfurt/Main, Federal Republic of Germany (FRG), 1963; PhD, physics, University of Munich, FRG, 1967] works for Max-Planck-Institut für Plasmaphysik. He has been a staff member of the Surface Physics Division since 1967. His field is atomic physics including spin-polarized electrons and ion bombardment of solids in experiments and by computer simulation. **Joachim Roth** (bottom) (Diploma, 1970, and PhD, 1974, physics, Technical University of Munich, FRG) has been a staff member of the Surface Physics Division of Max-Planck-Institut für Plasmaphysik since 1974. He is currently responsible for the plasma/wall interaction group and works on problems of the erosion of

*Wolfgang Eckstein  
Joachim Roth  
Eric Gauthier  
János László*



materials by ion bombardment and in plasma machines. **Eric Gauthier** (top) (Diploma, plasma and radiation physics, University of Marseille, France, 1986; PhD, plasma physics, Aix-Marseille University, France, 1988) works at Centre d'Etudes Nucléaires de Cadarache. He was a Euratom research fellow at the Max-Planck-Institut für Plasmaphysik in Garching in 1989-1990. He is involved with plasma/wall problems in Tore Supra. **János László** (bottom) (Diploma, engineering, 1980, and PhD, surface physics, 1983, Technical University of Budapest, Hungary) was a Humboldt research fellow in the Surface Physics Division of Max-Planck-Institut für Plasmaphysik in Garching in 1989-1990. He is a tenured associate professor at the Institute of Physics at the Technical University of Budapest. His basic research areas are sputter depth profiling, theory of electronic stopping, and computer simulation of atomic collisions.



#### **METAL SPUTTERING AND HYDROGEN RETENTION IN METAL-CARBON COMPOSITE LAYER MATERIALS**

**Kenji Morita** (Dr. Eng., nuclear engineering, Osaka University, Japan, 1970) is a professor in the Department of Crystalline Materials Science at Nagoya University. His main interests are fundamentals and applications of ion beam/material interactions. He is currently interested in plasma/material interactions in nuclear fusion research.

*Kenji Morita*



#### **BERYLLIUM, AN ALTERNATIVE MATERIAL FOR PLASMA-FACING COMPONENTS**

**Richard E. Nygren** (top) (BS, materials science, Massachusetts Institute of Technology, 1966; PhD, materials science, Northwestern University, 1973) is a senior member of the technical staff in the Fusion Technology Division of Sandia National Laboratories (SNL). He has worked on radiation effects on materials at Westinghouse Hanford and on fusion materials applications at the Fusion Engineering Design Center at Oak Ridge National Laboratory. He was manager of the Blanket Technology Program at Argonne National Laboratory from 1981-1985, he served as special assistant to the director of the U.S. Department of Energy Office of Fusion Energy in 1985-1986, and he performed research in plasma-materials interactions at the University of California-Los Angeles in 1987-1988. **Mark F. Smith** (PhD, metallurgy, Iowa State University, 1981) is a senior member of the technical staff in the Process Metallurgy Division of SNL. Since 1982, he has worked on materials and process research and development for high heat flux components in magnetic confinement fusion devices and has directed the thermal spray research program at SNL. Other materials research interests have included work in solar energy and satellite systems.

*Richard E. Nygren  
Mark F. Smith*



#### **PSI-1 DIRECT CURRENT ARC FACILITY FOR STUDYING PLASMA/WALL INTERACTION**

**Johann Lingertat** (right) [Dipl. Ing., 1963, and Dr. rer. nat., 1967, Technical University Dresden, Federal Republic of Germany (FRG); Dr. sc. nat., Academy of Sciences, FRG, 1987] served as a research fellow in radiation dosimetry at the Technical University Dresden from 1963 to 1967. He joined the Zentralinstitut für Elektronenphysik in 1967. In 1978, he began his research

*Johann Lingertat  
Heinz Grote  
Peter Pech*



activities in the field of nuclear fusion and spent 2 years (1978-1980) at the Kurchatov Institute in Moscow. He is now head of the department of plasma/surface interaction. **Heinz Grote** (top) (Dipl. Phys., Humboldt University Berlin, FRG, 1980; Dr. rer. nat., Academy of Sciences, FRG, 1989) is a member of the scientific staff of the plasma/wall interaction department at the Zentralinstitut für Elektronenphysik. He spent 2 years (1981-1983) at the Kurchatov Institute in Moscow. He worked in the field of probe diagnostics for tokamaks (collector probes and Langmuir probes). Since 1989, he has been the leader of the PSI-1 project. **Peter Pech** (bottom) (Dipl.-Ing. and Dr. rer. nat., Zentralinstitut für Elektronenphysik, FRG, 1960) worked on cathode problems in gas discharges from 1960 to 1972. He also has worked in the field of surface analysis and was responsible for the design, procurement, and assembly of the WASA I and II surface analysis stations for the T-10 and T-15 tokamaks, respectively, in Moscow (1976-1986). He worked from 1978 to 1980 on plasma/wall interactions with deposition probes. He also works on Langmuir probe diagnostics in strong magnetic fields.



## HIGH HEAT FLUX ION BEAM TEST FACILITY FOR MATERIAL RESEARCH AND DEVELOPMENT

**Martin Lochter** (top) (Dipl.-Ing., electrical engineering, 1969) is a member of the staff of Forschungszentrum Jülich's Institut für Plasmaphysik, Federal Republic of Germany (FRG), where he is involved in high-voltage engineering for fusion devices. He designed the poloidal field system for the Tokamak Experiment for Technology Oriented Research (TEXTOR) and was assistant project manager of the neutral beam injection (NBI) system team. **Reinhard Uhlemann** (center) (PhD, plasma and nuclear reactor physics, Technical University of Aachen, FRG, 1981) is a member of the staff of the Institut für Plasmaphysik at Kernforschungszentrum Jülich, where he is involved in the development of the NBI system for TEXTOR and the neutral beam test stand for materials tests. He is currently interested in the development of a high-power radio-frequency ion source, negative ion sources, and helium ash removal. **Jochen Linke** (bottom) (Dr. rer. nat., physics, Technical University of Aachen, FRG, 1977) joined the Institut für Reaktorwerkstoffe at Forschungszentrum Jülich in 1974. His first research was on the deposition of pyrolytic carbon. He is currently working on material characterization and the development and testing of plasma-facing components for fusion devices.

*Martin Lochter  
Reinhard Uhlemann  
Jochen Linke*



## COLD FUSION

### POSSIBLE NATURAL COLD FUSION IN THE ATMOSPHERE

**Nick Hawkins**, after being struck by an indoor ribbon of lightning, extended the Dijkhuis electron vortex filament model of ball lightning to cover ribbon lightning. In 1989, he applied the Dijkhuis model to elucidate Shah's lightning-associated neutron observations. He also modeled Fleischmann's high-yield fusion cells in terms of meteorologically available electron vortices and

*Nick Hawkins*



found positive correlation in tests at the Chinese Academy of Sciences. Now with Specialists Research, Ltd., he examines applications.

### A SIMPLE PLASMA MODEL FOR THE DESCRIPTION OF *d-d* FUSION IN CONDENSED MATTER

**Dieter Seeliger** (top) [Dr. rer. nat., 1968, and Dr. sc. nat., 1971, physics, Technische Universität Dresden (TUD)] is professor of experimental neutron and nuclear physics and head of the physics department at TUD. His research interests include neutron spectroscopy, neutron-induced reactions, nuclear fission, neutron resonances, preequilibrium processes and reaction mechanisms, fusion neutronics, and nuclear fusion in condensed matter. **Andreas Meister** (Dr. sc. nat., physics, TUD, 1984) is associate professor in the nuclear physics department at TUD. His research has focused on nuclear reactions with fast neutrons (nuclear reaction mechanism) and resonance neutrons (chemically induced shifts of neutron resonance positions, and crystal lattice effects on the resonance cross section). His current interests include fusion neutronics.

*Dieter Seeliger  
Andreas Meister*



### EVIDENCE FOR THE PRODUCTION OF *d-d* FUSION NEUTRONS DURING ELECTROLYTIC INFUSION OF DEUTERONS INTO A PALLADIUM CYLINDER

**Michael Bittner** (top right) [MSc, physics, Technische Universität Dresden (TUD), 1987] works as research associate at the nuclear physics department at TUD in the field of neutron detection techniques. **G. Ludwig** (no photo available) (MSc, electrochemistry, TUD, 1988) is a research associate in the chemistry department at TUD. **Andreas Meister** (top left) (Dr. sc. nat., physics, TUD, 1984) is associate professor in the nuclear physics department at TUD. His research has focused on nuclear reactions with fast neutrons (nuclear reaction mechanism) and resonance neutrons (chemically induced shifts of neutron resonance positions and crystal lattice effects on the resonance cross section). His current interests include fusion neutronics. A photograph and a biography for **J. Müller** were not available at publication time. **Detlef Ohms** (no photo available) (Dr. rer. nat., electrochemistry, TUD, 1978) is research associate in the chemistry department at TUD. He has researched electrocatalysis, energy conversion in electrochemical power sources, and electrochemical technologies. His current interests include fuel cell electrodes and electrocatalysis of oxygen reduction. **Elief Paffrath** (center right) (Dr. rer. nat., physics, TUD, 1985) is research associate at the nuclear physics department at TUD and works in the design of high-intensity neutron generators for 14-MeV neutrons. **Dietmar Rahner** (no photo available) (Dr. rer. nat., electrochemistry, TUD, 1981) is research associate in the chemistry department at TUD. He has researched electrochemical kinetics, corrosion, electrocatalysis, and electrochemical power sources. His current interests include study of materials and electrochemical research on lithium batteries. **Rainer Schwierz** (bottom left) (Dr. rer. nat., physics, TUD, 1988) works as research associate in the nuclear physics department at TUD. He researches instrumentation and methods for nuclear physics. **Dieter Seeliger** (bottom right) (Dr. rer. nat., 1968, and Dr. sc. nat., 1971, physics, TUD) is professor of experimental neutron and nuclear physics and head of the physics department at TUD. His research interests include neutron spectroscopy, neutron-induced reactions, nuclear fission, neutron

*Michael Bittner  
G. Ludwig  
Andreas Meister  
J. Müller  
Detlef Ohms  
Elief Paffrath  
Dietmar Rahner  
Rainer Schwierz  
Dieter Seeliger  
P. Stiehl  
Klaus Wiesener  
Peter Wüstner*



resonances, preequilibrium processes and reaction mechanisms, fusion neutronics, and nuclear fusion in condensed matter. **P. Stiehl** (no photo available) (MSc, electrochemistry, TUD, 1988) is a research associate in the chemistry department at TUD. **Klaus Wiesener** (no photo available) (Dr. rer. nat. habil., electrochemistry, TUD, 1969) is professor of electrochemistry and head of the electrochemical department at TUD. He has researched power sources, materials, electrochemical technologies, electrocatalysis, and the application of electrochemical techniques to environmental protection. **Peter Wüstner** (right) (MSc, physics, TUD, 1988) is a student researcher in the nuclear physics department at TUD. His area of study is fusion neutronics.



#### OBSERVATION OF QUAD-NEUTRONS AND GRAVITY DECAY DURING COLD FUSION

**Takaaki Matsumoto** (MS, nuclear engineering, Kyoto University, Japan, 1966) studied neutron and nuclear reactor physics at the Kyoto University Research Reactor Institute from 1966 to 1973. Since 1973 he has been with Hokkaido University as an associate professor of nuclear engineering. His interests include nuclear transmutation of radioactive wastes and nuclear alchemy.

*Takaaki Matsumoto*



#### SELF-CONSISTENT FIELD CALCULATIONS ON DIATOMIC HYDROGEN IN A POTENTIAL WELL

Photographs and biographies for **K. J. Bunch** and **R. W. Grow** were not available at publication time.

*K. J. Bunch  
R. W. Grow*

#### NEUTRON EMISSION DURING A LONG-TERM ELECTROLYSIS OF HEAVY WATER

**Ryuzo Takagi** (top right) (Dr. Eng., nuclear technology, Tokyo Institute of Technology, Japan, 1976) is an associate professor at the Tokyo Institute of Technology Research Laboratory for Nuclear Reactors. His current interests include computer simulations of the radiation damage of amorphous materials and electrolysis of multivalent ion metals in molten salts. **Hiroo Numata** (top left) (Dr. Eng., metallurgical engineering, Tokyo Institute of Technology, Japan, 1979) is a research assistant at Tokyo Institute of Technology. His current interests include electrochemical reaction processes (oxygen reduction, metal deposition, and corrosion) in molten salts. **Izumi Ohno** (center right) (Dr. Eng., applied electrochemistry, Tokyo Institute of Technology, Japan, 1971) is an associate professor in the Department of Metallurgical Engineering at Tokyo Institute of Technology. Her main interests include electrolytic metal deposition processes. **Kazutaka Kawamura** (bottom left) (Dr. Eng., metallurgical engineering, Tokyo University, Japan, 1953) is a professor at Tokai University Institute of Research and Development. His current interests include isotope separation by plasma and isotope chemistry. **Shiro Haruyama** (bottom right) is the president of Tokyo National College of Technology and a professor emeritus of Tokyo Institute of Technology. His research interests include electrode kinetics, corrosion, and electrodeposition.

*Ryuzo Takagi  
Hiroo Numata  
Izumi Ohno  
Kazutaka Kawamura  
Shiro Haruyama*

