Ferroelectricity Newsletter

A quarterly update on what's happening in the field of ferroelectricity

Volume 3, Number 1 Winter 1995

INTERNATIONAL FLAVOR OF FERROELECTRICS -- AN INDISPUTABLE FACT

The emphasis of this issue of the ***Ferroelectricity Newsletter*** -- the first one in our third year of publication -- is on conference reports from around the world: from Australia, Thailand, Japan, Germany, and Russia.

Pierre-Yves Lesaicherre of NEC Corporation writes about the **55th Autumn Meeting of the Japan Society of Applied Physics**, held from 19 to 22 September 1994 in Nagoa City, Japan.

Information about the **2nd Pacific Rim Conference on Ferroelectric Applications** is provided by **Maria Huffman** of Symetrix, Colorado Springs, and **Jim Scott** of RMIT Melbourne gives an overview of the **Third Regional Seminar on Microelectronics and Information Technology.**

Rainer Waser of Aachen University of Technology and chairman of Electroceramics IV and **Steven Butow** of San José State University, California, report on the **4th International Conference on Electronic Ceramics and Applications**, which took place from 5 to 7 September 1994 in Aachen, Germany. The extensive list of presentations at this conference fills more than a third of the pages in this issue.

We end our trip around the world of ferroelectrics meetings with a description of the main events at the **6th International Seminar on Ferroelastic Physics** in Voronezh, Russia, from 12 to 15 September 1994, which **Stanislav Gridnev** of Voronezh State Technical University put together for us.

The article on the developments and markets of **Piezoelectric Actuators/Ultrasonic Motors** by **Kenji Uchino** of The Pennsylvania State University, promised for this issue, will come out in Spring 1995.

The international flavor that pervades every aspect of ferroelectrics is a strong sign pointing into the future: progress will be best achieved through cooperation between countries and continents.

A prerequisite for cooperation is information exchange through communication. Therefore we again thank our contributors and those who assisted them behind the scenes for their important work in the field of ferroelectrics.

Rudolf Panholzer
Editor-in-Chief

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ELECTROCERAMICS IV PAPERS

DIELECTRIC AND MICRO-WAVE MATERIALS

Chemistry and Properties of Perovskite-Type Rare Earth Titanates for Microwave Applications
D. Kolar

Structure-Property Relations in Microwave Dielectrics
N. Setter, E. Colla, I. Reaney, R. Zumuhlen, A.K. Tagantsev

Infrared and Near-Millimeter Dielectric Spectroscopy of Some Commercial Microwave Ceramics
J. Petzelt, G.A. Komandin, V.V. Votsekhovskii, V. Koukal

Measurement of Complex Permittivity in the Microwave Range
R. Kurze, A. Schönecker

Permittivity of Fine Grained $BaTiO_3$
J.C. Niepce

Effects of A-Site Ion Substitution on Paraelectric Properties of Perovskite Compounds
H. Ikawa, M. Touma, T. Shirakami, O. Fukunaga

The Insulator-Semiconductor Transition in Perovskite Oxides
C.C. Dong, M.V. Raymond, D.M. Smyth

Ionic Relaxation in Thin Anodic Valve Metal Oxide Films
A.W. Hassel, M.M. Lohrengel

Dielectric Ceramics in the System SnO_2-ZrO_2-TiO_2
E. Andronescu, A. Folea, G. Bakila

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CONFERENCE REPORTS

ELECTROCERAMICS IV: 4th International Conference on Electronic Ceramics and Applications

We are fortunate to have two contributions reporting on ELECTROCERAMICS IV, the first written by Prof. Dr.-Ing. Rainer Waser, chairman of the conference, and the second by Steven J. Butow, who also provided the list of papers delivered at the conference (see pages 2 - 15 of this issue).

History

Initialized by the Belgian Ceramic Society, Electroceramics I and II were held as international conferences on electronic ceramics in Brussels in 1984 and 1988 respectively under the presidency of Prof. Duvigneaud.

The third conference of this series was organized in Maubeuge, France, in 1992. Based on the big success of this series and the growing number of participants, the Planning Committee decided in May 1993 to reduce the conference cycle to two years. In addition, it was decided to further strengthen the international character by incorporating more colleagues from the United States and the Far East into the Advisory Board. This is of special importance due to the fact that Electroceramics is the only conference which comprehensively covers all areas of electronic ceramics. Hence the conference is immensely important for a mutual exchange of knowledge between different areas. The Planning Committee recommended the Institut für Werkstoffe der Elektrotechnik (IWE) at the Aachen University of Technology (RWTH) to organize the conference for 1994.

Organizing Committee and Advisory Board

The Organizing Committee comprises the members of the permanent Planning Committee as well as persons from universities and industrial companies who represent the field of functional ceramics in Germany, the host country. In addition, many presidents of national ceramic societies within Europe are engaged in the Organizing Committee due to the fact that Electroceramics IV is now held--for the first time--under the auspices of the European Ceramic Society. For the Advisory Board we were able to engage many internationally renowned specialists of the different areas within electronic ceramics.

Scientific Program

The scientific program consisted of eight sessions of different lengths which ran partially in parallel. For every session we had two to four invited lectures, depending on the session size, and a limited number of contributed lectures. In addition, we organized a poster session with approximately 220 posters. The following invited speakers have been engaged for the sessions:

1. *Dielectrics and Microwave Materials*
   J.C. Niepce, University of Dijon (France)
   D. Kolar, University of Ljubljana (Slovenia)
2. *Ferroelectrics, Piezoelectrics, Relaxors*
   K. Uchino, Penn State University (USA)

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G. Arlt, RWTH Aachen (Germany)
D. Damjanovic, Ecole Polytechnique Federale de Lausanne (Switzerland)
A. Kingon, North Carolina State University (USA)
P. Osbourne, GEC (Great Britain)

3. *Grain Boundary Controlled Materials*
   P. Abelard, ENSCI, Limoges (France)
   E. Olsson (Sweden)
   T. Norby, University of Oslo (Norway)
4. *Electronic and Ionic Conductors*
   A. Feltz, Siemens Matsushita Components (Austria)
   B.C.H. Steele, Imperial College of Science (Great Britain)
   T. Norby, University of Oslo (Norway)
5. *Superconductors*
   B. Raveau, ISMRa Laboratoire CRISMAT (France)
   J. Maier, MPI für Festkörperforschung, Stuttgart (Germany)
   P. Komarek KfK Karlsruhe (Germany)
6. *Substrates and Integrated Functions*
   P.H.M. Keizer, Philips Components (The Netherlands)
   A. Okamoto, TDK Coporation (Japan)
   R. Tummala, IBM Corporation (USA)
   U. Ender, Murata Inc. (Germany/Japan)
7. *Magnetics*
   J. Pankert, Philips Forschungslaboratorium Aachen (Germany)
   P. Görnert, IPHT Jena (Germany)
8. *Processing and Mechanical Properties*
   B. de With, Technical University of Eindhoven (The Netherlands)
   M. Klee, Philips Forschungslaboratorium Aachen (Germany)

Results of the Conference

As the major task of the conference, the organizers considered further stimulation of the interaction between basic material sciences and the future development of electroceramic components, such as sensors, actuators, LCR components, and others. The related basic sciences comprise solid state physics and chemistry, electrochemistry, surface physics, microanalysis, crystallography, theoretical electrical engineering, and material technology. A new focal point at Electroceramics IV was an individual session on integrated functions, a first in the history of the conference. This topic deals with the joint sintering of different electronic ceramics (e.g., high permittivity ceramics, microwave ceramics, resistive ceramics, PTC and varistor ceramics) to a multifunctional integrated monolith. Technologically, this means a large step toward further miniaturization since printed circuit boards and passive substrates become--at least to a large extent--replaced by mechanically self-supporting ceramic functions. This new trend obviously poses a variety of new questions within the basic science disciplines, such as high temparature thermodynamics and kinetics.

This trend toward further integration of materials became obvious along

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ELECTROCERAMICS IV PAPERS continued

Chemical Reactions and Dielectric Properties in the $BaTiO_3$-$LaAlO_3$-$La_4Ti_3O_{12}$ System
S. Skapin, D. Kolar, D. Suvorov

High Permittivity Microwave Ceramics - the Influence of $Ba_{4.5}Gd_9Ti_{16}O_{54}$ Addition on the Temperature Stability of Dielectric Properties
M. Valant, D. Suvorov, D. Kolar

Dielectric Ceramics Based on (1-x)$BaTiO_3$x$BaMg_{0.33}M_{0.67}O_3$
E. Andronescu, A. Folea, A. Rahaianu

Sintering at Low Temperature of $BZn_{1/3}Ta_{2/3}O_3$ Ceramics: Influence of the Process on the Dielectric Properties
V. Tolmer, G. Desgardin

Anomalous Low Temperature Dielectric Behavior of Bismuth Pyrochlores
D.P. Cann, C.A. Randall, T.R. Shrout

Microwave Properties of Ferroelectrics and Antiferroelectrics with Admixtured Gd_2O_3
S. Sugihara, M. Okajima, N. Hoshino, H. Ohuchi

An Effective Method for the Prediction of Lifetime of the Ceramics Capacitors
J. Pogorzelska

Perovskite Ferroelectric Material and X-Ray Diffraction Diagram
C.M. Valot, J.F. Berar, M. Bessiere, N. Floquel, M. Mesnier, J.C. Niepce, P. Perriat

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ELECTROCERAMICS IV PAPERS continued

$NaNbO_3$ Doped $BaTiO_3$ Based Dielectric for Capacitors Application
N. Bernaben, S. Achour, A. Harabi, M.T. Beniehrache, S. Sahli

Pure Barium Titanate Ceramics: Crystalline Structure and Dielectric Properties as Function of Grain Size
N. Bernaben, A. Leriche, B. Thierry, J.C. Niepce, R. Waser

Dielectric Properties and Sintering Conditions in $BaTiO_3$ Ceramics
C. Proust, E. Husson

Ferroelectric Green Ceramics: Influence of the External “Stresses” on the Ferroelectric Domain Structure
P. Sarrazin, J. Lerreitre, J.C. Niepce, B. Thierry

$BaTiO_3$ Ferroelectric Ceramics Sintered at Low Temperature with the Aid of a Mixture of CaF_2 and LiF
L. Benziada, J. Ravez

Dielectric Materials with Flat Curve and High Dielectric Constant: Mechanism of Reaction between the Tetragonal Tungsten Bronzoid KSN and the Perovskite PMN
B. Boulrou, G. Desgardin

Effect of Grain Orientation on the Curie Temperature of $KSr_2Nb_5O_{15}$ Solid Solutions
T. Kimura, S. Saiubol, K. Nagata

Characterization of the Perovskite-Layer Structure, $SrBi_8Ti_7O_{27}$
I. M. Reaney, M. Roulin, H.S. Shulman, D. Damjanovic

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ELECTROCERAMICS IV -- continued from page 3

three independent routes:

1. The integration of aspects of structural ceramics (mechanical properties, fracture toughness, reliability) is increasingly important for the development of electronic ceramic components. This applies especially to microengineering, which will lead to a closer cooperation between electrical and mechanical engineers.
2. The integration of different electronic ceramics (e.g., dielectric, magnetic, ion conducting) in monolithic multifunctional components (e.g., combination of different sensors and actuators) gains further emphasis. Integrated ceramic substrates will increasingly be used as substrates for silicon chips in surface mount technologies.
3. The integration of electroceramic thin films on silicon chips opens a field of growing activities. The modern silicon chips (microprocessors, logic chips) offer considerable "intelligence." While the function of the "brain" in a microsystem is further elaborated every year, the silicon chip can offer sensor and actuator functions only to a very limited extent. These functions are realized by various electronic ceramics integrated as thin films.

Besides these R&D related aspects, we recognized an increasing need for communication between scientists and engineers working in the different fields of electronic ceramics, especially due to accelerated activities during the last years and the high innovation rate we currently encounter. According to the response of the participants, this need obviously has been nicely matched by the Conference.

Sponsorship

The Conference has been held under the auspices of the European Ceramic Society. The organizers gratefully acknowledge financial support obtained by the Deutsche Forschungsgemeinschaft (DFG) and the Ministry of Science and Technology of Northrhein-Westphalia.

-- Rainer Waser

Steven Butow's Report on Electroceramics IV

The program of the Fourth International Conference on Electronic Ceramics and Materials was organized by Dr. Rainer Waser of the Aachen University of Technology and Philips Research Laboratory.

Electroceramics IV was successful in promoting the exchange of ideas and experiences of more than 400 participants. This year's meeting hosted scientists and engineers from more than thirty countries, including Latvia, Slovenia, China, and Korea. Of course, Japan, the United States, and European communities were well represented.

Electroceramics IV was planned with two specific goals in mind. First, to bridge the gap between basic science and industrial applications; and second, to integrate different ceramic functions in order to broaden the scope of our respective disciplines. With respect to the latter, an interesting combination of electroceramic and structural ceramics talks highlighted the impor-

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tance of mechanical stresses, fracture, and thermal effects on materials. The momentum necessary for an integration of ceramic functions has been well established by microelectronics industry. In the future, the scope of electroceramics will include electrooptics, "highly intelligent" or "wise" silicon chips, and advanced piezoelectric devices.

A renaissance of fundamental fields is underway. Areas such as crystal chemistry, thermodynamics, phase relations, and kinetics were revisited throughout the conference. Likewise, there is renewed interest in defect chemistry for its relevance to superconductors and grain boundary phenomena. Microwave science is also emerging as a possible analytical tool capable of providing a new view of the microceramic world.

Despite the advances realized in recent years, problems of mechanical reliability, processing flaws, chemical contamination and production costs remain. The need for "better, faster, cheaper . . ." continues to provide the impetus for more study. Fortunately, there are many talented scientists and engineers who are dedicated to continuing the research and development necessary to meet the demands of the present, while forging new technologies for the future.

Electroceramics will most certainly continue to play a vital role in communications, semiconductors, and microdevices which impact every aspect of our lives.

Conference proceeding are published as a two-volume set (ISBN 3-86073-287-0 by Verlag der Augustinus Buchhandlung). The next International Conference on Electronic Ceramics and Applications (Electroceramics V) will be held in Aveira, Portugal, in 1996. The conference chairman will be J.L. Baptista, Universidade de Aveiro.

-- Steven Butow

PROFESSOR L. ERIC CROSS
UFFC-S DISTINGUISHED LECTURER FOR 1994-1995

Professor Cross, well-known in ferroelectrics circles as teacher and researcher and to the readers of the ***Ferroelectricity Newsletter*** as author of the history of ferroelectricity, has been nominated by the Administrative Committee of the Ultrasonics, Ferroelectrics, and Frequency Control Society as the UFFC-S Distinguished Lecturer for 1994-1995. In this capacity he is speaking before UFFC-S chapters, graduate and undergraduate student university seminars, IEEE groups, and other appropriate scientific and engineering associations. His topic is:

Ferroelectric Materials for
Electromechanical Transducer Applications.

ELECTROCERAMICS IV PAPERS continued.

Synthesis and Dielectric Properties of Complex Perovskites with Different Oxygen Vacancies in the System SrO-Ta_2O_5
J. Takahashi, K. Kodaira, T. Ota, M. Takahashi

Effect of Bi_2O_3 and Sintering Temperature on Pyrochlore Structure in the Bi_2O_3-ZaO-Nb_2O_5 System
H. Wang, B. Huang, X. Wang, X. Yao

Structural Study of Cubic Pyrochlore in the Bi_2O_3-ZnO-Nb_2O_5 System
H. Wang, X. Wang, I. Zhang, X. Yao

Formation Mechanism of Bismuth-Zinc-Niobium Oxide Pyrochlores
X. Cai, X. Yao

The Preparation and Structures of Bismuth-Based Oxide and Oxyfluoride Pyrochlores
X. Cai, X. Yao

Anomalous Resistivity Behavior of Prasodymium Doped Barium Lithium Niobate
K.S. Rao, K.K. Rao, C. Srinivasudu, A.S.V. Subrahmanyam

Experimental Research of Ceramic-Polymer Boundary
L.A. Pasechnik, A.I. Carpov, V.F. Zavorotny

Frequency and Power Characterization of Multilayer Ceramic Hi-Cap Capacitors by Infrared Thermography
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Loss Measurement of Microwave Ceramics by the Ghost-Mode Technique
J. Baurn, Ch. Hoffmann, R. Waser

Electrode Influence on the Charge Transport Properties of $SrTiO_3$ Thin Films
W. Antpöhler, G.W. Dietz, M. Klee, R. Waser

Relationship between Processing and Dielectric Loss of $MgTiO_3$ Based Ceramic Resonators
V.M. Ferreira, J.L. Baptista

FERROELECTRICS, PIEZOELECTRICS, RELAXORS

New Piezoelectric Devices for Smart Actuator/Sensor Systems
K. Uchino

Strong Dielectric Dispersion in Ferroelectric Ceramics at Microwaves
G. Arit

In Situ Studies of Phase Transitions in Ferrooelectric Perovskites
I.M. Reaney

La-Modified $Pb(Mg_{1/3}Nb_{2/3})O_3$-Based Relaxor Ferroelectric Ceramics
T. Takenaka, H. Takagi

Pyro-Ferro- and Dielectric Properties of PLT Thin Films
Y. Liu, W. Liu, L. Zhang, X. Yao

Ferroelectric Ceramics for Uncooled Infrared Detectors
P.C. Osbond, R.W. Whetmore

Sputtered Ferroelectric Films for Pyroelectric Detectors
R. Bruchhaus, H. Huber, D. Pilzer, W. Wersing

Structure and Chemical Compositions of PLZT Thin Films and Their Ferroelectric Properties
J. Hector, N. Floquet, D. Aymes, P. Gaucher

Phase Transitions and Radiation Damage in Lead Containing Perovskites for Applications in Electrooptics and Electronics
A. Sternberg, L. Shabanov, E. Birks, H.W. Weber, F.M. Sauerzopf, H. Schwabl

High Temperature Piezoelectric Ceramics and Extrinsic Contributions to their Properties
D. Damjanovic

Grain Growth in Multilayer PZT
J. Wen, H. Hellebrand, D. Cramer, K. Lubitz, G. Tomandl

Piezoelectric Coatings on Fibers
G.R. Fox, M. Kosec, P.A. Danai, N. Selter

Electrostrictive Properties of Based $PbMg_{1/3}Nb_{2/3}O_3$(PMN) Bulk Ceramics
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Structure-Property Relations for Ferroelectric Materials: Thin Films vs. Bulk
A. Kingon, C.E. Miller

Dielectric Design in Ferroelectric Thin Films
L.E. Cross

Defect Chemistry Model of the Time Dependent Electrical Response of Ferroelectric Memories
C.J. Brennan

Bistable Conduction in Metal-Ferroelectric Schottky Contacts
P.W.M. Blom, R.M. Wolf, J.F.M. Cilessen, M.P.C.M. Krijn

Film Thickness Dependence of Dielectric Properties on $BaTiO_3$ Films Prepared by Sol-Gel Method
T. Hayashi, N. Oji, H. Maiwa

Microstructure and Dielectric Properties of Sol-Gel Barium Titanate Thin Films on Nickel Alloy Electrodes
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F_{RL}-F_{RH} Transition in Nb Doped $Pb(Zr_{0.965}Ti_{0.035})O_3$ Ceramics
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Rapid Thermal Processing of Lead Zirconate Titanate Thin Films from High Molarity Sols
S. Meridein, A. Berger, S. Wahl, W. Grond, D. Spom

Preparation and Characterization of PZT Thin Films Derived from Metalloorganic Precursors by a Two-Step Heat Treatment
S.B. Xiong, X.Q. Wu, L.Y. Zhang, X. Yao

Preparation and Application of PZT Thick Films
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Obtention of La Modified Lead Titanate Films by an Alternative Chemical Method
J. Baltazar-Rodrigues, J.A. Eiras

Crystalline and Structural Analysis of Modified Lead Titanate Ferroelectric Thin Films by the GIXRD Method
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Structure and Optical Properties of Magnetron R.F. Sputtered Lead Titanate Thin Films
D. Remiens, B. Jaber, E. Dogheche, P.Y. Jouan, B. Thierry

Preparation and Ferroelectric Properties of (Pb,La)TiO_3 Thin Films by Multiple Cathode Sputtering
K. Okazaki, H. Maiwa, N. Ichinose

Laser Ablation Deposition of Ferroelectric Lead Zirconate Titanate and High Tc Superconducting Y-Ba-Cu-O Layers
J. Levoska, S. Leppävuori, T. Murtonierni, J. Lappalainen

Deposition of Ferroelectric Layers by Thermal Spraying
W. Häßler, R. Thielsch, M. Menzel, K. Fischer

Preparation and Characterization of PLT Thin Films by Hot-Wall LP-MOCVD
S.-S. Lee, H.-G. Kim

Preparation of Thin Films of Titanates and Zirconates by an Electrochemical-Hydrothermal Method
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Preparation and Properties of $BaTiO_3$ Films by Electrophonetic Deposition
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Direct Determination of Relaxation Distribution Function in Dielectrics Upon Experimental Data
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Statistical Properties of Random Spin-1/2 XY Chains
O. Derzhko, T. Krokhemalski, T. Verkholyak

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Comparison of Different Methods for the Displacement-Field Characterization of Piezoelectric Materials
M.G. Gee, M. Stewart, N.J. McCormick

Aging after Polarization Reversal in Acceptor Doped Ferroelectrics
U. Robels, A. Mellage, G. Arlt

Degradation of Multilayer Ceramic Actuator
K. Nagata, S. Kinoshita

Temperature Stabilized Ceramic Piezoelectric Elements
K. Nagata, E. Harashima

Elaboration of $LiNbO_3$-Based Piezoelectric Ceramics
L. Nibou, S.G. Brodie, C.E. Millar, J.P. Mercurio

Ferroelectric Ceramics in the $Na_{0.5}Bi_{0.5}TiO_3$-$K_{0.5}Bi_{0.5}TiO_3$, $Na_{0.5}Bi_{0.5}TiO_3$-$PbTiO_3$ and $K_{0.5}Bi_{0.5}TiO_3$-$PbTiO_3$ Systems
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The Influence of Processing and Microstructure on Piezoelectric and Mechanical Properties of Fine Grained PZT Ceramics
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The Effect of Interfacial Reaction on the Physical Properties of PZT
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X-Ray Diffraction Study of the Structure of Lead Zirconate and Modified Lead Titanate Ceramics
V. Vasilescu, M. Anghel, M. Spätanu

Effect of WO_3 Additions on the Microstructure and Electrical Properties of PZT Ceramics
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Processing Sol-Gel PZT Thin Films for Microactuators
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Non-linear Piezoelectric Metrology: Coefficients under Impact
J.A. Close, R. Stevens

Beading Strains in Piezoelectric Ceramics in the Electric Field
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High Field De-Aging and Fatigue Characteristics of Hard PZT Ceramics
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Electrooptic Properties of Sol-Gel Derived PT/SiO_2 and PZT/SiO_2 Glass Composites
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Optical Spectra of PLZT Ferroelectric Ceramics
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Total-Reflection Type Optical Modulator Utilizing Surface Acoustic Wave
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Characterization of Magnesium Diffused Lithium Niobate Substrates by XRD
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A Logic Gate on Surface Acousto-optic Devices
C.Y. Shen

$(Pb_{1-x}Ba_x)Sc_{1/2}Nb_{1/2}O_3$ Electrooptical Ceramics
M. Darnbekaine, A. Sternberg, K. Bormaris

The Use of Additives in the Low Temperature Sintering of KTN Ceramics
A. Pigram, J. Ravez, J.P. Bonnet

$Pb(In_{1/2}Nb_{1/2})O_3$ Ceramic: Preparation and Nanostructural Studies
J. Ravez, F. Weil, C. Elissalde

Dielectric Properties of Field-Induced Transition in Pure or Doped Ceramics $Pb(Mg_{1/3}Nb_{2/3})O_3$
M. Malki, M. Chabin, E. Husson, C. Proust, A.. Morell

Glassy State and Field-Induced Ferroelectric State in $PbMg_{1/3}Nb_{2/3}O_3$
P. Calvi, P. Camagni, E. Giulotto, L. Rollandi

Improving the Properties of PMN Ceramics by Selective Doping
K. Reichert, F. Schlenkrich, L. Seffner

Newly Developed Piezoceramic Material With High d_{33}/d_{31} Ratio
S.A. Gridnev, N.G. Pavlova, S.P. Rogova

Ferroelectric Properties of the Mixed Aurivillius Phase $Bl_yTi_4NbO_{21}$
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Processing and Sintering of $CaBi_4Ti_4O_{15}$ Powders for High-Temperature Piezoelectric Materials
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Microstructural and Electrical Properties of Doped $Bi_4Ti_3O_{12}$ Ceramic Materials for High Temperature Piezoelectrics
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W.K. Wlosinski, Z. Librant, W. Olesinska

Electrotechnical Ceramics, Based on Porcelain Stones of Kirgistan
S.J. Jelosheva, T.I. Koneshova

Gel Cordierite for Electronic Packaging
A. Goldstein, V. Belov, I. Belov

Powder Preparation of Inorganic Materials by Spray Drying
H.A.M. van Hal, W.A. Green

Electrophysical Properties of $Ca_5Ga_6O_{14}$ Single Crystals
S.L. Londar

Preparation of Materials With Controllable Grain Boundary Size From Water-Soluble Compounds
L.A. Reznitchenko, O.N. Razunovskaya, L.A. Shilliona, V.A. Aleshin, V.I. Makarov, Yu.F. Korovin, V.G. Chiprinko, A.G. Okhapkin

Conformational Mechanism of Pyroelectric Response in Macromollecules Systems
N.N. Malveev, A.F. Klinskilch

A Possible Application of Volcanic Stones for Electric and Electronic Ceramics
E. Albert

Preparation of La Doped $Sr(Ti_{(1-y)}Zr_y)O_3$ (y=0...1) Dielectric Ceramic Thin Films
S. Hoffmann, M. Klee, R. Waser

Hot-Forging of $Ba_{6-3x}Sa_{\partial+2x}Ti_{15}O_{54}$ Ceramics for Microwave Applications
Ch. Hoffmann, R. Waser

Pulsed Laser Deposition and Patterning of Electroceramic Thin Films
M. Mertin, D. Offenberg, C.W. An, D.A. Wesner, E.W. Kreutz

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CONFERENCE REPORTS

55TH AUTUMN MEETING OF THE JAPAN SOCIETY OF APPLIED PHYSICS

General Observations

The 55th Autumn Meeting of the Japan Society of Applied Physics (Oyo Butsuri Gakkai) was held in Meijo University, Nagoya City, from **19 to 22 September 1994.** Nagoya City is in Aichi prefecture, and ideally located between the Kyoto-Osaka-Kobe and Tokyo metropolis, about 2 hours west from Tokyo and 1 hour east from Osaka by Shinkansen. Divided into 15 main sessions and 48 subsessions, the conference attracted more than 10,000 participants and there were about 3,500 presentations. Eighty-six presentations were made in the subsession on thin films devoted to high permittivity materials and related topics, and 9 invited talks were given in a half-day symposium. The attendance varied between 150 and 200 researchers, almost only from Japanese companies and universities. This autumn, a presentation by Samsung, Korea, and the noted participation of Prof. S. Desu and Dr. J. Evans brought a slight international flavor to the meeting. Participation was once again roughly 50 percent from university and national research laboratory and 50 percent from industry. Contributed presentations at the Oyo Butsuri Gakkai last 15 minutes, including questions, and invited talks about 30 minutes. A booklet of abstracts if provided on the first day of the conference, but extended papers are not published afterwards.

This autumn, about 40 percent of the presentations were related to Pb-based titanates, 30 percent to $SrTiO_3$ and $(Ba,Sr)TiO_3$, and the remaining 30 percent to other materials ($Bi_4Ti_3O_{12}$, $BaMgF_4$,$LiNbO_3$, etc.). Though Pb-based materials are still the most studied materials, it should be noted that about 2/3 of the presentations on $SrTiO_3$/ $(Ba,Sr)TiO_3$ were made by participants from industry. Each totaling about 25 percent of the presentations, the sputtering, sol-gel, and MOCVD techniques were the most reported preparation methods.

Main Features

The main features of this conference were:

•The disclosure of the composition of Y1 material by Olympus-Symetrix (20p-M-18, 20p-M-19, 20p-M-20) and Matsushita (20p-M-16). The "Y1 family" includes all materials which have the generic composition: $(Bi_2O_2)^{2+}(A_{n-1}B_nO_{3n+1})^{2-}$. They are bismuth oxide based layered superlattice materials, in which paraelectric $(Bi_2O_2)^{2+}$ bismuth oxide layers are alternated with perovskitelike ferroelectric $(A_{n-1}B_nO_{3n+1})^{2-}$ layers. Materials investigated by Olympus-Symetrix for possible nonvolatile memory application were $SrBi_2Ta_2O_9$, $SrBi_2Nb_2O_9$, $SrBi_4Ti_4O_{15}$ and solid solutions of these materials. According to T. Mihara from Olympus, the present choice for Y1 is $SrBi_2Ta_2O_9$, or SBTO. It shows a-axis polarization, with no 90˚ domains and no polarization along the c-axis, and a lower polarization is obtained than for PZT. NEC also reported on SBTO (20p-M-17), and presented SIMS data showing that Bi diffuses into Pt/Ti at the high annealing temperature of 800˚C, required to obtain a large remnant polarization. Process improvements, such as lowering of the deposition temperature are necessary before practical integration of SBTO with conventional semiconductor devices.

•A presentation by Fujitsu on the preparation of an $SrTiO_3/RuO_2/Ru$ structure on Si by MOCVD (19p-M-9). $Ru(DPM)_2$, $Sr(DPM)_2$-tetraen and $Ti(i\text{-}OC_3H_7)_4$ were used as the metal organic sources, O_2 as the oxidant and Ar as the carrier gas. It was reported that the introduction of some O_2 is necessary for Ru deposition. XRD data showed that the RuO_2(1000Å)/Ru(500Å)/Si structure thus prepared was stable after annealing for 30 minutes in air at 700˚C. Ru and RuO_2 resistivities were 15 and 90 μΩ.cm, respectively. 1000 Å $SrTiO_3$ films prepared at 460˚C exhibited a maximum dielectric constant of $\varepsilon_r = 200$, and XRD data showed that the $SrTiO_3$(1000Å)RuO_2(1000Å)/Ru(500Å)/Si structure was unchanged by a 30 minutes annealing step in air at 600˚C. However, when the deposition temperature was more than 500˚C, $SrTiO_3$ films showed degraded electrical characteristics.

•A report by Mitsubishi on the TDS analysis of BST films prepared by liquid source MOCVD (19p-M-5). BST films were prepared by CVD n $Pt/SiO_2/Si$ at T = 550~750 ˚C and P = 10 Torr, using $Ba(DPM)_2$ and $Sr(DPM)_2$

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dissolved in THF and $Ti(i\text{-}OC_3H_7)_4$ as liquid metalorganic sources. Samples were heated at a rate of 1˚C/min from 50 to 1000 ˚C, and CO_2 (m/e = 44), CO (m/e = 28), H_2O (m/e = 18), CH_3 (m/e = 15), and C (m/e = 12) were monitored. H_2O, CO_2 and CO desorption occurred at 150˚C, 400˚C and 600˚C, respectively. BST films with a composition of (Ba+Sr)/Ti = 1.1 showed CO_2 desorption due to $BaCO_3$ in the films, whereas films with (Ba+Sr)/Ti = 0.9 did not contain any $BaCO_3$. The maximum CO peak was observed for (Ba+Sr)/Ti = 1.0, and it was said that it corresponds to the presence of C in the perovskite structure. H_2O, CO_2 and CO peaks were also observed for sputtered BST films, and the explanation given for this phenomenon was that BST films absorb carbon and water from air.

•A report by Toshiba that $(Ba_xSr_{1-x})TiO_3$ thin films epitaxially grown on Pt/MgO (100) show ferroelectricity for $0.44 \leq x < 1$ and paraelectricity for $0 \leq x < 0.44$ at room temperature (19a-M-11). BST films were prepared by co-sputtering of $BaTiO_3$ and $SrTiO_3$ targets at 600 ˚C and 0.7 Pa in an Ar/O_2 mixture (40/10sccm). XRD peaks of the BST films showed epitaxial growth and a strong (001) peak for both x = 0.24 and x = 0.68. Due to the lattice mismatch of the BST films with the Pt substrate, the c-axis length measured for the films was larger than the one reported for bulk ceramics, and this could help explain the shift in the Curie temperature. A maximum dielectric constant of more than $\varepsilon = 1100$ was measured at 100 kHz (0.1 V) and room temperature, for ~2000 Å BST films with x = 0.24.

•Reports by Kyoto University (20p-M-13) and Rohm (20p-M-14, 20p-M-15, 21p-M-8) on the use of Ir and IrO_2 as electrodes for PZT based nonvolatile memories and MFMIS structures. Kyoto University reported the electrical characteristics of various MOCVD PZT based capacitors. For an Au/PZT/Pt structure, $\varepsilon_r = 479$, $P_r = 21.9\ \mu C/cm^2$ and for an $Ir/IrO_2/PZT/IrO_2$, $\varepsilon_r = 579$, $P_r = 9.0\ \mu C/cm^2$. Moreover, leakage current increased from the $Au/PZT/IrO_2$ to the $Ir/IrO_2/PZT/IrO_2$ structure. Rohm previously reported on an MFMIS structure with sol-gel PZT sandwiched between Ir/IrO_2 bottom and top electrodes ($Ir/IrO_2/PZT/Ir/IrO_2$). Ir and IrO_2 films were prepared by sputtering and annealed by RTA at 400~700˚C. It was shown this time that if PZT is deposited directly on IrO_2, the electric characteristics are degraded (17 percent decrease in P_r after 10^{11} cycles). SIMS profiling showed that Pb diffuses in the bottom IrO_2 when PZT is grown directly on IrO_2, but there is no Pb diffusion when PZT is grown on Ir/IrO_2. Therefore, a metal barrier appears to be necessary between PZT films and the bottom IrO_2 electrode. No fatigue occurred for the $Ir/IrO_2/PZT/Ir/IrO_2$ structure with 200 nm PZT films, and C-V hysteresis could be observed.

•As mentioned above, there was a large number of presentations on $SrTiO_3$ and $(Ba,Sr)TiO_3$ by researchers from the semiconductor industry. Thanks to recent reports on the integration of $SrTiO_3$ and $(Ba,Sr)TiO_3$ with semiconductor memories, ST and BST are considered the most probable materials for use as capacitor dielectric in Gbit-scale DRAMs. Samsung, Texas Instruments Japan, Sharp, NEC, Fuji Electric, Toshiba, and Fujitsu reported on $SrTiO_3$; and NEC, Mitsubishi, Texas Instruments Japan, Toshiba, and Sharp reported on $(Ba,Sr)TiO_3$. Among Japanese large-volume DRAM makers, only Hitachi and Oki Electric did not report on ST or BST, and still focus their research on PZT.

•An increased number of reports on issues related to the integration of ferroelectric thin films with full capacitor processes. Sharp reported the high frequency characteristics of $SrTiO_3$ and $(Ba,Sr)TiO_3$ based capacitors with various configurations, for use in MMIC (19a-M-10). Capacitance remained constant up to 15 GHz for both ST and BST based small size capacitors (1.5~2 pF). NEC reported on the step coverage of ECR CVD $SrTiO_3$ films (19a-M-2) and on the characterization of sidewall sputtered BST deposited on RuO_2 patterns (19a-M-10). Hitachi reported the electrical characteristics of PZT based capacitors, measured by contacting the Au top electrode and the backside of the wafers (20a-M-1). Poly-Si plugs were fabricated in an SiO_2 layer to connect the Pt/TiN bottom electrode and the Si

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substrate. A maximum charge storage of 280 fC/μm^2 was obtained at 1.5 V for 75 nm PZT films (T_{eq} = 0.18 nm). Finally, there were two presentations on the etching of electrode materials. Mitsubishi reported the variation of the residue thickness on resist sidewalls for various Pt etching gas mixtures (22a-ZM-2). The best results were obtained for pure Argon (100 sccm at 5 mTorr). NEC showed the influence on RuO_2 etching of Cl_2 addition to an O_2 ECR plasma (22a-ZM-9). Using an SOG hard mask, fine RuO_2 patterns could be fabricated. A maximum etch rate more than 2000 Å/min and the best RuO_2 /SOG selectivity were obtained for 5 percent Cl_2 addition to the gas mixture.

Important tendencies reported for the previous Spring Oyo Butsuri Gakkai (*Ferroelectricity Newsletter*, Vol. 2, No. 3, Summer 1994) were again observed this autumn. Research results related to MFS, MFIS and MFMIS structures were widely reported, mostly by universities, such as Kyoto University (20p-M-13, 22a-M-6), The Tokyo Institute of Technology (22a-M-7, 22p-M-5, 22p-M-6, 22p-M-7), The Science University of Tokyo (22p-M-2, 22p-M-3, 22p-M-8), Osaka University (22p-M-4), and by Rohm on the company side (20p-M-14, 20p-M-15, 21p-MD-8). There were finally fewer reports on multilayers of ferroelectric materials than in the previous meeting, with reports on $SrTiO_3/BaTiO_3$ (21p-M-6), $CaTiO_3/BaTiO_3$ (21a-M-7) and $PbTiO_3/PbZrO_3$ (21a-M-9), all by Osaka University.

Many thanks to Dr. Y. Miyasaka and S. Yamamichi for reviewing this report.

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PAPERS PRESENTED AT OYO BUTSURI GAKKAI -- AUTUMN 1994

19a-M-1	Preparation of $BaTiO_3$ thin films by intense, pulsed, ion-beam evaporation	Nagaoka Univ.of Technology, Nippon Seiki, Nichicon
19a-M-2	Improvement of electrical characteristics of RF sputtered $SrTiO_3$ films by multi-step deposition	Samsung Electronics
19a-M-3	Sputtering gas pressure effect on structure, morphology, and dielectric properties for $(Ba,Sr)TiO_3$ thin films	NEC
19a-M-4	Preparation of $SrTiO_3$ films by RF sputtering using He gas	Yamaguchi University
19a-M-5	Composition and dielectric constant in $SrTiO_3$ layers	Hosei University, Oki Electric
19a-M-6	Thickness dependence of the surface free energy for BaTiO3 thin films	Nagaoka Univ. of Technology
19a-M-7	Dielectric properties of sputtered $(Ba_xSr_{1-x})TiO_3$ thin films (III)	Mitsubishi Electric
19a-M-8	Influence of deposition temperature of Pt electrode on electrial properties of RF sputtered $(Ba,Sr)TiO_3$ thin films	Texas Instruments Japan
19a-M-9	Leakage mechanism of $SrTiO_3$ capacitor	Texas Instruments Japan
19a-M-10	RF characteristics of high dielectric thin film capacitors	Sharp
19a-M-11	Induced ferroelectricity in epitaxially grown $(Ba,Sr)TiO_3$ thin films	Toshiba
19p-M-1	Preparation of $(Ba,Sr)TiO_3$ thin films by sol-gel processing	Sharp
19p-M-2	Influence of reaction mechanisms on the step coverage of MOCVD $SrTiO_3$ thin films	NEC
19p-M-3	Electrical properties of $SrTiO_3$ prepared by electron cyclotron resonance plasma chemical vapor deposition	NEC
19p-M-4	Role of oxidizing agent in CVD of BST film	Mitsubishi Electric
19p-M-5	TDS analysis of BST thin films fabricated by CVD	Mitsubishi Electric

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19p-M-6	Change in the physical properties of $BaTiO_3$ thin films by controlling the preferred orientation of Pt electrode	Univ. Osaka Prefecture
19p-M-7	Axis orientation of $SrTiO_3$ thin films of Pt (100) substrates	Fuji Electric
19p-M-8	Influence of lower electrode surface roughness on the electrical properties of $SrTiO_3$ thin film capacitors	Toshiba
19p-M-9	Preparation of $SrTiO_3/RuO_2/Ru/Si$ structure by the MOCVD method	Fujitsu
19p-M-10	Dielectric properties of sputter-deposited $(Ba,Sr)TiO_3$ thin films on the sidewalls of fine-patterned electrodes	NEC
19p-M-11	Effect of buffer layer on the epitaxial growth of $SrTiO_3$ thin films of Si (100)	Murata Mfg., Osaka Univ.
19p-M-12	Epitaxial growth of $Ba_{1-x}Sr_xTiO_3$ films on Si substrates by pulsed laser deposition	Tokyo Inst. Technology
19p-M-13	Dielectric properties of epitaxial $Ba_{1-x}Sr_xTiO_3$ films prepared by pulsed laser deposition on Si substrates	Tokyo Inst. Technology
19p-M-14	Effect of excimer laser annealing on $SrTiO_3$ thin films (II) Characterization by UV spectroscopy	Osaka Univ.
19p-M-15	Effect of excimer laser annealing on $SrTiO_3$ thin films (III) Application of excimer laser anneal to MIS structure	Osaka Univ.
19p-M-16	Effect of excimer laser annealing on $SrTiO_3$ thin films Analysis of laser anneal with internal stress	Osaka Univ.
20a-M-1	Properties of PZT thin films deposited by reactive evaporation	Hitachi
20a-M-2	Fabrication of PZT films on Si substrates using $SrTiO_3$ buffer layers	Tokyo Institute of Technology
20a-M-3	Switching properties of PZT thin films prepared by dual-source vacuum evaporation	Tokyo Institute of Technology
20a-M-4	Preparation of Pb-based ferroelectric thin films using excimer laser	Matsushita Electric
20a-M-5	Preparation of $PbTiO_3$ thin films by the laser ablation method (2)	Osaka University
20a-M-6	Microstructure of sputtered $PbTiO_3$ thin films	RITE, Matsushita Electric
20a-M-7	Occurrence of defect surface layer in sputtered PZT films and its control	Oki Electric
20a-M-8	Preparation of PZT thin films by ECR sputtering (II)	Murata Manufacturing
20a-M-9	Electrical characteristics of low-temperature PZT thin films prepared by the digital MOCVD method	Tokyo Univ. Agri. & Tech. Nissan Motor, Waseda Univ.
20a-M-10	Electrical evaluation of PZT thin films deposited by the laser MOCVD method	Himeji Inst. Techn., Osaka Gas, KRI International
20a-M-11	Fabrication of PZT films by the laser MOCVD method (III)	Japan energy Corporation
20p-M-1	Large area growth of PLZT thin films by MOCVD	Kyoto University, Amaya Co.
20p-M-2	Step coverage of $PbTiO_3$ thin films grown by surface reaction enhanced MOCVD	NEC
20p-M-3	Preparation of oriented PZT thin films by the sol-gel method	Sanyo
20p-M-4	Fabrication of ferroelectric PZT thin films by the sol-gel method	Sony
20p-M-5	Preparation of PZT thin films from chemically amplified photosensitive sol-gel solution (2)	Mitsubishi Materials
20p-M-6	Influence of buffer layers on the characteristics of sol-gel derived PZT thin films	Kanagawa University, Mitsubishi Materials
20p-M-7	Effect of Ti seeding treatment on the crystallization of sol-gel PZT	Texas Instruments Japan
20p-M-8	Examination of hysteretic leakage current through epitaxial ferroelectric thin films	Misubishi Kasei
20p-M-9	Effect of electrode materials on PZT film deposition by laser ablation (II)	Kanazawa Univ., Ishikawa Ind. Res. Inst.

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20p-M-10	Preparation of (Pb,La)TiO_3 thin films by multiple cathode sputtering (III)	Shonan Inst. Tech., Waseda Univ.
20p-M-11	Interface reaction in MOCVD prepared PLZT/RuO_2/Si structure	Chubu University
20p-M-12	Preparation and properties of RuO_2 and ITO as electrodes for ferroelectric thin films	Olumpus Optical
20p-M-13	MOCVD growth and properties of PZT thin films on an IrO_2 electrode	Kyoto University
20p-M-14	Study on PZT thin films prepared by the sol-gel method	Rohm, Mitsubishi Materials
20p-M-15	PZT thin films by the sol-gel method on IrO_2 electrodes	Rohm
20p-M-16	Preparation and characterization of ferroelectric thin films by LSMCVD	Matsushita Electronics, Symetrix, University of Colorado
20p-M-17	Fatigue characteristics of bismuth layer oxide thin films	NEC
20p-M-18	Development of Y1 (Bi layer structured ferroelectric) thin film capacitors (I)	Olympus Optical, Symetrix
20p-M-19	Development of Y1 (Bi layer structured ferroelectric) thin film capacitors (II)	Olympus Optical, Symetrix
20p-M-20	Development of Y1 (Bi layer structured ferroelectric) thin film capacitors (III)	Olympus Optical, Symetrix
21a-M-1	Cluster calculation of $PbTiO_3$ tetragonal modification using ab initio molecular orbital method (1)	Nissan Motor, Waseda University
21a-M-2	Transient photocurrent of PZT ferroelectric thin films prepared by the MOCVD method	Kyoto University
21a-M-3	Two dimensional stress effect in ferroelectric thin film properties	The National Defense Academy
21a-M-4	Surface treatment and homoepitaxy of $SrTiO_3$ (100) substrates by wet etching	Shinkosha Co., Tokyo Inst. Techn.
21a-M-5	Two-dimensional epitaxial growth of $BaTiO_3$ thin films on $SrTiO_3$ molecular step surface	Tokyo Inst. Techn., Shinkosha Co.
21a-M-6	Dielectric and IR properties of atomic order controlled $SrTiO_3$/$BaTiO_3$ strained superlattices	Osaka University
21a-M-7	Crystal structure and dielectric constant of $CaTiO_3$/$BaTiO_3$ superlattices	Osaka University
21a-M-8	Molecular dynamics simulation of the dielectric properties of (Sr,Ba)TiO_3 (II)	Osaka University
21a-M-9	Preparation and characterization of $PbTiO_3$/$PbZrO_3$multi-layer films by the laser ablation technique	Osaka University, Kinki University
21a-M-10	$SrTiO_3$ channel thin film transistor	Fujitsu
21a-M-11	Preparation of metal ferroelectric semiconductor FET using $BaTiO_3$ thin films	Tokai University
22a-M-1	Preliminary study on the atomic layer epitaxy of ferroelectric thin films (II)	Tokyo Univ. Agri. & Tech., Nissan Motor, Waseda University
22a-M-2	CVD deposition process of PZT elements	Tokyo University of Agr. & Tech., Waseda University
22a-M-3	Interaction of CVD ferroelectric films with Si substrate (3)	Waseda Univ., Nissan Motor, Nissan ARC
22a-M-4	Effect of sputtering on the depth profile of ferroelectric films	Nissan ARC, Nissan Motor, Waseda Univ.
22a-M-5	Structure and SAW properties of $LiNbO_3$ and $LiTaO_3$ films grown by pulsed laser deposition	Asahi Chemical, Osaka University
22a-M-6	Preparation and electrical properties of $LiNbO_3$ thin films prepared by RF magnetron sputtering	Kyoto University
22a-M-7	Preparation of $LiNbO_3$ films on Si substrates by the sol-gel method	Tokyo Institute of Technology
22a-M-8	Study of a CeO_2 epitaxial layer on Si as a buffer layer for MIS-FET	Asahi Chemical, Waseda University
22a-M-9	Synthesis and crystallographic characterization of $YMnO_3$ thin films	Osaka Prefecture University
22p-M-1	Fabrication and characterization of ferroelectric $Bi_4Ti_3O_{12}$ thin films by dipping pyrolysis of metal naphthenates	Science University of Tokyo

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22p-M-2	Investigation of the effect of precursors on the crystallization of $Bi_4Ti_3O_{12}$ thin films patterened by an electron beam	Science University of Tokyo, SUT Yamaguchi College
22p-M-3	Investigation of the film quality dependence on the assist gas flow rate in the fabrication process of ferroelectric $Bi_4Ti_3O_{12}$ thin films by MOCVD	Science University of Tokyo
22p-M-4	Preparation of $Bi_4Ti_3O_{12}$ thin films by the laser ablation method	Osaka University
22p-M-5	Formation and evaluation of ferroelectric $Pt/SiO_2/Si$ (100) structures	Tokyo Institute of Technology
22p-M-6	Growth temperature dependence of the interface characteristics of $BaMgF_4/GaAs(100)$	Tokyo Institute of Technology
22p-M-7	Electrical properties of ferroelectric $BaMgF_4/Si$ structures (2)	Tokyo Institute of Technology
22p-M-8	Fabrication of crack-free $BaMgF_4$ thin films on a limited area by vacuum evaporation	Science University of Tokyo

ETCHING

22a-ZM-2	Thickness of the sidewall deposited film in dry etching of platinum with various etching gases	Mitsubishi Electric, Ryoden Semiconductor System Engineering
22a-ZM-9	Effect on RuO_2 etching of Cl_2 addition to O_2 plasma	NEC

SYMPOSIUM

21p-MD-2	Electron theory of ferroelectricity	Pr. M. Tachiki	Tohoku Univ.
21p-MD-3	Polarization reversals in ferroelectrics	Pr. Y. Ishibashi	Nagoya Univ.
21p-MD-4	Fabrication methods and properties of ferroelectric thin films (1) CVD	Pr. T. Shiosaki	Kyoto Univ.
21p-MD-5	Laser ablation	Pr. T. Kawai	Osaka Univ.
21p-MD-6	Semiconductor memories with high dielectric constant ferroelectric material	Pr. Y. Tarui	Waseda Univ.
21p-MD-7	High permittivity materials for DRAM application	Dr. Y. Miyasaka	NEC
21p-MD-8	Applied ferroelectrics for nonvolatile memory	Dr. A. Kamisawa	Rohm
21p-MD-9	Application of ferroelectric thin films to neurodevices	Pr. H. Ishiwara	Tokyo Inst.Techn.

PZT	(22)	$SrTiO_3$	(16)	$Bi_4Ti_3O_{12}$	(5)	Sputtering	(21)
PbTiO3	(8)	$BaSrTiO_3$	(11)	$SrBi_2Ta_2O_9$	(5)	Sol-Gel	(19)
PLZT	(3)	$BaTiO_3$	(5)	$LiNbO_3$	(4)	MOCVD	(18)
PLT	(2)	$SrTiO_3/BaTiO_3$	(1)	$BaMgF_4$	(4)	PLD	(14)
$PbTiO_3/PbZrO_3$	(1)			$LiTaO_3$	(1)	MBE	(7)
				CeO_2	(1)	Evaporation	(5)
				$YMnO_3$	(1)		

University - National Laboratory	(62)
Industry	(59)

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6TH INTERNATIONAL SEMINAR ON FERROELASTIC PHYSICS

The 6th International Seminar on Ferroelastic Physics ISFP-6 was held in Voronezh, Russia, from 12 to 15 September 1994. The meeting was organized by the Department of Solid State Physics of the Voronezh State Technical University. It was the sixth in a series that began at Bologoe, Russia, in 1978 for the purpose of conveying a better understanding of ferroelastic properties in crystals undergoing structural phase transitions.

The seminar was arranged to link the subjects of an earlier chain of conferences on ferroelastics and recent studies of different crystals. Areas of current interest were covered by the following sessions: Phase transitions, lattice dynamics and soft modes, domain boundaries and other imperfections, spectroscopy, ferroelasticity and superconductivity, modulated phase, disordered systems, and applications. These sessions provided a forum for sharing the latest research results and technical developments, and a chance to meet old friends and make new ones.

Ten invited lectures and 57 posters were presented by about 70 participants. Recent achievements were reported during oral plenary presentations and poster sessions by leading experts in their respective areas. Also, there was a round table session on "Glasses and Glasslike States in Crystals," that raised lively interaction between participants and long, late night discussions.

Eight postgraduate researchers participated in ISFP-6 and presented contributed papers in various sessions.

Topics Presented

The seminar began with a general presentation by Prof. Lev A. Shuvalov, Institute of Crystallography, Russian Academy of Sciences (Moscow). During his welcome address, he described the **main events of ferroelastic physics and the latest research achievements in this area**. He made the important point that fundamental research should have strong ties to industry, which creates a long-term concern for technological and applied research development.

B.M. Darinsky (Voronezh, Russia) presented his work on the **acoustic axes of ferroelastic crystals**. He had theoretically solved a problem for a number of orientations of acoustic axes in the crystals of different crystallographic systems. In particular, it was shown that the quasi-longitudinal mode and quasi-shear modes of elastic oscillations are split practically for all crystals. In this way all possible systems of acoustic axes of ferroelastic crystals have been found. This approach made it possible to find a change of the acoustic axes systems caused by ferroelastic phase transition and a temperature variation.

Experimental aspects of the observation of modulated structure in the ferroelastic crystal $KCOPO_4$ were discussed in detail by H.Schmid (Geneva, Switzerland). He illustrated various methods, such as polarized light microscopy, X-ray precession photographs, and X-ray powder spectra, by showing their application to the study of the crystal structure and the features of ferroelastic domains with a “tweed” pattern typical of modulated structures. The modulation of the structure disappears when the crystals are ground to a grain size of less than 7 microns and are heated and cooled through the phase transition.

A.A. Bulbich (Rostov-on-Don, Russia) concentrated on the **theoretical analysis of nucleation in the low-symmetry phase near the elastic lattice defects**, such as dislocations, clusters, twin boundaries, cracks, and inclusions in improper ferroelastics. He described, for example, the nucleation that can take place not only near a defect at rest but also near a moving defect. In this case the order parameter distribution is compressed in the head of a moving defect and stretched in its back, i.e., the “trail” appears. It was shown that in the case of a first-order phase transition there is a place on the phase diagram in which the metastable trail exists.

The **characteristic features of the ferroelastic phase transitions between the low-conductive and superionic phases** were considered by A.I. Baranov (Moscow, Russia). Particular attention was focused on the improper ferroelastic phase transition in the superprotonic $Me_nH_s(AO_4)_p$ crystals. The review of the dielectric and ultrasonic experiments showed that the properties of disordered paraelastic as well as the ordered ferroelastic phases are of special interest to ferroelastic physics.

I.N. Flerov (Krasnoyarsk, Russia) gave a talk on the **experimental study of heat capacity near the phase transitions** and other properties depending both on hydrostatic pressure and atom replacements in ferroelastic crystals of several haloid perovskitelike families. He showed that the normalized shift of phase transition temperature under

-- continued on page 23

CONFERENCE REPORTS

6TH INTERNATIONAL SEMINAR ON FERROELASTIC PHYSICS -- continued from page 22
hydrostatic pressure has a characteristic value in different families for the same type of symmetry change. There exists a strong correlation between the number of layers linked to each other by common halogen atoms and thermodynamic characteristics of layered perovskites. It was shown that the behavior of physical properties near ferroelastic phase transitions can be described within the scope of thermodynamic theory.

V.Ya. Shur (Ekaterinburg) gave his talk on the **capabilities of elastic light scattering in ferroelastics and computer simulation for the study of domain evolution and phase kinetics**. He described the new approach to kinetics of phase transitions in ferroelastic crystals based on the model of geometrical transitions (catastrophes). It was demonstrated that the process of phase evolution in finite media can be described by expressions of the Kolmogorov-Avrami type. As a result, he developed the theoretical bases of a new technique, proposed the method of mathematical treatment of experimental results, and gave many examples about its possibilities, both topological and spectroscopic.

Included in **novel materials** discussed at the meeting was a **ferroelectric-superconductor ceramic composite** that is formed when ferroelectric-ferroelastic $BaTiO_3$ and superconductor $YBa_2Cu_3O_7$ are fired together at a high temperature. In some regions of concentration the materials are nonstoichiometric and undergo phase separation forming precipitates. This material may have various interesting applications.

The **eight poster sessions**, where all participants had the opportunity to present and discuss their current research activities, were highly successful. Lively discussions lasted long after the official ending of the sessions. This was largely due to the fact that all participants were lodged in the same hotel complex where the scientific activities took place.

The seminar also benefited from the **excellent facilities of the meeting site** and beautiful weather. Attendance at the lectures and at social events, including outdoor games, conference dinner, and after dinner talks, was high. The overall impression was that ISFP-6 has evolved into an interesting forum and that the policy of embracing new areas within the seminar topics should continue.

Part of the **proceedings of ISFP-6** will be published in a special issue of ***Ferroelectrics*** and also in Russian in ***Izvestiya RAN, ser. fiz.*** under the editorship of Lev Shuvalov, Moscow.

The ISFP series will continue in 1997 in Kazan, Russia, and will be organized by Kazan State University. I encourage scientists interested in ferroelastic physics and related topics to participate in the next conference and to contact the organizers.

-- Prof. S.A. Gridnev
ISFP-6 Vice Chairman

MEETINGS ANNOUNCED BY THE AMERICAN ASSOCIATION FOR CRYSTAL GROWTH

Current Issues on Crystal Growth of Novel Electronics Symposium • 30 Apr-4 May • Cincinnati, OH
Contact Dr. R.K. Pandey, Phone (409) 845-7449, Fax (409) 845-6259

Fourteenth Conference on Crystal Growth and Epitaxy • 4-7 Jun • Fallen Leaf Lake, CA
Contact Harold Olsen, Phone (310) 317-5927

9th International Summer School on Crystal Growth • 11-16 Jun • Papendal, Arnhem, The Netherlands
Contact +31 20 626 1372, Fax +31 20 625 9574

The Eleventh International Conference on Crystal Growth • 18-23 Jun • The Hague, The Netherlands
Contact +31 20 626 1372, Fax +31 20 625 9574

Sixth Eastern Regional Conference on Crystal Growth • 15-18 Oct • Atlantic City, NJ
Contact Stuart Samuelson, Phone (201) 361-2222

CONFERENCE REPORTS

2ND PACIFIC RIM CONFERENCE ON FERROELECTRIC APPLICATIONS

The 2nd Pacific Rim Conference on Ferroelectric Applications took place in Melbourne, Australia, from 21 - 24 November 1994. In general, the conference was well organized, but the attendance was relatively small. Approximately 50 researchers from several countries were present. It is hoped that the conference will pick up momentum as it becomes more established in the ferroelectric community.

In the plenary session, good overview presentations were given on CVD (T. Shiosaki, Japan) and PEMOCVD (S. I. Woo, Korea) of ferroelectric thin films, mainly PZT family, on the status of ferroelectric integration and d.c. breakdown mechanisms in DRAMs (J. F. Scott, Australia), and an overview of device physics and modelling in ferroelectric storage cells (M. Huffman, USA).

Discussions on electrodes included good results on Ir/IrO_2 using PZT (T. Nakamura, Japan), and a very interesting discussion by L Sheldon (Australia) on biocompatibility considerations at electrode-neural interfaces. The possibilities of bioapplications of ferroelectric/piezoelectric materials should be thoroughly pursued.

On the theoretical side, papers on ferroelectric switching (Y. Ishibashi, Japan) and on the theory of frequency response of ferroelectric films (D. R. Tilley, Mapaysia) were presented. Various deposition techniques for ferroelectric films were discussed, such as excimer laser deposition, liquid source misted chemical deposition, and spin-on techniques. For device application, various presentations were given, including infrared sensors (S.T. Kim, Korea) and optoelectronic devices (D. Sengupta, Australia).

A session on biomedical applications and organic ferroelectrics informed us on PVDF applications (M. Podiasak, Australia, and H. L. W. Chan, Hongkong), and the talk on the status of cochlear and other implants by G. Clarke (Australia) provided valuable information. The last session of the conference was on characterization of ferroelectric materials and single crystal growth. Among the presentations in that session, the paper on HREM of relaxors gave an overview of the technique as well as the extensive modeling efforts in understanding domain structures (L. Bursili, Australia), and the one on heavy ion recoil spectrometry discussed the capabilities of the technique in bulk compositional analysis of thin film ferroelectrics (P. Johnston, Australia).

-- *Maria Huffman, Symetrix Corporation, Colorado Springs, CO*

FERROELECTRICS COMPUTERIZED INDEX

Compiled by **Sidney B. Lang**
Ben-Gurion University of the Negev, Israel

The *Ferroelectric Computerized Index* combines approximately 5500 entries including papers, editorials, book reviews, and errata from the three Gordon and Breach ferroelectrics journals: ***Ferroelectrics*** (1980 through 1992), ***Ferroelectric Letters*** (1982 through 1992), and ***Integrated Ferroelectrics*** (1992).

The index was compiled using Papyrus Retriever ™ (Research Software Design, Portland, Oregon), which has fast powerful search capabilities allowing Boolean strategies and is compatible with most IBM software programs. Updates are planned.

This tool is now available **free** with any new paid 1995 journal subscription to *Ferroelectrics*. The index can also be purchased separately for $60.

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CONFERENCE REPORTS

THIRD REGIONAL SEMINAR ON MICROELECTRONICS AND INFORMATION TECHNOLOGY

The third Regional Seminar on Microelectronics and Information Technology (TARSMIT '94) was held in Bangkok from 9 to 11 August 1994. Forty-one papers were presented. The conference may be of interest in that the participating countries (Thailand, Australia, Malaysia, Indonesia, Korea, Singapore, and the Philippines) are not often represented at North American or European conferences.

In addition to offering some insight into the level of microelectronics and information technology in these countries, the conference revealed emphasis on some practical problems of great financial impact, less related to ferroelectrics and high dielectrics, that are worthy of note. Highlights were microcomputer controller systems for small-industry applications, electricity use recording for individual consumers in apartment buildings, adaptive powerline interference cancellation in electrocardiography, and multiple microcomputer control of steam plants.

-- James Scott, Dean, Applied Science, RMIT Melbourne, Australia

Plenary Session - Overviews
CVD Deposition
T. Shiosaki
DC Breakdown Mechanisms in DRAMs
J.F. Scott
PEMOCVD of $PbTiO_3$ and PZT
S.J. Woo
Device Physics of Ferroelectric Storage Cells
C.A Paz de Araujo

Electrodes and Interfaces; High Frequency Devices
Ohmic Contact Characterization
G. Reeves
Excellent PZT Memories with Ir/IrO_2 Electrodes
M. Takasu
Is Titanium a Suitable Substrate for PZT?
P. Knight
Biocompatibility Considerations at the Electrode-Neural Interface
L. Seldon
Ferroelectric Phase-Shifters
D. Maddison
Theory of Frequency Response of Ferroelectric Films
D.R. Tilley

Deposition Techniques
Thin Films Deposited by Pulse Laser Ablation
Y.S. Kim
Preparation of PZT Films on SOI by Excimer Laser Deposition
L.C. Lu
Liquid Source CVD: Technology Status and Recent Results
L.D. McMillan
Structure, Composition, and Pyroelectric Characteristics of $PbTiO_3$ Thin Films Deposited by ECR-PECVD
W.J. Lee
Thin Film and Patterning Technologies for Integration of Ferroelectric Memories
K. Sakiyama
Production of Flexible Thin Film Oriented PZT Sensors by Sol-Gel
G. Tulloch
Preparation and Properties of Nano-Crystalline $Pb_{0.72}La_{0.28}TiO_3$
W.G. Luo

MOD, RTP, Degradation
Silicon Dielectric Engineering for the Nineties
H.B. Harrison
Influence of Rapid Thermal Annealing on Structural and Interfacial Properties of PZT Thin Films Prepared by Excimer Laser Deposition
L.C. Luo
An Expanded MOD System for Advanced Oxide Synthesis
M.C. Scott
MOD Technology for PLZT Nonvolatile RAMs and DRAMs
W. Zhu
Degradations in PZT Thin Film Capacitors
I.K. Yoo
Reliability of ASIC Devices
R. Thornton

Device Applications
Device Applications of Ferroelectric Thin Films
K.S. No
Memories, CCD Microprocessors, and Pyroelectric Detectors Based Upon Sol-Gel Ceramic Ferroelectric Films
A.S. Sigov
Electron Emission from PZT Thin Plate by Pulsed Electric Field
M. Okuyama
Fabrication and Characterization of a Thin-Film Infrared Sensor
S.T. Kim
Novel Deep Sub-Micron Device Structures
S. Dmitriev
Surface Laser Intensity Modulation Method (SLIMM)
S. Lang
Optoelectronic Devices
D. Sengupta

Organics and Biomedical
Application of PVDF Film Technology to Active Control of Water-Borne Noise
M. Podlesak
A Poling Study of PZT/P(VDF-TrFE) Copolymer 0-3 Composites
H.L.W. Chan
Hydropiezoelectrics -- Latest Developments
G.W. Taylor
C-V Properties of MIS Structures with a Ferroelectric Polymer Insulating Layer
I. Guy
Ferroelectricity in Inorganic-Organic Ionic Crystals
J. Liesegang
Cochlear and Other Implants
G. Clarke

Growth and Characterization, Optical Effects
The Crystallization Process and Electrical Properties of PZT Thin Films Deposited by Low-Temperature MOCVD
H. G. Kim
Growth of Lithium Tetraborate Single Crystals
R. Komatsu
High-Resolution Transmission Electron Microscopy of Relaxors
L. Bursill
Heavy-Ion Recoil Spectrometry of Barium Strontium Titanate Films
P. Johnston
Spontaneous Aperiodic Optical Switching in Crystalline Lead Magnesium Niobate
R. O'Sullivan
Numerical Modeling of Thermal Induced Optical Bistability in a Ferroelectric Fabry-Perot Cavity
X. Zheng □

UPCOMING MEETINGS

2nd International Conference on Space Charge in Dielectric Materials (CSC'2)
2 - 7 April 1995
Antibes, France

This is the first meeting of the IEEE-DEIS Technical Committee on Space Charges in Dielectric Solids, organized by the French Vacuum Society in collaboration with the Association for the Advancement of Microtechnologies.

Topics

- Physics of space charges in dielectric solids
- Characterization of space charges
- Applications: dielectric breakdown fracture, wear, laser ablation
- Standards

Sessions

1. Synthesis of observations made during experiments related to dielectric breakdown, fracture, friction, and wear. These observations include, but are not limited to, the formation of space charges, structural changes, emission of particles, lifetime materials, probability of failure, etc.
2. Physics of space charges developed to explain the causes that led to previous observations and to guide the implementation of techniques for the characterization of space charges.
3. Characterization of space charges in order to evaluate different methods of characterization, to identify the elemental physical processes predicted by theory, to obtain data which can be directly compared and to reproduce data obtained by different techniques.
4. Applications aimed at demonstrating the impact of theoretical and experimental developments on technological processes and diagnostics.
5. Norms and expert systems: Definition of technical terms, measurables, procedures for testing and characterization, and statistics.

Sponsors

Ministry of Higher Education and Research; Ministry of Defense; Secretary of National Defense; Ministry of Foreign Affairs; Commission of European Community; Atomic Energy Commission; Alcatel Electronic Tubes; Leica.

Contact

SFV, 19, rue du Renard, 75004 Paris, France, Phone +33 142 78 15 82, Fax +33 142 78 63 20.

8th European Meeting of Ferroelectricity (8th EMF)
4 - 8 July 1995
University of Nijmegen, Nijmegen, The Netherlands

Topics

Phase transitions and critical phenomena
Electronic structure
Lattice dynamics
Charge-density wave systems
Structure and growth
Acoustic and ferroelastic properties
Dielectric, piezo- and pyroelectric properties
Optical properties. Phase conjugation
Thin films, surfaces, small particles
New materials
Modulated and incommensurate phases
Disordered and glassy systems
Domains, domain walls, imperfections
Raman, Brillouin, IR spectroscopy
X-ray, neutron, and electron spectroscopy
Polymers
(Anti)ferroelectric liquid crystals
Ceramics and composite materials
Sensors, actuators, transducers
Ferroelectric/semiconductor integration

Contact

Mrs. Rina Vos, Secretariat EMF8, Insitute for Theoretical Physics, University of Nijmegen, Toernooiveld, 6525 ED Nijmegen, The Netherlands

UPCOMING MEETINGS

1st European Meeting on Integrated Ferroelectrics (EMIF1)
3 - 5 July 1995
University of Nijmegen, Nijmegen, The Netherlands

EMIF1, a satellite conference of the 8th European Meeting on Ferroelectricity (EMF8), is a two and a half day, single session conference.

Topics

Thin film deposition	Electrodes and interfaces
Microstructure and characterization	Dielectric, ferroelectric, piezoelectric, and optical properties
Epitaxial structures	Domains and switching
Processing and integration	Memory devices
Thin film sensors and actuators	Thin film optical devices

Organizing Committee

P.K. Larsen, chairman; T. Rasing, secretary; R. Vos, secretariat

Contact

EMIF1, Theoretical Physics I, University of Nijmegen, PO Box 9010, NL-6500 GL Nijmegen, The Netherlands, Fax +31 80 652 120

Second International Workshop on Low-Energy Electrodynamics in Solids (LEES2)
26 - 30 June 1995
Trest', Czech Republic

Scope

Workshop LEES2 is a continuation of the series started in 1993 as "International Workshop on Infrared and Millimeter Waves Spectroscopy" held at Bad Honnef, Germany. In order to make the topic slightly broader, we are including dielectric (impedance) spectroscopy in the lower frequency range and changed the title accordingly.

The aim of the workshop is to bring together experimentalists working in the field of dielectric spectroscopy in a broad sense (frequency range 0 - 10^{14} Hz) and theoreticians working in the field of low-energy excitations, both applied to various types of condensed matter systems. Emphasis will be laid on complex and disordered systems.

Topics

- Dynamics of freezing in disordered systems (classical, dipolar and quadrupolar glasses, polymers, relaxor ferroelectrics
- Collective dynamics of quasiordered structures (charge and spin density waves, vortex dynamics in type II superconductors, domain wall dynamics, discommensurations in incommensurate systems, dynamics of nanoclusters
- Low-energy excitations in superconductors
- Dynamical conductivity in fast ionic conductors
- Dynamics of structural and metal/nonmetal phase transitions
- Diffuse excitations in liquid crystals and liquid-crystalline polymers

Sponsors

- Professional group "Dielectrics"
- Physics Section of the Union of Czech Mathematicians and Physicists
- Institute of Physics of the Czech Academy of Sciences
- ICARIS Ltd. Conference Management, Prague

Contact

Dr. Jan Petzelt, LEES2 chairman, Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 2, 180 40 Praha 8, Czech Republic. Phone +42-2-660-52166, Fax +42-2-82 1227, E-mail trest95@fzu.cz

CALENDAR OF EVENTS 1995

Mar 20-22	• 7th International Symposium on Integrated Ferroelectrics (ISIF 95), Colorado Springs, CO. For information contact Alona S. Miller, Symposium Coordinator, University of Colorado at Colorado Springs, PO Box 7150, Colorado Springs, CO 80933-7150. Phone (719) 593-3488, Fax (719) 594-4257
28-31	• 42nd Spring Meeting of the Japan Society of Applied Physics, Tokai University in the Tokyo area, Japan. For information contact The Japan Society of Applied Physics, Kudanshita Bldg., 1-12-3 Kudan-kita, Chiyoda-ku, Tokyo 102, Phone +81 33 238 1044, Fax +81 33-221 6245
Apr 2-7	• 2nd International Conference on Space Charge in DielectricMaterials (CSC'2), Antibes, France. For information contact SFV, 19, rue du Renard, 75004 Paris, France, Phone +33 142 78 15 82, Fax +33 142 78 63 20 (see p. 26)
May 24-27	• 12th Meeting on Ferroelectric Materials and their Applications (FMA-12), Coop-Inn, Kyoto. For further information contact Dr. Tadashi Shiosaki, Electrical Engineering Department, Kyoto University, Yoshida-honmachi, Sakyou-ku, Kyoto-shi, Japan 606-01, Fax +81 75 753-5749
Jun 1	• Deadline for First European Meeting on Integrated Ferroelectrics (EMIF1) manuscripts
26-30	• Second International Workshop on Low-Energy Electrodynamics in Solids (LEES2), Trest', Czech Republic (see p. 27)
Jul 3-5	• 1st European Meeting on Integrated Ferroelectrics (EMIF1), Nijmegen, The Netherlands (see p. 27)
4-8	• 8th European Meeting on Ferroelectricity, University of Nijmegen, The Netherlands (see p. 26)
Aug 26-29	• 56th Autumn Meeting of the Japan Society of Applied Physics, Kanazawa Institute of Technology, Kanazawa City, Japan. For information contact the Japan Society of Applied Physics, see address of Spring Meeting above
	1996
Aug 18-21	• IEEE International Symposium on the Application of Ferroelectrics (ISAF '96), Brunswick Hilton and Tower, East Brunswick, NJ/Rutgers University. For information contact Prof. A. Safari, Rutgers University, Dept. of Ceramic Engineering & Center for Ceramic Research, PO Box 909, Piscataway, NJ 08855-0909, Phone (908) 445-4367, Fax (908) 445-3258, E-mail safari@safari.rutgers.edu

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