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# Ferroelectricity Newsletter

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

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## **NEWS OF SCIENTIFIC PROGRESS AND EDUCATIONAL INNOVATION**

Over the years, when reporting on programs of scientific meetings, we mentioned special efforts to contribute to the education of the next generation of scientists and engineers so that they can carry on the work we are doing now.

A few weeks ago we heard about a project that expands this educational concern to even younger students. The Materials Research Society (MRS) announced the launch of *Strange Matter*, a touring exhibition and accompanying Web site designed to illustrate the principles and concepts behind materials science to a target audience of 5th through 8th grade students.

The *Strange Matter* exhibition opened in North America in June 2003 with a public preview at the Ontario Science Centre. It will begin its three-year tour to major science centers in February 2004. For the most up-to-date information on this project, visit the Web site at [www.mrs.org](http://www.mrs.org).

As indicated in the previous issue, you are getting a comprehensive report on ISIF 2003 by Orlando Auciello, one of our senior contributors, and we continue the list of ISIF 2003 papers begun in the summer issue. Part II covers the poster session of CVD processing; domains and nanostructures; FeRAM materials; as well as testing and characterization.

The section "Upcoming Meetings" features two MRS meetings, the Fall Meeting in Boston (page 12) and the Spring Meeting in San Francisco (page 14), and the **16th International Symposium on Integrated Ferroelectrics** to be held on 5 - 8 April 2004 in Gyeongju, Korea (page 13).

Gyeongju, which is located on the southeast skirt of Korea at approximately 360 km from Seoul, was the cradle of ancient *Shilla Dynasty* culture and the site of the dynasty's capital from 57 B.C. to 935 A.D. It is called a "Museum without Walls" because of the wealth of historical buildings and treasures to be found all over the region. Gyeongju has many temples, stone pagodas, ancient tombs, mounds, and castle sites, which are the essence of the ancient north-eastern Asian culture.

We hope that you will be able to join us in this beautiful city for another exciting exchange of the newest developments in the field of ferroelectricity.

Rudolf Panholzer  
Editor-in-Chief

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### **Ferroelectricity Newsletter**

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## CONFERENCE REPORT

### 15TH INTERNATIONAL SYMPOSIUM ON INTEGRATED FERROELECTRICS (ISIF 2003)

*In the editorial of our last issue we expressed the hope that we might bring you a report on ISIF 2003 by one of our senior contributors. We are very grateful to **Orlando Auciello** for having taken time out from his extraordinarily busy schedule to write the following report.*

The science and technology of ferroelectric thin films and integrated ferroelectrics constitutes one of the fastest evolving interdisciplinary fields of research worldwide. A major driving force for the extensive research being performed in many universities and industrial and national laboratories is not any longer the promise of applications of ferroelectric thin films into revolutionary advanced microdevices but the reality of ferroelectric thin films integrated into nonvolatile ferroelectric random access memories (FeRAMs) now in “smart cards” already in the market and the upcoming shipping of the first 0.18  $\mu\text{m}$  embedded FeRAM in System on Chip (SoC) into the market announced by Masushita (Panasonic) on 9 July 2003 (see <http://www.panasonic.co.jp/global/top.html>). These technological developments are creating new multibillion dollar markets.

Properties of ferroelectric thin films that are being intensively investigated include electrical conductivity, ferroelectricity, piezoelectricity, pyroelectricity, and electro-optic activity. The science and technology of ferroelectric thin films and bulk materials has advanced in recent years because of the development of new synthesis techniques that resulted in the integration of films and bulk materials in novel devices. In addition to the major application to FeRAMs as described above, researchers are investigating these materials as high dielectric constant materials for integration as high dielectric constant (high-k) layers in capacitors for high-density DRAMs and high-frequency devices, and as high-k gate oxides for the next generation of integrated circuits. Ceramic conductors are used in ohmic, voltage-dependent, and thermally sensitive resistors, fast-ion conductors, humidity and gas sensors. Piezoelectricity is exploited in micromachines such as accelerometers, displacement transducers, and actuators. Pyroelectricity is utilized in the fabrication of high-sensitivity infrared detectors, while electro-optic activity is used in displays,

image storage systems, and optical switches for integrated optical systems. The materials science and device issues related to ferroelectric thin films and integrated ferroelectric are discussed intensively at the International Symposium on Integrated Ferroelectrics, which is the premier conference in this field.

The ISIF 2003 was characterized by the excitement that FeRAMs are now in the market integrated into “smart cards” and by the promise that high-density FeRAMs are on their way for introduction into the market in the near future. On this basis, the plenary, invited and contributed talks, as well as poster presentations provided views to new advances on fundamental and applied science, as well as on device architecture related to FeRAMs. In addition, there were also advances presented on other fields of application of integrated ferroelectrics.

The ISIF started on Sunday, March 9, with a series of excellent tutorials on thin film materials and processing, fundamentals of electroceramic materials, process integration, and characterization and testing presented by recognized researchers in the field from national laboratories, universities, and industry.

ISIF 2003 featured several plenary talks on a broad range of topics, as discussed below:

Hans Stork (Texas Instrument) presented a talk titled “Enabling the Mobile Internet: System-on-Chip with Ferroelectric Memory” that provided a view of the status of the mobile internet and the role that different memories may play in this broad technology. Low cost, low power, and nonvolatile memories are required. A comparison of available and future memory technologies was made showing that DRAMs are volatile (need continuous refreshing and therefore consume more power), SRAMs exhibit large area and high leakage limitations. Flash memories are slow in writing and have limited lifetime (up to about  $10^{5-6}$  cycles) in addition to being difficult to integrate. The upcoming competing

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memories, ferroelectric random access memories (FeRAMs) and magnetic random access memories (MRAMs), face their own challenges, such as yield and switch polarization. Young-Jin Park (Hynix Semiconductor) presented “The Vision and Future Direction of FeRAM” from the Hynix perspective, making comparisons between FeRAMs based on SBT and PZT ferroelectric technologies. Rainer Waser (RWTH Aachen University and Forschungszentrum Jülich) discussed ferroelectric phenomena at the nanoscale, addressing materials issues critical for the far generation of FeRAMs.

ISIF 2003 featured several parallel sessions that are highlighted below.

The **FeRAM Process Integration Session** featured invited talks that discussed challenges of integration for embedded FeRAMs in the sub 180 nm scale, embedded FeRAMs with 0.58  $\mu\text{m}$  cell size using 130 nm, 5 LM Cu/FSG Logic Process, novel common cell via etch stopper technology for fabrication of FeRAMs, and improvement in ferroelectric properties of Pt/SBT/Pt capacitor via blocking impurity diffusion from interlevel dielectric layers. Perhaps the most important highlight presented in an invited paper was the discussion of the first 0.18  $\mu\text{m}$  SBT-based embedded FeRAM technology with hydrogen damage-free stacked cell structure. In addition to the invited papers, there were several good contributed papers that discussed diverse topics relevant to FeRAM process integration, including plasma etch processes, oxygen and hydrogen barriers, processing of PZT films by MOCVD, processing of Ir electrode layers as well as other electrode materials.

The **FeRAM Materials Session** was a good complement to the process integration session, featuring invited talks that discussed important issues, such as large area deposition of Bi-based films, low temperature processing of PZT thin films on Pt and SRO electrode layers, materials characterization and testing of FeRAM PLZT film-based capacitors with improved reliability with respect to prior state-of-the-art technology for PZT-based FeRAMs. Contributed talks in this session dis-

cussed relevant topics such as new ferroelectric materials for single transistor FeRAMs, modification of crystallization of PZT films via incorporation of nanosized powders, improvement of crystallinity in sol-gel derived BLT capacitors using an optimized sol-gel process, production of ion-substituted BTO films via chemical solution deposition, influence of asymmetric electrodes including SrO and IrO layers on the interfacial capacitance and the failure mechanisms in PZT films, effects of Mn doping on the fatigue of PZT capacitors, influence of  $\text{SiO}_2$ -based additives in BTO films for FeRAM capacitors,  $\text{IrO}_2$ /Ir electrodes for MFIS ferroelectric gate transistors, and low temperature growth of BTO films by hydrothermal treatment.

The **CVD Processing Session** addressed several issues related to the synthesis of ferroelectric thin films by the technique that is mainly used in fabrication of FeRAMs. Invited talks discussed critical issues, such as synthesis and characterization of SBT films for 3-D stack capacitors, film thickness dependence of the crystal structure and electrical properties of PZT films below 50 nm produced by MOCVD, and the synthesis of SBT thin films via advanced MOCVD. Contributed talks also provided important discussion on several topics including flash CVD techniques for mass production of FeRAMs, MOCVD of PZT films for embedded FeRAMs, low temperature MOCVD process for fabrication of LNO/PZT/LNO capacitors for high density embedded FeRAMs, preparation of PZT films via MOCVD, using new, more efficient precursors, CVD synthesis of Ru electrodes and characterization of electrical performance for application to FeRAMs.

The **Testing and Characterization Session** provided valuable information on the latest advances in characterization of ferroelectric materials and devices. Invited papers included discussion of characterization of 16Mb FeRAMs using a novel sensing scheme, a discussion of the use of *in situ* synchrotron X-ray scattering techniques to study ferroelectric film growth processes and effect of film thickness on ferroelectricity in epitaxial PTO thin films (this talk provided first evidence for the limit of ferroelectricity in an inorganic ferro-

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electric thin film, such as PTO, with a demonstration that the limit appears to be 3 unit cells for single crystal PTO film grown on a single crystal STO substrates), a discussion of Raman spectroscopy as a reliable method for characterization of ferroelectric perovskite thin films, and a description of characterization of depth profile of hydrogen and oxygen in ferroelectric thin films using high-energy ion beams. Highlights of contributed papers included discussions on effect of geometry on switching kinetics in PZT capacitors, structural interfacial studies of textured PZT films on GaN and sapphire substrates, nonlinear imprint behavior of PZT films, fatigue and retention stability of low voltage PZT films, high-speed and high-resolution measurements of submicron capacitors for FeRAMs, new approaches for the analysis of switching current in ferroelectric capacitors recorded during conventional measurements of polarization hysteresis, studies of recovery of polarization in fatigued PZT capacitors, an insightful study with a direct lateral observation of the depth profile of domain configuration in fatigued PZT capacitors, and a discussion of mechanisms of charge retention loss in Pt/PZT/Pt capacitors and its relation to fatigue and imprint.

A **Domains and Nanostructure Session** provided valuable insights into the issues that are critical to the development of the future high-density FeRAMs. Invited papers were focused on issues such as nanoscale phenomena in ferroelectric thin films investigated by the atomic force microscopy piezoresponse force microscopy method, domain structure of epitaxial PZT thin films with morphotropic phase boundary composition, synthesis of novel ferroelectric nanotubes, low dimensional ferroelectrics, and 3-D structures in nanoscale ferroelectrics including patterned cylindrical nanoferroelectrics and self-assembled patterned pyramid nanoferroelectrics, and ferroelectric domain observation and manipulation by nanoprobe. Contributed talks provided information on ferroelectric properties of self-assembled PZT islands prepared on various substrates via MOCVD, fast and superfast motion of ferroelectric domain boundaries and finite size effect on structural and physical properties of nanocrystalline ferroelectric thin

films.

The **MEMS, Pyroelectric and Optoelectronic Session** addressed scientific and technological issues in several invited and contributed papers. Invited papers were presented on piezoelectric devices based on ferroelectric thin films, giant piezoelectric response in epitaxial PMN-PT films on Si for high performance MEMS, recent advances in piezoelectric micromachined ultrasonic transducers based on PZT films, design and fabrication of PZT-based acoustic sensors, characterization of mechanical and electrical properties of MEMS devices based on piezoelectric films, microwave properties of high-K materials, fabrication and characterization of piezo cantilevers and membranes used for MEMS, and many other materials and property issues critical to MEMS, pyroelectric and electro-optic devices.

The **Circuit Design and Architecture Session** was characterized by the discussion of new concepts related to device architecture and writing and readout schemes. Invited papers focused on discussions of issues such as nondestructive readout ferroelectric gate FET memory concepts, a current giant scheme for 16 Mb FeRAM, circuits for data sensing in FeRAMs. Contributed papers covered various topics such as ferroelectric nonvolatile logic devices, design of ferroelectric programmable logic gate arrays, ferroelectric test chip designed for process integration and direct capacitor characterization, a novel approach for the incorporation of ferroelectric materials into microwave systems, improved performance of BST-based tunable circuits employing low-loss dielectrics, improved performance compact phase shifters based on BST capacitors.

The **Multiferroics and Graded Ferroelectrics Session** provided a new platform for discussing scientific and technological issues related to this relatively new and still small subfield of integrated ferroelectrics. Invited papers addressed issues such as graded ferroelectrics, transcapacitors, and other graded ferroic materials and devices, and computational design of new multiferroics. Contributed papers were presented on rectifying effect of graded films, observation of ferroelectricity and ferromagnetism in BiFeO-ReFeO-PbTiO solid solutions,

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origin of hysteresis offsets from polarization graded ferroelectrics, and doping effects on the piezoelectric properties of low-temperature sintered PTO-based ceramics.

*Properties of ferroelectric thin films that are being intensively investigated include electrical conductivity, ferroelectricity, piezoelectricity, pyroelectricity, and electro-optic activity.*

A short **Modelling and Theory Session** was focused on discussions of electromechanical properties of constrained single crystal domain and polydomain ferroelectric films, theory of nano-phase self-patterned electrodes as applied to oxide ferroelectrics, first principle computations of PMN materials, nucleation limited switching in ferroelectric films, including a discussion of imprint/retention modeling and polarization kinetic reversal, and order parameter in relaxors.

The **High-K Dielectric Session** in the ISIF 2003 included discussions of high-k dielectric science and technology focused on application to high-frequency devices and DRAMs. Invited papers covered scientific and technological issues related to a broad range of devices. For example, an invited paper provided the first demonstration that Cu can be used as electrode material for high-k dielectric BST-based capacitors via the use of a novel oxygen diffusion barrier that enables the integration of Cu layers with BST and eventually with other oxide ferroelectric layers. A review was also presented on the status of high-k dielectrics for DRAMs. A discussion of thick dielectric BST films produced by MOCVD was presented with a focus on the properties of the thick films. Multilayer BST capacitors were reviewed also. Contributed papers covered a wide range of scientific and technological issues, such as nickel integration and enhanced dielectric properties of STO and BST film-based capacitors, properties of ultrathin BTO films grown by MBE, dielectric properties of single crystal

PMNT films, extension of operational temperature range for microwave ferroelectric tunable devices, synthesis and characterization of nanostructured BST films for microwave applications, PZT-based films synthesized on metal foils by chemical solution deposition for advanced electronic systems, S-band microwave phase shifters based on varactors, and millimeter-wave line ferroelectric phase shifters.

A new session on **Oxides on Si** was organized to address the new field of research and technological development focused on high-k dielectric layers for application to the replacement of SiO<sub>2</sub> as the gate material in the next generation of integrated circuits. This has become a hot topic of research that is attracting researchers in the ferroelectric field, triggered by a shift in funding from several agencies. An invited paper was presented on processing issues related to high-k dielectric layers integrated with Si. Contributed papers addressed issues such as MOCVD synthesis of high-k layers for gate applications, growth of HfO<sub>2</sub> by MOCVD using oxygen-free precursors, and growth of STO films by ALD using remote plasma oxidant. It is expected that this session will increase in size in future ISIFs, reflecting a shift in research and development in the field of complex oxide thin films.

In conclusion, the ISIF 2003, as prior ISIFs, was characterized by scientific and technological advances, but most importantly, it was characterized by the realization that integrated ferroelectrics has reached a state of development where commercial devices, such as smart cards based on FeRAMs are already in the market and high-density embedded FeRAMs are nearing introduction into the market and leading the way to a future stand-alone FeRAM. All in all, the future of integrated ferroelectrics is bright, and evolution into alternative subfields, such as high-k dielectrics, for the new generation of integrated circuit gates will provide new energy to this vibrant scientific and technological field of research.

*Orlando Auciello*  
Argonne National Laboratory  
Materials Science Division, Argonne, IL

**ISIF 2003 PAPERS**

**15TH INTERNATIONAL SYMPOSIUM ON INTEGRATED FERROELECTRICS (ISIF 2003)**

In the last issue we listed the ISIF 2003 papers in the following fields: FeRAM process integration; MEMS, pyroelectrics and optoelectronics; high-K dielectrics; circuit design and architecture; crystalline oxides; multi-ferroics and graded ferroelectrics; modelling and theory; and the oral presentations of CVD processing.

Now we bring you the authors and titles of the papers given in the rest of the fields covered at ISIF 2003: Poster presentations of CVD processing; domains and nanostructures; FeRAM materials; and testing and characterization.

**CVD PROCESSING - POSTERS**

Effect of PbTiO<sub>3</sub> seed layer on the growth of metalorganic chemical vapor deposited Pb(Zr,Ti)O<sub>3</sub> thin films

*Youngsoo Park, Choong-Rae Cho, June-Mo Koo, and June Key Lee*

Thickness dependencies of Pb(Zr,Ti)O<sub>3</sub> thin film using MOCVD technique

*June-Mo Koo, Choong-Rae Cho, June Key Lee, and Youngsoo Park*

Characteristics of ZnO thin film by atomic layer deposition for film bulk acoustic resonator

*Su Bong Jung, Soo Gil Kim, Gon Min Jeong, Young Hwa Shin, and Neung Heon Lee*

Investigation of Ru thin films prepared by chemical vapor deposition as bottom electrodes for memory applications

*Sang Yeol Kang, Ha Jin Lim, Cheol Seong Hwang, and Hyeong Joon Kim*

Effects of oxidizers on the characteristics of ZrO<sub>2</sub> films deposited by MO-ALD

*Juwahn Park, Daekyun Jeong, Nohheon Park, and Juyoung Kim*

MOCVD growth and characterization of switching ferroelectric thin film oxides for high-density memory

*J.D. Cuchiaro, C.E. Rice, S. Sun, L.G. Provost, G.S. Tompa, T. Davenport, G. Fox, S. Sun, and F. Chu*

Preparation of PZT thin films by liquid source MOCVD using a cyclohexane solvent

*Y. Nishioka, T. Jinbo, T. Yamada, T. Masuda, M. Kajinuma, M. Uematsu, K. Suu, and M. Ishikawa*

ZnO thin films deposited by atomic layer deposition technique using O<sub>3</sub> as oxidant

*Seong Keun Kim, Oh Seong Kwon, Cheol Seong Hwang, Sang-Hee Ko, and Sun Jin Yun*

Development of low-temperature Al<sub>2</sub>O<sub>3</sub> MOCVD for ferroelectric film passivation on 8" wafers

*C.E. Rice, J.D. Cuchiaro, S. Sun, L.G. Provost, G.S. Tompa, T. Davenport, G. Fox, S. Sun, and F. Chu*

Highly conformal ruthenium films by digital CVD using Ru(THD)<sub>2</sub>COD and oxygen

*Jaydeb Goswami, Anirban Das, Wei Cao, Diefeng Gu, Sandwip K. Dey, Steve Marcus, Henk de Waard, and Chris Werkhoven*

Liquid flash evaporation (LFE) technology for ferroelectric MOCVD

*C.E. Rice, S. Sun, L.G. Provost, J. Cuchiaro, and G.S. Tompa*

Atomic layer deposition (ALD) of bismuth titanium oxide thin films using direct liquid injection (DLI) method

*Young Jin Cho, Yo-Sep Min, Jung-Hyun Lee, Bum-Seok Seo, June Key Lee, and Young Soo Park*

Vortex-CVD for advanced 3-D capacitor FeRAMs

*R. Grant, M. Brubaker, and S. Narayan*

Low temperature PZT films by MOCVD for IR imaging

*J.D. Cuchiaro, C.E. Rice, S. Sun, L.G. Provost, G.S. Tompa, Howard Beratan, Charles Hanson, and Hilary Tanner*

Metal-organic chemical vapor deposition of Hf<sub>x</sub>Al<sub>y</sub>O<sub>z</sub> thin films using a single molecular precursor

*Hong Bae Park, Jaehoo Park, Moonju Cho, Cheol Seong Hwang, Seok Joon Won, Moon Han Park, and Ho Kyu Kang*

Preparation of Pb(Zr,Ti)O<sub>3</sub> thin films by liquid delivery MOCVD using a cocktail solution

*Yohei Otani, Norikazu Abe,*

## ISIF 2003 PAPERS

Masato Nishinouchi, Masato Miyake, Soichiro Okamura, and Tadashi Shiosaki

## DOMAINS AND NANOSTRUCTURES

Nanoscale phenomena in ferroelectric thin films investigated via piezoresponse force microscopy  
V. Nagarajan and R. Ramesh

Piezoresponse force microscopy study reaching the limit of ferroelectricity  
A. Roelofs, T. Schneller, Ch. Szot, K. Prume, and R. Waser

Domain structures of epitaxial  $\text{Pb}(\text{Zr},\text{Ti}_{1-x})\text{O}_3$  thin films with MPB composition  
Keisuke Saito, Toshiyuki Kurosawa, Takao Akai, Shintaro Yokoyama, Takahiro Oikawa, Hitoshi Morioka, and Hiroshi Funakubo

Piezoresponse force microscopy: Characterization of domains and switching behavior in ferroelectric capacitors  
A. Gruverman, B.J. Rodriguez, A.I. Kingon, R.J. Nemanich, J.S. Cross, and M. Tsukada

Low dimensional ferroelectrics  
Marin Alexe

Ferroelectric properties of self-assembled  $\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$  islands prepared on various substrates by MOCVD  
M. Shimizu, H. Fujisawa, H. Nonomura, and H. Niu

Compositional dependence of electromechanical response of Ba,Zr-codoped sodium bismuth titanate and its origin

A.N. Soukhovjak and Y.-M. Chiang

Three-dimensional structures in nano-scale ferroelectrics: Patterned cylindrical nano-ferroelectrics and self-patterned pyramidal nano-ferroelectrics  
J.F. Scott

Ferroelectric domain observation and manipulation by nano probe  
Seungbum Hong, Hongsik Park, Juhwan Jung, Dong Ki Min, Sungdong Kim, Jungwon Woo, Kwangsoo So, and Hyunjung Shin

Fast and superfast motion of ferroelectric domain boundaries  
Vladimir Shur, Evgenii Rumyantsev, Ekaterina Nikolaeva, and Eugene Shishkin

Dielectric and nonlinear optical properties of ferroelectric polymer films  
K.A. Verkhovskaya and N.I. Kuznetsova

Finite size effect on the structural and physical properties in nanocrystalline  $\text{BaTiO}_3$   
J. Yu, J. Meng, J.L. Sun, G.S. Wang, and J.H. Chu

## POSTERS

Piezoelectric effects during domain switching in epitaxial PZT thin films  
Yong Kwan Kim, Sunggi Baaik, Young Il Joo, Ke Sun Sohn, and Sang Sub Kim

Reproducible and bistable switching events in *I-V* curves of ultrathin  $\text{Pb}(\text{Zr},\text{Ti})\text{O}_3$  and  $\text{BaTiO}_3$  films

H. Kohlstedt, J. Rodríguez Contreras, N.A. Pertsev, A. Gerber, J. Schubert, K. Szot, C.L. Jia, and R. Waser

Ferroelectric nanotubes  
Finlay D. Morrison, J.F. Scott, Ralf B. Wehrspohn, Marin Alexe, Toshiaki Tatsuta, and Osamu Tsuji

Ferroelectricity in stress-free  $\text{BaTiO}_3$  ultrathin films and nanocells  
M.G. Stachiotti

Dielectric and nonlinear optical properties of ferroelectric polymer films  
K.A. Verkhovskaya, and N.I. Kuznetsova

Nanoscale ferroelectric elements fabricated by electron beam lithography  
Dong-Joo Kim, Jin Seo Im, Carol Thompson, S.K. Streiffner, G. Wiederrecht, and O. Auciello

Self-assembled ferroelectric nanocrystals  
I. Szafraniak, C. Harnagea, S. Bhattacharyya, M. Alexe, and U. Gösele

Determination of cross sectional variation of ferroelectric properties for thin film (ca. 500nm) PZT (30/70) via PFM  
Andrew Dyer and Steven Dunn

Fabrication of isolated ferroelectric domains in nano-scale  
Won-Ku Jung, Young-Soo Choi, Seung-Hyun Kim, and Hyunjung Shin

## ISIF 2003 PAPERS

Ferroelectric lead zirconate titanate and barium titanate nanotubes

*Y. Luo, I. Szaframiak, V. Nagarajan, R.B. Wehrspohn, M. Steinhart, J.H. Wendorff, N.D. Zakharov, R. Ramesh, and M. Alexe*

### FeRAM MATERIALS

Large-area deposition of Bi<sub>2</sub>SiO<sub>5</sub>-added ferroelectric thin films with super critical fluid

*Takeshi Kijima, Koji Ohashi, Yasuaki Hamada, Junichi Karasawa, Eiji Natori, and Tatsuya Shimoda*

A novel ferroelectric material for single transistor ferroelectric memory cells

*Fred P. Gnadinger, Klaus Dimmler, Greg Huebner, David Klingensmith, T.S. Kalkur, and Ali Mahmud*

Novel ferroelectric candidates in a series of ABi<sub>4</sub>Ta<sub>4</sub>O<sub>15</sub> (A: alkaline earth metals) thin films

*Kazumi Kato, Kazuyuki Suzuki, Desheng Fu, Kaori Nishizawa, and Takeshi Miki*

Modification on crystallization characterization of Pb(Zr,Ti)O<sub>3</sub> thin films by incorporation of nano-sized powders

*Shih-Yen Liu, Chen-Shan Chou, Jin-Hua Huang, and I-Nan Lin*

Low-temperature fabrication of Pb(Zr,Ti)O<sub>3</sub> thin films on Pt and SrRuO<sub>3</sub> electrodes

*K. Maki, Y. Tokita, M. Ishikawa, N. Soyama, B.T. Liu, Y. So, H. Vu, and R. Ramesh*

Improvement of crystallinity in sol-gel derived BLT by optimizing dry-gel structures

*Kumie Iseki, Yoshihisa Fujisaki, and Hiroshi Ishiwara*

Fabrication of ion-cosubstituted bismuth titanate thin films by chemical solution deposition method

*Hiroshi Uchida, Isao Okada, Hirofumi Matsuda, Takashi Iijima, Takayuki Watanabe, and Hiroshi Funakubo*

Compositional dependence of ferroelectric properties for (Y,Yb)MnO<sub>3</sub> thin films prepared by chemical solution deposition

*Kazuyuki Suzuki, Desheng Fu, Kaori Nishizawa, Takeshi Miki, and Kazumi Kato*

Materials characterization and testing of FRAM PLZT film capacitors for improved reliability

*J.S. Cross and M. Tsukada*

Influence of asymmetric electrode structures including SRO and IrO on the interfacial capacitance and the failure mechanisms in PZT thin films

*U. Ellerkmann, P. Schorn, D. Bolten, U. Boettger, R. Waser, R. Bruchhaus, and K. Yamakawa*

Effect of Mn doping on fatigue in Pb(Zr,Ti)O<sub>3</sub> capacitors

*Qi Zhang and Roger W. Whatmore*

Preparation of BaPbO<sub>3</sub> electrode thin films by RF magnetron sputtering

*T. Nishida, I. Kawakami, S.*

*Okamura, and T. Shiosaki*

Preparation of PbRuO<sub>3</sub> thin films by RF magnetron sputtering

*Sung-Nam Ryoo, Nak-Jin Seong, and Soon-Gil Yoon*

Address of SiO<sub>2</sub>-based additives in Bi<sub>4</sub>Ti<sub>3</sub>O<sub>12</sub> thin films

*Kazumi Kato and Hiroshi Ishiwara*

IrO<sub>2</sub>/Ir multilayer structure electrode for MFMIS ferroelectric gate transistors

*N. Sugita and E. Tokumitsu*

A very low-temperature growth of BaTiO<sub>3</sub> thin film by hydrothermal treatment following sol-gel coating at 200 degree Celsius

*M. Noda, Z. Wei, and M. Okuyama*

Laser annealing of Pb(Zr<sub>0.52</sub>Ti<sub>0.48</sub>)O<sub>3</sub> thin films using pulsed excimer (KRF) laser

*Srinivas Kuchipudi, I-Nan Lin, Yung-Chen Lin, Yu-Lin Luo, Hsui-Chuan Lee, Jin-Hua Huang, Nyan-Hwa Tai, and Su-Jien Lin*

Influence of Pt/TiO<sub>2</sub> bottom electrodes on the properties of ferroelectric Pb(Zr,Ti)O<sub>3</sub> thin films

*Norikazu Abe, Yohei Otani, Masato Miyake, Soichiro Okamura, and Tadashi Shiosaki*

Structural and interfacial studies of textured Pb(Zr<sub>0.3</sub>Ti<sub>0.7</sub>)O<sub>3</sub> thin films on (0001) GaN/sapphire substrates

*S. Bhaskar, W. Cao, and S.K. Dey*

## ISIF 2003 PAPERS

## POSTERS

Comparison of lead source material on the microstructure and ferroelectric properties of sputter deposited PZT films using lead and lead oxide for compensation

*W.L. Chang, M.Z. Lin, and J.L. He*

Oxygen partial pressure controlled post-anneal process on PZT thin films

*Junichi Karasawa, Taki Aoyama, Yasuaki Hamada, Koji Ohashi, Takeshi Kijima, Eiji Natori, Tatsuya Shimoda, and Masato Kakihana*

Studies on current transport mechanism of Ca substituted  $\text{SrBi}_2\text{Ta}_2\text{O}_9$  thin films

*Rasmi R. Daas, P. Bhattacharya, and R.S. Katiyar*

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**mail:** **Hannah Liebmann**  
**215 Thompson Square, Mountain View, CA**  
**94043-4218 USA**

**UPCOMING MEETINGS****2003 MRS Fall Meeting  
1-5 December 2003****Hynes Convention Center and Sheraton Boston Hotel, Boston, Massachusetts, USA**

The 2003 MRS Fall Meeting will serve as a key forum for discussion of interdisciplinary leading-edge materials research from around the world. More than 4400 papers in 38 topical symposia will be presented. Various meeting formats—oral, poster, round-table, forum, and workshop sessions—are offered to maximize participation.

**Symposia**

- Integrated Device Technology  
C: Ferroelectric thin films XII
- Organic, Soft, and Biological Materials
- Nano- to Microstructured Materials
- Inorganic Materials and Films  
U: Thin films — Stresses and mechanical properties X
- Photonics  
V: Critical interfacial issues in thin film optoelectronic and energy conversion devices
- Energy Storage, Generation, and Transport
- Information Storage Materials
- Design of Materials by Man and Nature

**Symposium Tutorial Program**

Available only to meeting registrants, the symposium tutorials will concentrate on new, rapidly breaking areas of research.

**Exhibit and Research Tools Seminars**

A major exhibit encompassing the full spectrum of equipment, instrumentation, products, software, publications, and services is scheduled for 2-4 December in the Hynes Convention Center, convenient to the technical session rooms. Research Tools Seminars, an educational seminar series that focuses on the scientific basis and practical application of commercially available, state-of-the-art tools will be held again this fall.

**Meeting Chairs**

Paula T. Hammond  
Massachusetts Institute of Technology  
hammond@mit.edu

Rommel Noufi  
National Renewable Energy Laboratory  
rommel\_noufi@nrel.gov

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**UPCOMING MEETINGS**

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**The 16th International Symposium on Integrated Ferroelectrics (ISIF 2004)****5 - 8 April 2004****Gyeongju, Korea**

The science of ferroelectric thin films and their applications have experienced rapid progress in recent years. The worldwide increase in commercial applications is a sign of both the maturity of the field and the acceptance of the technology.

The field of ferroelectric/high-dielectric/piezoelectric materials is still growing rapidly due to the potential applications in MEMS technologies and the development of new generations of random access memory devices. The recent interest in the high-k gate dielectrics makes the science of ferroelectric thin films more attractive.

This symposium will address topics including pyroelectric sensors, integrated high-frequency devices, electro-optical components, nanotechnology, theory, *ab-initio* calculations and the research and exploitation of nano-size effects.

The symposium will be jointly organized with the 5th Korean Workshop on Ferroelectrics and FRAM Technology.

**Topics**

- Circuits and devices
- Device integration issues
- FeRAMs, DRAMs and materials
- Ferroelectrics for space applications
- 1T-type field effect devices
- Graded or superlattice devices
- High-frequency devices
- High-k gate dielectrics and electrodes
- Integrated sensors
- Modeling, theory and *ab-initio* calculations
- Domain dynamics and engineering
- Nano-structure and nano-size effects
- Nonvolatile memory applications
- Piezoelectric and MEMS applications
- Pyroelectric/IR and optical applications
- Testing and characterization
- Other thin films

**General Co-Chairs**

C.A. Paz de Araujo and R. Panholzer

**International Advisory Board**

O. Auciello (Chair), Y. Miyasaka, A.I. Kingon, R. Ramesh, B.A. Tuttle, R. Waser, D. Wouter, G. Fox, and S. Trolier-McKinstry

**Technical Program Chairs**

S. Baik, I. Yoo, H.J. Kim

**Technical Program Committee**

Local: T.W. Noh, J. Lee (Tutorial Chair), S.G. Yoon, T.S. Kim, C.S. Hwang, K.S. Noh, S.Y. Lee, S.K.

<b>UPCOMING MEETINGS</b>
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Hong, B.G. Yoo, H.J. Nam, S.S. Kim. International: R. Waser, N. Setter, C.B. Eom, M. Okuyama, S. Streiffer, D.G. Schlom.

**Tutorial Sessions**

Several parallel sessions are planned prior to the symposium on 5 April 2004.

**Exhibits**

A number of booths will be prepared for company or product exhibit or display during the symposium.

**Call for Papers**

Abstracts are requested on state-of-the-art topics that reflect the maturity of the field and research problems that continue to challenge workers in this area. Submitted papers should deal with the topics listed, but other topics of relevance to the field are also solicited.

ISIF 2004 abstracts will only be accepted in electronic format. Please visit the Web site for the abstract format.

[www.isif.net](http://www.isif.net)

**The deadline for abstract submittals is 30 November 2003.**

**2004 MRS Spring Meeting  
12 - 16 April 2004  
San Francisco, California, USA**

**Symposia**

- Electronics, Spintronics, and Photonics
  - D: High-k insulators and ferroelectrics for advanced microelectronic devices
- Nano- and Microstructured Materials
- Molecular, Biological, and Hybrid Materials
- General
  - X: Frontiers of materials research
  - BB: Educating tomorrow's materials scientists and engineers
  - CC: Scientific basis for nuclear waste management XXVIII

**Meeting Chairs**

Israel J. Baumvol  
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[www.mrs.org/meetings/spring2004/](http://www.mrs.org/meetings/spring2004/)

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**Upcoming Meetings**

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3rd Asian Meeting on Electroceramics (AMEC-3), Singapore	29 Jun-4 Jul 03	No.1, p. 9
10th European Meeting on Ferroelectricity (EMF2003), Cambridge, UK	3-8 Aug 03	No.1, p.12
9th International Conference on Ferroelectric Liquid Crystals (FLC2003), Dublin, Ireland	24-29 Aug 03	No.1, p.14
4th (9th) International Seminar on Ferroelastic Physics, Voronezh, Russia	15-18 Sep 03	No.1, p.15
55 years of ferroelectrics, Leeds, UK	21-23 Sep 03	No.2, p. 9
15th American Conference on Crystal Growth & Epitaxy, Keystone, Colorado, USA	20-24 Jul 03	No.2, p.10
11th Biennial Workshop on OMVPE, Keystone, Colorado, USA	20-24 Jul 03	No.2, p.10
3rd International Symposium on Laser and NLO Materials, Keystone, Colorado, USA	20-24 Jul 03	No.2, p.11
Processing of Electroceramics Symposium 2003, Bled, Slovenia	31 Aug-3 Sep 03	No.3, p.12
8th Wide-Bandgap III Nitride Worrkshop, Richmond, Virginia, USA	29 Sep-1 Oct 03	No.3, p.13
Polymer Chemistry: Principles and Practice, Blacksburg, Virginia, USA and again on	17-22 Aug 03 7-12 Dec 03	No.3, p.13
Introduction to Polymeric Adhesives and Composites, Blacksburg, Virginia, USA	12-17 Oct 03	No.3, p.14
Frontiers in Inorganic Polymers, Philadelphia, Pennsylvania, USA	16-17 Oct 03	No.3, p.15
2003 MRS Fall Meeting, Boston, Massachusetts, USA	1-5 Dec 03	No.4, p.12
16th International Symposium on Integrated Ferroelectrics (ISIF 2004), Gyeongju, Korea	5-8 Apr 04	No.4, p.13
2004 MRS Spring Meeting, San Francisco, California, USA	12-16 Apr 04	No.4, p.14

**Conference Report**

15th International Symposium on Integrated Ferroelectrics (ISIF 2003)	9-12 Mar 03	No.4, p.2
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**Index of Conference Papers**

5th European Conference on Applications of Polar Dielectrics (ECAPD-V)	28-30 Aug 00	No.1, p.2
2nd Ferroelectric Workshop in Puerto Rico (FWPR-2001)	31 May-2 Jun 01	No.1, p.6
4th Conference on Magnetoelectric Interaction Phenomena in Crystals (MEIPIC-4)	16-19 Oct 01	No.2, p.2
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15th International Symposium on Integrated Ferroelectrics (ISIF 2003), Part I	9-12 Mar 03	No.3, p.2
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**Publications**

Papers on Antiferroelectricity, a special issue of <i>FERROELECTRICS</i> , Vol. 266 (2002)		No.2, p.8
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***Ferroelectricity Newsletter***

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Fall 2003

Ferroelectricity Newsletter

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| Sep 21-23        | • 55 years of ferroelectrics, Leeds, England (see <i>Ferroelectricity Newsletter</i> , Vol. 11, No. 2, p. 9)  |
| Sep 29-<br>Oct 1 | • 8th Wide-Bandgap III Nitride Workshop, Richmond, Virginia, USA (see <i>Ferroelectricity Newsletter</i> , Vol. 11, No. 3, p. 13)   |
| Oct 12-17        | • Introduction to Polymeric Adhesives and Composites, Blacksburg, Virginia, USA (see <i>Ferroelectricity Newsletter</i> , Vol. 11, No. 3, p. 14)  |
| Oct 16-17        | • Frontiers in Inorganic Polymers, Philadelphia, Pennsylvania, USA (see <i>Ferroelectricity Newsletter</i> , Vol. 11, No. 3, p. 15)   |
| Dec 1-5          | • 2003 MRS Fall Meeting, Boston, Massachusetts, USA (see p. 12)   |
| Dec 7-12         | • Polymer Chemistry: Principles and Practice, Blacksburg, Virginia, USA (see <i>Ferroelectricity Newsletter</i> , Vol. 11, No. 3, p.13)   |
| Dec 12-15        | • 4th Asian Meeting on Ferroelectrics 2003 (AMF-4), Bangalore, India (see <i>Ferroelectricity Newsletter</i> , Vol. 10, No. 3, p. 22) Info: <a href="http://mrc.iisc.ernet.in/~amf4/amf2003.html">http://mrc.iisc.ernet.in/~amf4/amf2003.html</a> |

### 2004

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|-----------|--|
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| Apr 12-16 | • 2004 MRS Spring Meeting, San Francisco, California, USA (see p.14)                                 |