# Ferroelectricity Newsletter

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

Volume 6, Number 1 Winter 1998

## *ESTABLISHING A LINK BETWEEN ISIF, TVER UNIVERSITY IN RUSSIA, AND NEW DELHI, INDIA*

In the first issue of our sixth year of publishing the *Ferroelectricity Newsletter* we celebrate two anniversaries. One is the **10th International Symposium on Integrated Ferroelectrics**, held from 1 - 4 March 1998 in Monterey, California. The other is the **20th anniversary of the existence of research in ferroelectrics and piezoelectrics at the Physics Department of Tver University in Russia.**

Given the close global interconnection between engineers and scientists in the ferroelectrics community, the development of any given sequence of conferences reflects in some degree the development of research in the whole field. The article "ISIF Memories Made Nonvolatile," beginning on page 2, was written with this in mind. This history of ISIF is accompanied by the list of presentations at this year's conference.

Looking back at 20 years of ferroelectrics research at the Physics Department of Tver University has still another significance. If we consider the often difficult situations under which researchers have to work in the former Soviet block countries, we appreciate their achievements even more. In many instances the scarcity of funds makes it impossible to join colleagues at international meetings and thus deprives them of valuable personal discussion of problems and exchange of ideas. Our special thanks go to **Dr. Olga Malyshkina**, who put together the report on what's happening in the field of ferroelectricity at Tver University.

In our next issue we will focus our attention on another geographical area whose scientific accomplishments are not well known. Last August at the IMF-9 conference in Seoul I had the pleasure of meeting **Dr. R.P. Tandon** from the National Physical Laboratory in New Delhi. He had organized the Ninth National Seminar on Ferroelectrics and Dielectrics at his institute and was willing to send us a report of this conference, together with the list of presentations because, as he said, "almost nothing is being covered from this part of the globe." And he continued, "Let me assure you there is enough interest here. I have no doubt that this newsletter can serve as a bridge."

Serving as a bridge will continue to be the purpose of this publication, and with your help we will accomplish it.

Rudolf Panholzer
Editor-in-Chief

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**Ferroelectricity Newsletter**
Volume 6, Number 1
Winter 1998

The *Ferroelectricity Newsletter* is published quarterly by the Naval Postgraduate School, Space Systems Academic Group, Monterey, California, with the support of the Defense Advanced Research Projects Agency (DARPA) and the Office of Naval Research (ONR).

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## *ISIF 98 PAPERS*

*The following is a list of titles and authors of presentations given at the* ***10th International Symposium on Integrated Ferroelectrics****, held from 1 to 4 March 1998 in Monterey, California.*

**Plenary Sessions**

SBT-Based Nanoscale Ferroelectric Memories
*J.F. Scott*

Science and Technology of PZT Thin Films and Capacitors for NVFRAMs
*R. Ramesh*

Technology Challenges and Solutions for 1Gbit-DRAMs and Beyond
*C. Mazuré*

Electrical Characterization of Ferroelectric and Superparaelectric Thin Films
*R. Waser*

Biomedical Applications of Ferroelectric MEMS
*D.L. Polla, R.C. McGlennen, and L.T. Furcht*

**Device Integration Issues**

Ferroelectric Embedded Devices
*H. Takasu*

Integration of High Density Ferroelectric Memories with Submicron Silicon CMOS Technology
*B. Melnick, P. Chu, P. Zurcher, B. White, S. Zafar, D. Taylor, D. Roberts, M. Raymond, P.Alluri, T. Remmel, M. Kottke, E. Apen, W. Chen, R. Liu, P. Fejes, C. Tracy, B. Jones, S. Gillespie*

Evaluation of Electrical Properties and

# HISTORY

## *ISIF MEMORIES MADE NONVOLATILE*

**How it all began**

When scientists discovered the ferroelectric effect more than eighty years ago, they had no idea how these materials would fundamentally revolutionize many aspects of our high-tech activities today.

During the following sixty years nothing of great importance happened with ferroelectric materials. To be sure, there was a flurry of promising activities around using ferroelectric thin films and single crystals in computer memories in the sixties.

It was only during the last twenty-five years that a tremendous increase in the investigation of ferroelectric materials took place. This activity included not only thin films and single crystals but also ceramics, composites, liquids, and polymers.

The cross-fertilization between research in thin-film ferroelectric and semiconductor materials and technology proved to be the key for the takeoff of integrated ferroelectrics. During the last twelve years advances in this field were made at an ever increasing pace.

The time was ripe to provide a forum for scientists to come together, exchange research results, and thus enhance further development.

**ISIF 89**

It happened on 30 March 1989 at the Antlers Hotel in Colorado Springs, Colorado. The first International Symposium on Integrated Ferroelectrics with 65 attendants was held in conjunction with the Colorado Microelectronics Conference and was organized by George W. Taylor, Leonard Schwee, J.F. Scott, C.A. Paz de Araujo, and L.D. McMillan. On this one day devoted strictly to integrated ferroelectrics, 21 papers were contributed by researchers from the United States. The proceedings were published by ColorTek with R. Kwor as editor.

**ISIF 90**

Alternating the venue of the Symposium between Colorado Springs, Colorado, and Monterey, California, started right at the beginning with the second meeting held at the Naval Postgraduate School in Monterey, California. Back then the invited lecturers were asked to give tutorials which lasted between 45 minutes to two hours. Some speakers apparently gave two talks of 45 minutes each. The number of attendees, most of them from the United States, with some participation from foreign countries, approached 100. Academic Short Course Certificates were mailed to everyone who attended ISIF 90. CDR Carl Josefson and LCDR Randy Wight assisted Rudolf Panholzer with the planning and execution of this meeting. George W. Taylor and Roman Fedorak acted as co-chairmen. The luncheon was held at the Naval Postgraduate School but did not yet feature a keynote speaker.

## HISTORY

The proceedings were published by Gordon and Breach Scientific Publishers in the international journal *Ferroelectrics* with G.W. Taylor as editor and C.A. Paz de Araujo as guest editor.

**ISIF 91**

At the third Symposium, held from 3 - 5 April 1991 at the Antlers Hotel in Colorado Springs, the number of participants jumped to 220, more than doubling the participation of the previous year. Fifty-eight papers were presented, with approximately 30 of them given by scientists from Canada, England, Germany, Switzerland, Japan, and Russia. Dr. Araujo was chairman, assisted by Prof. Panholzer, at this truly international convocation of scientists and engineers dedicated to the advancement of research and application of integrated ferroelectrics.

The presentations at ISIF 91 differed in several distinct ways from the papers given the previous year. First, the scope was wider; ferroelectric random access memory arrays (FERAMs) for memory applications were still central in their emphasis, but other integrated devices—high dielectric films for DRAMs, surface acoustic wave (SAW) devices, integrated pyroelectrics, CCD, and other optical applications—were growing in importance. Second, although lead zirconate titanate retained its popularity, other materials, such as $BaMgF_4$, $LiNbO_3$, and bismuth titanate, were investigated carefully. Third, the underlying integrated circuit was not limited to CMOS silicon but included bipolar technology and GaAs JFETs. Finally, the participation of European and Pacific Rim scientists and laboratories had grown in size and quality to rival the US programs.

Col. Will Stackhouse, US Air Force, gave the keynote address at the buffet luncheon held at the Antlers Hotel and thus started a tradition which has been well received by attendees ever since.

Commemorative plaques honoring "Pioneers in Integrated Ferroelectrics" were presented to L.D. McMillan, M. Okuyama, G.A. Rohrer, N.W. Schubring, H.L. Stadler, G.W. Taylor, H.H. Wieder, Shu-Yau Wu, and R. Zuleeg. The Symposium was co-sponsored by the University of Colorado Springs, Naval Postgraduate School, Defense Advanced Research Projects Agency (DARPA), Gordon and Breach Scientific Publishers, Storage Technology Corporation, and the University of Colorado Foundation, Inc.

The papers for the proceedings were assembled by Alona Miller and published by Johnson Publishing in Boulder, Colorado, with Carlos A. Paz de Araujo as guest editor.

**ISIF 92**

The fourth Symposium, held 9 - 11 March 1992 at the Hyatt Regency in Monterey, proved Carlos A. Paz de Araujo's prediction right that the field of integrated ferroelectrics would become part of the mainline research in integrated circuits. A total of 87 papers was presented at this conference,

### *ISIF 98 PAPERS*

Composition Profiles Using SIMS on Hydrogen Baked Pt/PZT/Pt Capacitors
*H. Ashida, M. Tomotani, T. Tamura, K. Matsuura, Y. Goto, and S. Otani*

Effect of RIE Plasma of $Pb(Zr,Ti)O_3$ Thin Films
*S.-J. Oh, S. Oh, H.-B. Park, S.-H. Joo, M.-H. Yoo, B.-H. Kim, J.-H. Lee, C.-Y. Yoo, S.-I. Lee, and M.-Y. Lee*

A Novel Method of Dry-Etching Fence-Free Pt Electrodes for Gbit DRAMs
*G. Xing, T. S. Moise, S.R. Summerfelt, M.R. Visokay, R. Khamankar, M. Kressley, L. Co lombo, C. Hartfield, T. Moore, A. Ali, and C. Lee*

High-Quality $IrO_2$/Ir/TaSiN Electrode Barrier for $SrBi_2Ta_2O_9$ Capacitor in High-Density Ferroelectric Memory Devices
*M. Nagata, S. Yokoyama, S. Mitarai, N. Ogata, K. Ishihara, H. Urashima, A. Okutoh, S. Yamazaki, and J. Kudo*

Memory Effects of $SrBi_2Ta_2O_9$ Capacitors on Si with a Silicon Nitride Buffer
*J. Han, X. Guo, and T.P. Ma*

Electrical Characteristics of Metal/ Ferroelectric/ Insulator/Semiconductor Structure of $Pt/SrBi_2Ta_2O_9/Y2O_3/Si$
*H.-N. Lee, D.-S. Shin, and Y.-T. Kim, and S.-H. Choh*

Dependence of Electrical Properties of PZT Capacitors on the Thickness of Ir-Based Bottom Electrodes

### *ISIF 98 PAPERS*

*H. Fujisawa, S. Hyodo, S. Nakashima, M. Shimizu, H. Niu, H. Okino, and T. Shiosaki*

Degradation-Free Ferroelectric $Pb(Zr,Ti)O_3$ Thin Film Capacitors with an $IrO_2$ Top Electrode
*Y. Fujisaki, K. Kushida-Abdelghafar, H. Miki, and Y. Shimamoto*

A Qualitative Model for Degradation of FRAM Products during Plastic Packaging
*E.M. Philofsky and S. Mitra*

Optimization of Plastic Packaging of Ferroelectric Semiconductor Memories
*D. White, T. Culbreth, and S. Mitra*

Insertion of a Ru Thin Layer for Protection of Underlying TiN from Oxidation in Pt/TiN/Ti/Poly-Si Contact Structure
*E.-C. Park, B.-I. Lee, S.-K. Joo, and J.-H. Joo*

Improvement on Ferroelectric Properties of $(Pb_{1-x}La_x)(Zr_yTi_{1-y})_{1-x/4}O_3$ Thin Films by Using Ru as Intermediate Layers
*I-Nan Lin, K.-S. Kiu, and T.-F. Tseng*

Influence of Cationic Stoichiometry on $La_{1-x}Sr_xCoO_3$ Electrodes on the Ferroelectric Properties of Lead-Based Thin Film Memory Elements
*S. Aggarwal, T.K. Song, A.M. Dhote, A.S. Prakash, R. Ramesh, N. Velasquez, L. Boyer, and J. T. Evans, Jr.*

$Sr_2(Ta,Nb)_2O_7$ Ferroelectric Thin Films for Ferroelectric Memory FETs
*Y. Fujimori, N. Izumi, T. Nakamura, and A. Kamisawa*

## HISTORY

with 28 papers delivered by scientists from foreign countries, including Australia, Germany, The Netherlands, Sweden, Japan, and Korea.

The range of topics included integrated ferroelectric devices, processing and integration, theory and testing, and optical and pyroelectric devices. The session Late News Invited Papers attracted special interest since these presentations dealt with the development of fatigue-free thin films.

As in the previous year, the papers for the proceedings were assembled by Alona Miller and this time published by Hirshfield Press.

Dr. Gota Kano, Director of the Electronics Research Laboratory at Matsushita Eletronics Corporation in Osaka, Japan, delivered the keynote address on “International Cooperation and Application of Integrated Ferroelectrics in Consumer Electronics” at a luncheon held in the elegant Barbara McNitt Ballroom at the Naval Postgraduate School.

The possibility of publishing a newsletter promoting efficient networking and minimizing duplication of research efforts was discussed by Rudolf Panholzer of the Naval Postgraduate School and Wallace Smith of the Office of Naval Research. The result of these deliberations was the birth of the *Ferroelectricity Newsletter*, whose premier issue was published in December 1992.

A conference highlight of a different kind was the Monterey Bay Aquarium dinner, where 186 participants had the opportunity to explore the facts, myths, and mysteries of the spectacular Monterey Bay at one of the world’s largest aquariums and enjoy a sit-down dinner in front of the huge kelp tank. At the dinner Carlos A. Paz de Araujo was awarded a plaque honoring his contributions in the field of integrated ferroelectrics.

Support for the symposium came from DARPA, Naval Postgraduate School, Office of Naval Research, and the University of Colorado at Colorado Springs.

**ISIF 93**

The Fifth International Symposium on Integrated Ferroelectrics, held 19 - 21 April 1993 at Antlers Doubletree Hotel in Colorado Springs, confirmed the fact that the field of integrated ferroelectrics was now firmly established in the scientific world. It was a period of consolidation, with 189 participants and 92 papers given. Of these, 26 papers were authored by scientists from foreign countries who represented the same regions as the previous year plus Brazil and Ukraine. Dr. Gary Coulter, program manager of NASA, was the keynote speaker at the traditional luncheon. The proceedings were published by Gordon and Breach Science Publishers in their international journal *Integrated Ferroelectrics*.

# HISTORY

**ISIF 94**

From 14 - 16 March 1994, 230 participants representing the international ferroelectrics community gathered at the Hyatt Regency Monterey for their sixth symposium. This was an increase of about 20 percent from the previous year's count. C.A. Araujo, Technical Program Chairman, coordinated the presentation of 150 papers. Participation from countries outside the United States also showed an increase from the previous year, with 42 papers delivered by researchers from Japan, Korea, Canada, Germany, Belgium, and Australia. Seven scientists from the former Soviet block countries, who were scheduled to give presentations, could not attend the conference.

The presence of oldtimers and newcomers to the field created a spirited atmosphere for scientific discussions and personal contacts. Topics such as theory of nucleation, space-charge effects, contact properties, and device and circuit design were proof of the expanding technology.

All papers of ISIF 94 were considered for publication in *Integrated Ferroelectrics*. Under the leadership of guest editor Rainer Zuleeg the reviewing procedures were partly delegated to the chairperson(s) of each session.

Dr. Will Stackhouse gave the keynote address on "The Communication Superhighway" at the luncheon in the beautifully redecorated Barbara McNitt Ballroom at the Naval Postgraduate School.

The ISIF Advisory Board, in existence since ISIF 92, met twice during the conference and came up with several recommendations. One was to add a venue to the two existing ones, possibly Tucson, for ISIF 96. Another one was to investigate the feasibility of having a tutorial session on Sunday afternoon before the beginning of the conference. Dr. Ramesh volunteered to ascertain the level of interest in such a program and thus initiated an important feature of ISIF. The Advisory Board also decided that the financial and organizational headquarters would remain in Colorado Springs.

Monday night brought the conference participants together for a tour at the Monterey Bay Aquarium and a sit-down dinner in front of the spectacular kelp tank.

**ISIF 95**

Back at the Antlers Doubletree Hotel in Colorado Springs, 255 ferroelectrics enthusiasts—27 from Japan, 23 from Korea, 12 from Canada, 3 each from Switzerland and England, 2 each from The Netherlands and Belgium, 8 from Germany, 1 each from France, Russia, India, and Australia, and the rest from the United States—congregated from 19 - 22 March for ISIF 95. A total of 129 abstracts was submitted for presentation. This year's conference offered a poster session for the first time.

Reflecting on the early symposia in the series, it became clear that the excitement of the early 1990s was entirely warranted, yet the extent and

## *ISIF 98 PAPERS*

**DRAMs and Materials**

Dielectric and Electrical Behavior on CVD $(Ba,Sr)TiO_3$ Thin Films
*S. Streiffer, C. Basceri, S.E. Lash, C.B. Parker, R.R. Woolcott, and A.I. Kingon*

A Review of $(Ba,Sr)TiO_3$ for a DRAM Capacitor
*D.E. Kotechi*

Deposition of $Ba_{1-x}Sr_xTiO_3$ by Chemical Vapor Deposition with an Integrated Cluster Tool
*L. Colombo, Y. Okuno, M. R. Visokay, C. Dornfest, S. Kher, J. Zhao, and T. Sajoto*

Bottom Electrode Structures for $(Ba,Sr)TiO_3$ Capacitors in ULSI DRAMs
*Y.-C. Jeon, J.-H. Joo, J.-M. Seon, J.-S. Lee, K.-Y. Oh, J.-S. Roh, and J.-J. Kim*

A Form of BST with Small Dependence of Dielectric Constant on Voltage
*H. M. O'Bryan, R. K. Watts, and G. T. Stauf*

Resistance Degradation Behavior on $Ba_{0.7}Sr_{0.3}TiO_3$ Thin Films Compared to Mechanisms Found in Titanate Ceramics and Single Crystals
*M. Grossmann, S. Hoffmann, R. Waser, S.K. Streiffer, C. Basceri, and A.I. Kingon*

Curie-von Schweidler Behavior Observed in Ferroelecric Ceramic Thin Films for FRAM Applications and Comparison to Superparaelectric Thin Film Materials
*M. Schumacher and R. Waser*

Dielectric Relaxation of $Ba_{0.7}Sr_{0.3}TiO_3$ Thin Films

### *ISIF 98 PAPERS*

*J. D. Baniechi, Q. Y. Ma†, R.B. Laibowitz T.M. Shaw, P.R. Duncombe, D.A. Neumayer, D.E. Kotechi, and H. Shen*

Dry Etching of $(Ba,Sr)TiO_3$ with $Cl_2$ and $SF_6$
*K R. Milkove*

Study of $SrTiO_3$ Thin Films on Ir Bottom Electrodes for Ultra-Large-Scale Integrated DRAM Application
*T.-S. Chen, V. Balu, S. Katakam, J.-H. Lee, Jack C. Lee, B. Melnick, P. Zurcher and R.E. Jones*

The Evolution of Pt Surface Morphology during Processing and Its Impact on Device Performance
*M. R. Visokay, R. Khamankar, M. Kressley, G. Xing, and L. Colombo*

The Influence of Microstructure on the Electronic Properties of Thin Films of Barium Strontium Titanium Oxide Composites
*S. Sengupta, M.W. Cole, S. Stowell, C.G. Fountzoulas, L.C. Sengupta, J. Synowczynski, and C. Hubbard*

Electrical Properties of $O_2$ and $N_2$ Annealed $(Ba,Sr)TiO_3$ Thin Films
*M.S. Tsai, T.Y. Tseng, and S.C. Sun*

**Testing and Characterization**

Direct Nanoscale Visualization of Domain Switching and Investigation of Degradation Effects in Ferroelectric Thin Films by Scanning Force Microscopy
*Alexei Gruverman, O. Auciello, and H. Tokumoto*

Recent Progress in Sputtering of PZT Thin Films for Ferroelectric Memories

## HISTORY

depth of the required research was probably underestimated. ISIF 95 offered a forum for one of the first presentations on the processing and composition of layered perovskite materials, which sparked lively debates. Prof. E.C. Subbarao, one of the early investigators of the materials, presented a well-attended invited review.

Dr. Ramesh organized the first tutorial held on Sunday from 1:00 to 6:00 pm. The instructors L.Eric Cross, Joseph T. Evans, Bruce Tuttle, and Richard Womack shared their knowledge and experience in the field with 36 attendees. This year the luncheon keynote speaker was H. Watanabe from NEC in Japan.

For the first time, companies had the opportunity to exhibit their products at the conference. Ramtrom Corporation, Radiant Technologies, Gordon and Breach Science Publishers, MKS Instruments, and PlasmaQuest availed themselves of this opportunity.

At the general meeting called by the ISIF Advisory Board, by-laws were presented for acceptance at the following ISIF after having been reviewed by a legal counsel.

Gordon and Breach published the proceedings in *Integrated Ferroelectrics*, with Angus Kingon as guest editor.

**ISIF 96**

The recommendation of the ISIF Advisory Committee to hold the conference at a different venue resulted in choosing the Tempe Mission Palm Hotel in Tempe, Arizona, as the site of the 8th ISIF from 17 - 20 March. Sixty percent of the 256 participants came from academia, 40 percent from industrial communities. They highlighted ferroelectrics research and application efforts in the following countries: 29 attendees coming from Japan, 19 from Korea, 3 from China,10 from Germany, 2 each from Canada and France, and 1 each from Italy, Switzerland, Belgium, and Australia, with the major portion coming from the United States. During the previous years, the number of abstracts had climbed steadily. ISIF 96 followed that trend with a record total of 135 papers (five plenary talks, 20 invited talks, 73 contributed papers, and 37 posters). The poster session was again a success and became a standard feature in the following conferences. Due to financial constraints which limited travel budgets, 17 authors did not present their papers: 10 from Russia, 2 from India, and 1 each from Ukraine, France, The Netherlands, Japan, and Korea.

As in previous years, the proceedings were published by Gordon and Breach Science Publishers. Guest editors were Sandwip K. Dey, Bradley M. Melnick, and Deborah J. Taylor. The tutorials, held on Sunday between 1:00 and 6:00 pm under the direction of Dr. Ramesh, covered ferroelectric materials, ferroelectric thin films, process integration, and testing. Twenty-five participants enrolled and profited from the instruction by L. Eric Cross, Joseph T. Evans, Lee Kammerdiner, and Bruce Tuttle.

## HISTORY

The corporate exhibits of PlasmaQuest, Ramtrom Corporation, Symetrix Corporation, Gordon and Breach Publishers, Radiant Technologies, and MKS Instruments were housed in a separate building, which diminished the opportunity for close contact with conference attendees.

**ISIF 97**

The venerable La Fonda Hotel in Santa Fe, New Mexico, was the meeting place for the 9th ISIF on 2 - 5 March 1997. The 1997 meeting was the largest to date with respect to both the number of abstracts submitted (161) and the number of attendees. With 290 paid registrations, the number of participants climbed close to a record 300. Of the 144 presentations the strongest contingent came from the United States (82), followed by Japan (28), Korea (17), Germany (6), and several each from Italy, Switzerland, France, Belgium, England, Canada, Australia, and China. Fifty-six presentations were accommodated in poster sessions on Monday and Tuesday afternoon. Duane Dimos and Bruce A. Tuttle served as technical program chairmen and guest editors of the proceedings published in *Integrated Ferroelectrics.* Accelerated growth was also evident in the number of exhibitors, which grew from six in 1996 to 10 in 1997.

Maturation, the leitmotif of ISIF 97, showed not only in increased numbers but also in the predominance of industrially sponsored research in the main technology areas (NVRAMs and DRAMs), especially in the Far East, as opposed to the federally funded research that drove the field several years ago. In addition, the presentations demonstrated the wide variety of applications being developed based on perovskite thin films. These applications included integrated decoupling capacitors, tunable microwave capacitors, piezoelectric devices, and integrated pyroelectric detectors. The increased understanding of the physical properties of these materials, such as fatigue and imprint, the device integration issues, and the wide range of available fabrication techniques helped move the application development efforts forward.

All these factors contributed to a general atmosphere of confidence in the ability to successfully accomplish the next step. Alona Miller reported favorable, even enthusiastic, feedback from the participants. □

### *CORRECTION IN PIEZOELECTRICITY AND PYROELECTRICITY DATABASE ANNOUNCEMENT*

In the fall 1997 issue of the *Ferroelectricity Newsletter* (Vol.V, No. 4) page 10, there were two typographical errors.
The correct URL is:

**http://www.gbhap-us.com/c3/lit_guide/**

The correct fax number is:

**+972-7-6472916**

### *ISIF 98 PAPERS*

*Y. Fukuda, T. Sakoda, and K. Aoki*

Imprint in Ferroelectric $SrBi_2Ta_2O_9$ Capacitors for Nonvolatile Memory Applications
*M. Grossmann, O. Lohse, M. Schumacher, R. Waser, W. Hartner, G. Schindler, and N. Nagel*

Nanometer-Scale Domain Dynamics in Ferroelectric Thin Films
*C. Hubert, Jeremy Levy, A.C. Carter, W. Chang, S.W. Kirchoefer, J.M. Pond, J.S. Horwitz, and D.B. Chrisey*

A Method for Improving Leakage Current Characteristics of $Ba_{0.5}Sr_{0.5}O_3$ Films Using Plasma Surface Treatment
*H.J. Cho, C.S. Kang, S. Oh, C.S. Hwang, B.T. Lee, K.H. Lee, H. Horii, W.D. Kim, S.I. Lee, and M.Y. Lee*

A New Circuit for Measuring Ferroelectric Polarization and Current Response to an Applied Voltage
*A.D. DeVilbiss*

Changes in Domain Structure in Hard PZT Observed Using Atomic Force Microscopy
*Z. Wang and J. Blendell*

Microscopic Observation of "Region by Region Polarization Domains Freezing during Polarization Fatigue of the Pt/PZT/Pt System
*E.L. Colla, D.V. Taylor, A.K. Tangatsev, and S. Hong*

A Time-Independent Model for Simulating Switching Current and Hysteresis Characteristics of PZT Thin Film Ferroelectric Capacitors
*A. Bartic, D.J. Wouters, and H.E. Maes*

# ISIF 98 PAPERS

Pulse Polarization Measurements of Ferroelectric $Pb(Zr,Ti)O_3$ Thin Film Capacitors
*T.K. Song, S. Aggarwal, J. Ahn, and R. Ramesh*

Characterization of Bi-Layered Ferroelectric Capacitors
*A.-S. Lee, E.-Y. Kang, Y.-K Baek, J.-S. Lee, D.-H. Lee, I.-S. Hwang, J. Cuchiaro, V. Joshi, L. McMillan, and C.A. Paz de Araujo*

Investigation of Fatigue and Imprint Behavior at Elevated Temperatures in Layered Perovskite Films
*A.D. DeVilbiss, V. Joshi, N. Solayappan, and C.A. Paz de Araujo*

An Accelerated Reliability Test for Retention after Fatigue in Ferroelectric Memory Devices
*D. I. Dalton and T. D. Hadnagy*

Detection of Internal Electric Fields in $(Ba,Sr)_xTiO_{2+x}$ Thin Films by Optical Second Harmonic Generation
*L.D. Rotter and D.L. Kaiser*

Synchrotron XRD Study on Domain Formation and Switching in Epitaxial PLZT Thin Films
*K.-S. Lee, and S. Baik*

High Intensity Electron Emission from Ferroelectrics
*H.W. Gundel*

**NVFRAMs and Materials**

Modification of Dielectric and Ferroelectric Properties in Heteroepitaxial BST Films for Memory Applications
*K. Abe, N. Yanase, K. Sano, M. Izuha, N. Fukushima, and T. Kawakubo*

Recent Progress in Ferroelectric Nonvolatile Memory Technology with Bismuth-Layer Structured Thin Films
*T. Nasu, T. Otsuki, E. Fujii, Y. Shimada, M. Azuma, Y. Uemoto, S. Hayashi, K. Arita, Y. Nagano, Y. Izutsu, K. Nakao, K. Tanaka, Y. Judai, K. Hirano, T. Ito, T. Mikawa, and T. Kutsunai*

Ultra-Thin Encapsulated Barrier Layer for FRAM Devices
*Y.-K. Kim, I.-S. Park, S.-M. Lee, C.-S. Park, C.-Y. Yoo, S.-I. Lee, and M.-Y. Lee*

Ferroelectric Characteristics of Pt/$Pb(Zr,Ti)O_3$/Pt/$TiO_2$ Capacitor with $PbTiO_3$ Seed Layer in a 64k FRAM Device
*H.-B. Park, S. Oh, B.-H. Kim, S.-J. Oh, Y.-T. Lee, M.-H. You, S.-H. Joo, J.-H. Lee, C.-Y. Yoo, and S.-I. Lee*

Addition of Ca and Sr in PLZT to Improve FRAM® Performance and Reliability
*D. Hadnagy and T. Davenport*

Imprint and Fatigue Properties of PLZT Thin Films as a Function of Top Electrode Material
*S.-H. Kim, D.-J. Kim, J.-G. Hong, S.K. Streiffer, and A.I. Kingon*

$SrRuO_3$ Films for Use as Electrodes with PZT
*J.S. Cross, M. Fujiki, T. Sakai, and M. Tsukada*

Influence of Ferroelectric Processing on CMOS in FeRAM
*E.Y. Kang, S.W. Lee, S.K. Hong, J. Lee, and D.H. Lee*

Degradation of Electrical Properties due to Fatigue in Pb-Based Ferroelectric Capacitors
*O. Lohse, D. Bolten, M. Grossmann, M. Schumacher, and R. Waser*

Influence of Niobium Doping on the Switching Dynamics of PZT Thin Film Capacitors
*I. Jenkins, S. Aggarwal, T.K. Song, and R. Ramesh*

Low Voltage PZT-Based Films
*L. Boyer and J. Evans*

Ferroelectric Memory Cell for 4~16Mbit FRAM
*N. Izumi, Y. Fujimori, T. Nakamura, and A. Kamisawa*

The Characteristics of PZT/STO/Si Thin Films for MFIS Structure by RF-Magnetron Sputtering
*S.-T. Park, D.-S. Shin, and I.-H. Choi,*

Crystallography and Texture Engineering of $SrBi_2Ta_2O_9$ Thin Films
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# HISTORY

## *A 20TH ANNIVERSARY AT TVER UNIVERSITY*

Last year the **Department of Physics of Ferroelectrics and Piezoelectrics** at Tver State University in Russia celebrated 20 years of existence. It was founded in 1977 by Professor Vladimir M. Rudyak.

The two main objectives of the Department are:
1. Training of specialists in condensed matter and
2. Research in ferroelectrics, piezoelectrics, and ferroelastics.

The educational branch offers theoretical courses to prepare students for independent research and provides teaching laboratories covering dielectrics and piezoelectrics, ferroelectrics, and ferroelectric semiconductors. A number of postgraduate fellowhips are available at the Department each year.

The Department publishes an annual collection of scientific articles, called ***Ferroelectrics and Piezoelectrics***, where not only Tver scientists but also researchers from all over Russia present their papers.

The Department's main research is carried out in the following five areas:

**1. Barkhausen Effect in Ferroelectrics and Ferroelastics**

The founder of this field is V.M.Rudyak (1928-1996). Department Head V.V. Ivanov together with T.I. Ivanova, A.A. Bogomolov, and N.N. Bolshakova continue this research. Viscosity phenomena in ferroelectrics and ferroelastics, and the effect of domain mechanism on switching characteristics of ferroelectric crystals are investigated in a broad temperature range. The correlation between the Barkhausen Effect and elements of hysteresis loop in ferroelectrics and ferroelastics is also studied.

**2. Electrical Conduction of Ferroelectrics**

V.V. Ivanov researches the electrical conduction properties of ferroelectrics, the effect of illumination on switching properties of ferroelectric semiconductors and the physical properties of polycrystal ferroelectrics with diffuse phase transition .

**3. Pyroelectric Properties of Ferroelectrics**

A.A. Bogomolov, O.V. Malyshkina, O.N. Sergeeva and A.V. Solnyshkin are investigating the relation between nonlinear pyroelectric effects resulting from exposure of crystals to intensive heat fluxes and switching processes; the effects of temperature gradient on polarization of surface layer; and the pyroelectric properties and nonstationary photocurrents of $Sn_2P_2S_6$ films.

**4. Domain Structure of Ferroelectrics and Ferroelastics**

N.N. Bolshakova and N.N. Chereshneva are conducting research on the realignment processes of domain structure and phase transition in ferroelectrics and ferroelastics, as well as the effects of temperature gradient and stress on switching processes in ferroelastics.

**5. Optic and Electrooptic Properties of Ferroelectrics**

B.B. Ped'ko studies new memory effects in photorefraction crystals of $LiNbO_3$, the kinetics and temperature behavior of optic inhomogeneity in crystals and the effect of compounds on these characteristics. A new method of investigation of physical effects described by tensor, e.g., piezoeffect, is being developed.

## HISTORY

In 1993 the **Laboratory of Science Technologies and Equipment**, headed by V.P. Kamentsev and B.B. Ped'ko, was formed as an offshoot of the Research Laboratory of the Department.

The main areas of research at the Laboratory are the investigation of ferroelectric solid solutions, as well as engineering and production of equipment based on piezoelectric materials:

- Diffuse phase transition in some ferroelectric solid solutions
- Methods for determination of the best process variable of piezoelectric materials polarization
- Design of ionizer and ionizer-ozonizer of air (both individual and collective) and electrostatic filters with decreased energy expenditure based on piezoelectric transducers
- Design and implementation of technologies and equipment for ultrasound welding and cutting of thermoplasticity materials
- Design of ultrasound equipment for pulverization of water.

A database containing information on scientific research developments in the Tver area was created as one of the Laboratory projects. Research results are presented at Russian and foreign exhibitions, especially in England, France, Germany, and Italy, and are published in German and French professional journals.

-- *O.V. Malyshkina*

### *FREE COPY OF THE 1998 MRS PUBLICATIONS CATALOG NOW AVAILABLE*

The *1998 Materials Research Society Publications Catalog*, containing more than 525 books, plus videotapes, database and journals--all exploring interdisciplinary research on advanced materials--is now available. The new catalog features:

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# UPCOMING MEETINGS

## Short Course on Ferroelectrics and Their Applications
## 29 March - 3 April 1998
## Cranfield University, Cranfield, England

This course has been set up to give engineers and scientists using or wishing to use ferroelectric materials the opportunity to develop their knowledge under the tutelage of some of the world's leading figures in this technology.

**Scope**

- To provide an understanding of how ferroelectrics can be used in a wide range of applications, and to relate the requirements of these applications to the basic structures and properties of materials.
- To provide a firm grounding in the basic properties of the materials and how they relate to crystal structure and materials form.
- To review the properties of, and fabrication/characterization techniques for, ferroelectrics, especially in ceramic and thin film forms with reference to specific materials examples.
- To survey major current emerging applications for ferroelectrics and relate them to specific examples.
- To discuss the rationale for selecting particular materials.
- To provide a forum to discuss future trends in the application of ferroelectrics and major materials issues affected.

**Topics**

- Introduction to ferroelectrics
- Tensor properties of materials
- Ferroelectric structures
- Ferroelectric ceramics
- Ferroelectric polymers and ceramic/polymer composites
- Ferroelectric oxide thin films
- Dielectric applications
- Piezoelectric applications
- Pyroelectric applications
- Ferroelectric microstructures
- Ferroic domains
- Defects and conduction
- Future trends

Example and practical classes will be used to teach:

- Tensors
- Characterization of materials' properties (piezoelectric, dielectric, pyroelectric, electrooptic)

**Written Assignment**

A post-course written assignment will be set on a topic to be selected by each student from a given list.

**Total Course Duration**

40 hours of teaching, consisting of 24 hours of lectures, 6 hours of examples classes plus 6 hours of practical classes. The course will start on a Sunday evening and finish on the following Friday afternoon.

**Course Tutors**

Prof. L. Eric Cross, Evan Pugh Professor of Electrical Engineering, Pennsylvania State University, USA
*Dielectrics, Ferroics Domains, Future Trends*

## UPCOMING MEETINGS

Dr. David A. Hall, Lecturer in Materials Science (Ceramics), University of Manchester Materials Science Center
*Piezoelectric Materials and Devices*
Dr. Caroline Millar, Electroceramics Group Leader, GEC Marconi Materials Technology. Caswell
*Piezoelectric Actuators and Other Devices*
Dr. Michael W. Darlington, Reader in Polymer Physics and Engineering, Cranfield University
*Tensors*
Dr. Jeffrey Alcock, Lecturer in Advanced Materials, Cranfield University
*Ceramics Fabrication*
Dr. Rainer Waser, Professor of Materials Science, University of Aachen
*Defects and Conduction in Ferroelectrics*
Prof. David J. Barber, F. Inst. P, F.I.M., Visiting Professor, Cranfield University
*Ferroelectric Microstructures*
Dr. Anil Patel, Research Scientist, GEC Marconi Infrared, Caswell
*Ferroelectric Thin Films*
Mr. R. Watton, Consultant
*Pyroelectric Thermal Imaging*
Prof. Roger W. Whatmore (Course Director), Royal Academy of Engineering Professor of Engineering Nanotechnology, Cranfield University
*Piezoelectric and Pyroelectric Materials and Devices*

**Contact**

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### The Dielectrics Society 29th Annual Conference: Anisotropic Dielectrics and Ferroelectrics
and
### The 4th UK Transducer Materials and Transducers Workshop
### 6 - 9 April 1998
### Rutherford College, University of Kent at Canterbury

This conference will cover both dielectric interfaces and ferroelectric and magnetostrictive materials and their application.

**Topics**

- Dielectric interfaces and composite materials
- Ferroelectric materials (ceramics and thin films), applications especially in sensors and transducers

**Contact**

Dielectrics Society: Dr. J.C. Fothergill, Leicester University, Engineering Department, Leicester, LEI 7RH, UK
phone: +44 (0) 116-252-2569; fax: +44 (0) 116-252-2619; e-mail: jcf@le.ac.uk

4th UK Transducer Materials and Transducers Workshop: Dr. S.W. Mahon, Structural Materials Centre, Griffith Building (A7), DERA, Farnborough, GU14 0LX, UK

**Conference Web Site**

**http://www.le.ac.uk/eg/jcf/dielectrics/**

# UPCOMING MEETINGS

## 16th Conference on Crystal Growth and Epitaxy
## 7 - 10 June 1998
## Stanford Sierra Camp, Fallen Leaf Lake, California

**Session Chairs and Session Topics**

- Terry Land (LLNL), *Surface Dynamics*
- Peter Bordui (CTI), *Oxides*
- Andy Allerman (Sandia), *Narrow Gap Materials*
- H.P. Gillis (UCLA) & J. Speck (UCSB), *Wide Gap Materials*
- Bill Bonner (Crystallod), *Melt Growth/Semiconductors*
- Jim De Yoreo (LLNL), *In-situ Characterization*
- K.A. Jackson, *Kinetics*
- A. Ostragorsky, *Organic Materials*
- A. Clawson, *Thin Films/Epitaxy*

**Conference Chair**

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**Local Arragnements Chair**

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**Conference Web Site**

**http://www.aml.arizona.edu/aacg/aacghome.html**

### *IT MIGHT INTEREST YOU…*

In Volume 6, Issue 2 of *Condensed Matter News*, Editor-in-Chief Patrick Bernier announced that the focus of the magazine is shifting toward the nanoworld, where matter becomes aggregate, nanostructure, or molecule.

He goes on to say that editorial policy will encourage overviews which try to close the gap between basic research and industrial research. He states, "We will also encourage the publication of reports on the situation of research or education (in the field of Condensed Matter) in selected areas in the world and, in particular, in developing countries."

# CALENDAR OF EVENTS 1998

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| Apr 12-16 | • | 5th International Symposium on Ferroic Domains and Mesoscopic Structures (ISFD-5), University Park, Pennsylvania (see *Ferroelectricity Newsletter*, Vol. 5, No. 3, p. 11) |
| May 3-8 | • | Conference on Lasers and Electrooptics (CLEO '98), San Francisco, California, USA<br>Contact: OSA Conference Services, 2010 Massachusetts Ave. NW, Washington, DC 20036-1023, USA; phone: +202-223-0920; fax: +202-416-6100; http://www.osa.org |
| May 27-30 | • | 15th Meeting on Ferroelectric Materials and Their Applications (FMA-15), Kyoto, Japan (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 12) |
| Jun 1-6 | • | 10th International Summer School on Crystal Growth (ISSCG-10), Rimini, Italy<br>Dr. R. Fornari, MASPEC-CNR Institute, Via Chiavari 18/A, 43100 Parma, Italy<br>phone: +39-521-269201; fax: +39-521-269206; e-mail: fornari@maspec.bo.cnr.it<br>http://www.maspec.bo.cnr.it/CG/school_cg.html |
| Jun 23-26 | • | 2nd International Seminar on Relaxor Ferroelectrics (ISRF-II), Dubna, Russia (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 12) |
| Jul 19-22 | • | Innovations in Materials Conference (IMC), Washington, DC, USA (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 13) |
| Jul 26-31 | • | 12th International Conference on Crystal Growth and 10th International Conference on Vapor Growth and Epitaxy, Jerusalem, Israel (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 14) |
| Aug 24-27 | • | 11th International Symposium on Applications of Ferroelectrics (ISAF XI), European Conference on Applications of Polar Dielectrics (ECAPD IV), and Electroceramics VI, Montreux, Switzerland (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 15) |
| Aug 24-27 | • | 4th International Conference on Electronic Materials (IUMRS-ICEM-98). Cheju, Korea (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 16) |
| Sep 20-23 | • | 3rd International Meeting of Pacific Rim Ceramic Societies (PacRim 3), Kyongju, Korea (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 17) |
| Oct 5-7 | • | 4th International Conference on Intelligent Materials (ICIM'98), Chiba, Japan (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 16) |
| Dec 8-11 | • | 2nd Asian Meeting on Ferroelectrics, International (AMF-2), Singapore (see *Ferroelectricity Newsletter*, Vol. 5, No. 4, p. 18) |

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