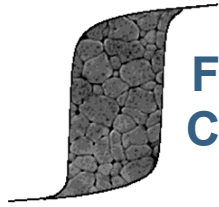


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## GLEN R. FOX - PRESIDENT

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**Fox Materials  
Consulting, LLC**

7145 Baker Road  
Colorado Springs, CO 80908  
Tel : (719) 332-9823  
Email: glen\_fox\_pa@msn.com

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### BACKGROUND SUMMARY

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Dr. Glen R. Fox is the President of Fox Materials Consulting, LLC, which was established in 2007. The company provides engineering consulting services for the research and development of electronic materials and specializes in providing information and guidance on the mass production, materials processing, testing, and reliability of ferroelectric materials for integrated devices such as ferroelectric random access memory (FRAM), pyroelectric based infrared imaging arrays and piezoelectric sensors and actuators. Consulting services are founded on a scientific basis as well as from practical process, test and design methods gained from experience in manufacturing environments. The company mission is to provide up-to-date information through written reports, presentations and data analyses to aid start-up and established manufacturers of integrated devices that use or want to introduce ferroelectric and piezoelectric materials into their products. Related experience and qualifications for Dr. Fox include:

- 35+ years experience with integrated semiconductor and ferroelectric processing.
- 13 years management experience in research and product development.
- experience with managing projects with annual budgets in excess of \$5,000,000.
- directed development of first commercial high density ferroelectric memory product.
- worked at and collaborated with industrial, academic and government institutions.
- managed multicultural projects within, Europe, Asia and the United States.
- experience with semiconductor processing and test fab equipment and flow design.
- direct experience with materials and device modeling and design.
- 16 patents issued for integrated ferroelectric devices and processes.
- more than 80 scientific publications.

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### EDUCATION

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**Ph.D., SOLID STATE SCIENCE**, The Pennsylvania State University **1992**

*Thesis: Composition/Structure/Property Relations of Ferroelectric Lead-Lanthanum-Titanate (PLT) Thin Films Deposited by Multi-Ion-Beam Reactive Sputtering (MIBERS).*

**B.S., CERAMIC SCIENCE AND ENGINEERING**, The Pennsylvania State University **1987**  
**Graduated – With Distinction**

*Thesis: Coprecipitation of PbTiO<sub>3</sub> Nanocomposite Fillers for Electro-Optic Composites.*

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**WORK EXPERIENCE**

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**FOX MATERIALS CONSULTING, LLC**, Colorado Springs, CO**2007 – pres.****President/Owner (Jan. 2007 – pres.)**

- provide domestic and international consulting services for the development of electronic materials.
- specialize in mass production, materials processing, testing, and reliability of ferroelectric materials for integrated devices such as ferroelectric random access memory (FRAM), pyroelectric detectors, and piezoelectric sensors and actuators.
- developed a multinational clientele of more than 30 companies and institutions including small start-up and large multinational companies and academic and government.
- collaborate with approximately 20 companies, universities and national laboratories in addition to clientele.
- aided piezoelectric MEMS device processing, characterization, and manufacturing development at 11 companies for applications in medical ultrasound, acoustic sensing/emission, inertial sensing, microfluidics, optical scanning, and RF communications.
- consulted on non-volatile memory development for 5 companies including memories based on PZT, SBT, HfO<sub>2</sub> and doped-AIN.
- aided development of pyroelectric infrared imaging devices at two companies.
- provided marketing and equipment development consulting for two semiconductor process equipment manufacturers.
- consulted on a \$6,000,000 micro-electromechanical systems (MEMS) process equipment upgrade for the Army Research Laboratory and continue to consult on piezoelectric MEMS materials and device development.
- Consulted for the Army Research Laboratory since 2009 and assisted development of piezoMEMS processes and devices including RF switches and resonators.

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**, Arlington VA**2018 – 2021****Science and Engineering Advisor**, subcontractor under ECS **(Jan. 2018 – Oct. 2021)**

- Initiated and aided development and monitoring of the Tunable Ferroelectric Nitrides SBIR program that funded 5 university research projects resulting in demonstration of novel dope-AIN ferroelectric devices.
  - Aided the development and monitoring of the SBIR PiezoMEMS PDK program that funded 3 companies developing standardized piezoelectric MEMS manufacturing processes.
  - Aided the monitoring of the Ultrathin Dielectric Elastomer Actuator Fibers and Actuators program.
  - Supported the Short-Range Independent Microrobotic Platforms program.
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**THE PENNSYLVANIA STATE UNIVERSITY**, University Park, PA

**2007 – pres.**

**Adjunct Scientist, Materials Research Institute (May 2007 – pres.)**

- developed user facility process control documentation and recommended new equipment for improved operation of the PSU Nanofabrication Facility - National Nanotechnology Infrastructure Network and the Keck Materials Research Lab.
- consulted on process flow and test methods for devices incorporating complex oxides.
- consulted on the development of integrated PZT mirror actuators for X-ray telescope in collaboration with the Smithsonian Astrophysical Observatory.

**UNIVERSITY OF COLORADO**, Colorado Springs, CO

**2011 – 2017**

**Adjunct Professor, Department of Electrical Engineering (Mar. 2011 – 2017)**

- developed memory cell architecture and process integration flow for correlated electron memories (CeRAM) and FRAM.
- granted access to US Air Force Academy research facilities through a UCCS CRADA and advised cadets on research projects.

**RAMTRON INTERNATIONAL CORPORATION**, Colorado Springs, CO

**1997 – 2006**

**Director, High Density FRAM Development (Jan. 2005 – Oct. 2006)**

- directed process development, design, test development, product and reliability teams for qualification of the first commercial 2 Mb, 4 Mb and 8 Mb non-volatile ferroelectric random access memory (FRAM) products.
- directed qualification of the 4 Mb FM22L16 product, winner of the Electronics Design News China's Industry Innovation Award – Digital IC and Digital Logic Category.
- managed a multi-disciplinary group of 6 engineers and scientists for the development of high density lead zirconate titanate (PZT) based FRAM products using the Texas Instruments 130 nm CMOS production line.
- led FRAM joint development and foundry relations with Texas Instruments.

**Manager, High Density FRAM Development (Aug. 2001 – Dec. 2004)**

- directed a FRAM joint development program with Texas Instruments, which successfully demonstrated FRAM test chips ranging from 256 kb to 64 Mb densities produced from a 130 nm CMOS production line.
  - responsible for coordinating package and wafer level functional, parametric and reliability testing.
  - developed chemical and physical analysis methods and models that explain bit level electrical failure mechanisms observed in FRAM.
  - worked with engineers to determine process and integration solutions for MOCVD deposited ferroelectric capacitors embedded within a 5-level metal Cu/FSG process.
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- developed mathematical models for ferroelectric capacitor performance that could predict temperature dependent signal margins for memory operation and reliability.
- developed X-ray diffraction and electron backscatter diffraction techniques for process control and crystallographic texture quantification of electrode and ferroelectric materials.

#### **Sr. Materials Scientist (Oct. 1997 – Jul. 2001)**

- project leader for development of mass production electrode (Ir, IrO<sub>x</sub> and Pt) and ferroelectric PbZr<sub>x</sub>Ti<sub>1-x</sub>O<sub>3</sub> thin film sputter deposition processes for commercialized FRAM at the 0.5 μm and 0.35 μm CMOS process nodes.
- principle engineer for multiple FRAM technology transfer programs with several major Japanese semiconductor companies including Fujitsu, ULVAC, and Toshiba.
- initiated and managed Ramtron Thin Film Foundry services and worked with customers to organize technology development programs for microwave dielectric, tunable dielectric, piezoelectric, pyroelectric and electrooptic integrated device applications.
- managed X-ray diffraction facilities and developed new quantitative X-ray characterization techniques for ferroelectric and electrode thin film analysis.
- extensive experience with electrical property analysis and process/property modeling for dielectric and electrode thin film materials.

**École Polytechnique Fédérale de Lausanne**, Lausanne, Switzerland    **1993 - 1997**

#### **Assistant Professor/Senior Research Associate, Laboratory of Ceramics**

- managed a group of researchers and several research projects focused on the fabrication and characterization of piezoelectric and ferroelectric materials for applications in microelectronics, micro-electro-mechanical systems (MEMS) and active optical fiber devices.
  - developed research projects on processing and properties of ferroelectric and electrode thin and thick films.
  - wrote proposals resulting in research grants of more than \$700,000 from the European Union, Swiss Priority Program, and Swiss National Science Foundation.
  - taught courses on joining and bonding of materials, glass science and laboratory practice.
  - designed and built a multi-magnetron sputtering system for depositing multi-component thin films.
  - deposited piezoelectric coatings of ZnO and PbZr<sub>x</sub>Ti<sub>1-x</sub>O<sub>3</sub> onto optical fibers and prepared integrated acoustooptic phase modulation and wavelength tunable optical fiber devices.
  - developed a combined sputtering and fugitive phase method for fabricating 10 μm diameter micro-tubes of ZnO, PbZr<sub>x</sub>Ti<sub>1-x</sub>O<sub>3</sub>, and metal/ceramic multilayers.
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**THE PENNSYLVANIA STATE UNIVERSITY**, University Park, PA **1987 - 1992**

**Research and Teaching Assistant, Materials Research Laboratory**

**OAK RIDGE NATIONAL LABORATORY**, Oak Ridge, TN **Nov. 1990**

**Aug. 1991**

**Invited Researcher, High Temperature Materials Laboratory  
Electron Microscopy Facility**

**Oct. 1991**

**IBM CORPORATION**, Yorktown Heights, NY **Summer 1986**

**Summer 1987**

**Ceramic Research Scientist, T.J. Watson Research Center**

**GENERAL MOTORS CORPORATION**, Flint, MI **Summer 1985**

**Ceramic Research Engineer, AC Spark Plug Division**

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## **GOVERNMENT CONTRACTS**

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Cooperative Agreement No. W911NF2020160, US Army Research Laboratory, Adelphi, MD, "Integrated Piezoelectric Microelectromechanical Systems Program Description Section II A. 2. k. Position, Navigation and Timing (PNT)," July 27, 2020 – July 26, 2023.

Cooperative Agreement No. W911NF-15-2-0118, US Army Research Laboratory, Adelphi, MD, "Piezoelectric Microelectromechanical Systems (PiezoMEMS) Technology," September 16, 2015 – July 31, 2020.

Cooperative Agreement No. W911NF-11-2-0053, US Army Research Laboratory, Adelphi, MD, "Sensors, Actuators and Micromechanics," August 1, 2011 – September 15, 2015.

SHARE Project ID: 2011\_Fox\_81, Oak Ridge National Laboratory, Materials Science and Technical Division, "Study of Nano-scale Seed Layers for Textured Electrodes Used in PZT Based Piezoelectric MEMS and Ferroelectric Thin Film Devices," July 1, 2011 – June 30, 2013.

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## **SHORT COURSES**

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"Processing and Characterization Challenges for Integrated Ferroelectric/Piezoelectric Devices," IEEE International Ultrasonics Symposium, Orlando, Florida, 2011.

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**INVITED/PLENARY CONFERENCE PRESENTATIONS**

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“Investigation of Non-Volatile Memory Behavior in PZT MEMS Cantilever Switches,” International Symposium on Applications of Ferroelectrics (ISAF) included in IFAAP 2018 Joint Conference, Hiroshima, Japan, 2018.

“Seed Layer TiO<sub>2</sub> Structure Impact on {111}-Textured Pt Electrodes for PZT Devices,” The American Ceramic Society, Electronic Materials and Applications 2014, Orlando, Florida, 2014.

“Lessons Learned on Integration of PZT and How They Are Characterized,” 3<sup>rd</sup> International PiezoMEMS Workshop, Washington D.C., 2013.

“Review of FRAM Technology and Comparison with Other Non-Volatile Memory Technology,” IEEE International Symposium on the Applications of Ferroelectrics, Edinburgh, Scotland, 2010.

“Ferroelectric Integration and Contamination Control Methods Developed for Ferroelectric Memories,” Government Microcircuit Applications and Critical Technology Conference, Reno, Nevada, 2010.

“Ferroelectrics and High Density Memory Technology,” International Symposium on Integrated Ferroelectrics and Functionalities, Colorado Springs, Colorado, 2009.

“Ferroelectric Memories,” Center for Nanoscale Systems Annual Nanotechnology Symposium – Nanoscale Memories and Their Use in Systems, Cornell University, Ithaca, New York, 2009.

“Advanced FeRAM – Prospects for Nanostructures,” International Symposium on Integrated Ferroelectrics, plenary presentation, Singapore, 2008.

“Processing and Characterization Challenges For Integrated Ferroelectric Devices – Lessons Learned From FRAM Production,” DARPA Piezoelectric MEMS Workshop, San Francisco, 2008.

“Thin Film Texture and Scaling Effects in Ferroelectric Random Access Memory,” Gordon Research Conference on Solid State Studies in Ceramics, Andover, New Hampshire, 2006.

“Non-Volatile FRAM – Current Production Status and Near-Term Scaling Challenges,” Materials Research Society Workshop on Physics and Chemistry of Switching in Condensed Matter, San Francisco, California, 2005.

“Commercial Status of FRAM and Roadmap for Scaling,” Semiconductor Research Council, Non-Volatile Memory Forum, Palo Alto, California, 2004.

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“FRAM - Where Are We? / What’s Next?” International Symposium on Integrated Ferroelectrics, Gyeongju, Korea, 2004.

“Model Relating Thin Film PZT Crystallographic Texture to Ferroelectric Switching Performance,” Materials Research Society Spring Meeting, San Francisco, California, 2002.

“Material Processing Requirements for Ferroelectric Non-Volatile Memory (FRAM) Technology,” The 10<sup>th</sup> US-Japan Seminar on Dielectric and Piezoelectric Ceramics, Providence, Rhode Island, 2001.

“Current and Future Ferroelectric Non-Volatile Memory (FRAM) Technology,” International Conference on Microelectronics and Interfaces, Santa Clara, California, February, 2001.

“Ferroelectric Non-Volatile Memories (FRAM),” Center for Dielectric Studies, The Pennsylvania State University, October, 2000.

“Challenges in Mass Production of PZT for Non-Volatile Ferroelectric Random Access Memories,” International Conference on Metallurgical Coatings and Thin Films, San Diego, California, April, 2000.

“Applications of Active Thin Film Coatings on Optical Fibers,” Materials Research Society Fall Meeting, Boston, Massachusetts, November, 1996.

“Piezoelectric Coatings for Active Optical Fiber Devices,” 3<sup>rd</sup> European Conference on Applications of Polar Dielectrics,” Bled, Slovenia, August, 1996.

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## HONORS

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2007 Electronics Design News, China’s Industry Innovation Award – Digital IC and Digital Logic Category, awarded for the FM22L16 4Mb FRAM memory chip.

2005 IEEE Custom Integrated Circuits Conference Best Regular Paper Award for “An 8Mb 1T1C Ferroelectric Memory with Zero Cancellation and Micro-Granularity Redundancy.”

1987 XEROX Research Award for outstanding work in materials research.

Keramos Ceramic Engineering Honors Fraternity.

National Institute of Ceramic Engineers.

Institute of Electrical and Electronics Engineers – Senior Member.

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**PROFESSIONAL ACTIVITIES:**


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**IEEE, Ferroelectrics Technical Committee** 2004 – pres.  
 Ultrasonics, Ferroelectrics and Frequency Control Division

**IEEE ISAF Technical Program Committee – member** 2010 – 2014, 2022  
 Ultrasonics, Ferroelectrics and Frequency Control Division

**IEEE Administration Committee – Historian** 2011 – 2016  
 Ultrasonics, Ferroelectrics and Frequency Control Division

**IEEE Administration Committee – elected member** 2009 – 2011  
 Ultrasonics, Ferroelectrics and Frequency Control Division

**IEEE Standards Committee – Co-Chair** 2004 – 2015  
 Ferroelectrics and Related Materials

**Microsystems Technology Office Review Committee** 2018 – 2021  
 DARPA

**Panel Member/Reviewer** 2002 – 2015  
 National Science Foundation

**Advisory Board Member** 2002 – 2006  
 International Symposium on Integrated Ferroelectrics

**Review Committee Member** 2002 – 2004  
 Solid State Device Meeting

**Publication Referee** 1993 – pres.  
*Journal of Applied Physics*                      *Applied Physics Letters*  
*Philosophical Magazine*                      *Journal of Materials Research*  
*Electroceramics*                                  *Journal of Materials Science*  
*IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*

**Society Memberships**

American Ceramic Society.

American Vacuum Society.

Materials Research Society.

Institute of Electrical and Electronic Engineers – Senior Member.

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**PATENTS**

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1. Glen R. Fox, Jeffrey S. Pulskamp, Ronald G. Polcawich, "Ferroelectric Mechanical Memory and Method," US Patent 9887205, Feb. 6, 2018.
  2. US 9,761,785, Glen R. Fox, Ronald G. Polcawich, Daniel M. Potrepka, Luz M. Sanchez, "Stylo-Epitaxial Piezoelectric and Ferroelectric Devices and Method of Manufacturing," Sept. 12, 2017.
  3. US 9,385,306, Glen R. Fox, Jeffrey S. Pulskamp, Ronald G. Polcawich, "Ferroelectric Mechanical Memory and Method," Jul. 5, 2016.
  4. US 8,866,367, Glen R. Fox, Ronald G. Polcawich, Daniel Potrepka, "Thermally Oxidized Seed Layers for the Production of {001} Textured Electrodes and PZT Capacitors," Oct. 21, 2014.
  5. US 7,344,939, Jarrod Randall Eliason, Glen R. Fox, and Richard A. Bailey, "Ferroelectric Capacitor with Parallel Resistance for Ferroelectric Memory," Mar. 18, 2008.
  6. US 7,108,141, Jarrod Randall Eliason, Glen R. Fox, and Richard A. Bailey, "Ferroelectric Capacitor with Parallel Resistance for Ferroelectric Memory," Feb. 20, 2007.
  7. US 6,964,873, Katsuyoshi Matsuura, Mari Tani, Yoshimasa Horii, Fan Chu, Glen R. Fox, and Brian Eastep, "Semiconductor Device Having a Ferroelectric Capacitor and a Fabrication Process Thereof," Nov. 15, 2005.
  8. US 6,887,716, Glen Fox, Fan Chu, Brian Eastep, Tomohiro Takamatsu, Yoshimasa Horii, Ko Nakamura, "Process for Producing High Quality PZT Films for Ferroelectric Memory Integrated Circuits," May 3, 2005.
  9. US 6,853,535, Glen Fox and Thomas Davenport, "Method for Producing Crystallographically Textured Electrodes for Textured PZT Capacitors," Feb. 8, 2005.
  10. US 6,728,093, Glen Fox, "Method for Producing Crystallographically Textured Electrodes for Textured PZT Capacitors," Apr. 27, 2004.
  11. US 6,682,772, Glen Fox, and Koukou Suu, "High Temperature Deposition of Pt/TiO<sub>x</sub> for Bottom Electrodes," Jan. 27, 2004.
  12. US 6,627,930, Glen Fox, Fan Chu, Brian Eastep, and Shan Sun, "Ferroelectric Thin Film Capacitors Having Multi-Layer Crystallographic Textures," Sep. 30, 2003.
-

13. US 6,597,028, Glen Fox and Thomas Evans, "Capacitively Coupled Ferroelectric Random Access Memory Cell and a Method for Manufacturing the Same," Jul. 22, 2003.
14. US 6,492,673, Glen Fox and Thomas Evans, "Charge Pump or Other Charge Storage Capacitor Including PZT Layer for Combined Use As Encapsulation Layer and Dielectric Layer of Ferroelectric Capacitor and a Method for Manufacturing the Same," Dec. 10, 2002.
15. US 6,376,259, Fan Chu, and Glen Fox, "Method for Manufacturing a Ferroelectric Memory Cell Including Co-Annealing," Apr. 23, 2002.
16. US 6,287,637, Fan Chu, Glen Fox and Brian Eastep, "Multilayer Approach for Optimizing Ferroelectric Film Performance," Sept. 11, 2001.

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## PUBLICATIONS

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1. N.A. Strnad, W.L. Sarney, G.B. Rayner, Jr., R.R. Benoit, G.R. Fox, R.Q. Rudy, T.J. Larrabee, J. Shallenberger, and J.S. Pulskamp, "Plasma Enhanced Atomic Layer Deposition of Textured Aluminum Nitride on Platinized Substrates for MEMS," *J. Vac. Sci. Technol. A* **40**, 042403 (2022); doi: 10.1116/6.0001633.
  2. R. Miyake, M. Kiuchi, S. Yoshida, S. Tanaka, G.R. Fox, "Commercial Production of Epitaxial PZT for Piezoelectric MEMS Applications," *Proc. IEEE International Frequency Control Symposium and International Symposium on Applications of Ferroelectrics (IFCS-ISAF)*, p46, paper no. 4106, (IEEE, 2020).
  3. M. Rivas, R.Q. Rudy, B. Sanchez, M.B. Graziano, G.R. Fox, P. Sunal, L. Nataraj, E. Sandoz-Rosado, A.C. Leff, B.D. Huey, R.G. Polcawich, and B. Hanrahan, "Iridium oxide Top Electrodes for Piezo- and Pyroelectric Performance Enhancements in Lead Zirconate Titanate Thin-Film Devices," *J. Mater. Sci.*, **55**, 10351–10363 (2020).
  4. D.M. Potrepka, M. Rivas, H. Yu, M. Aindow, G.R. Fox, and R.G. Polcawich, "Effect of IrO<sub>2</sub>/Pt, IrO<sub>2</sub>, and Pt bottom Electrodes on the Structure and Electrical Properties of PZT Based Piezoelectric Microelectromechanical System Devices," *J. Mater. Sci: Mater. Electron.* **29** (13), 11367–11377, <https://doi.org/10.1007/s10854-018-9224-8>, (2018).
  5. G.R. Fox, D.M. Potrepka, R.G. Polcawich, "Dependence of {111}-textured Pt Electrode Properties on TiO<sub>2</sub> Seed Layers Formed by Thermal Oxidation," *J Mater Sci: Mater. Electron.*, DOI 10.1007/s10854-017-7930-2, (2017).
  6. D.M. Potrepka, M. Rivas, H. Yu, R.G. Polcawich, M. Aindow, and G.R. Fox, "Characterization of IrO<sub>x</sub> Sputtering for IrO<sub>2</sub> and IrO<sub>2</sub>/Pt Bottom-Electrode Piezoelectric Micro-Electro-Mechanical Systems Applications," *Thin Solid Films*, **638**, 127-137 (2017).
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7. A.J. Fox, B. Drawl, G.R. Fox, B.J. Gibbons, and S. Trolier-McKinstry, "Control of Crystallographic Texture and Surface Morphology of Pt/TiO<sub>2</sub> Templates for Enhanced PZT Thin Film Texture," *IEEE Trans. Ultrason. Ferroelect., Freq. Control*, **62** (1) 56-61 (2015).
  8. L.M. Sanchez, D.M. Potrepka, G.R. Fox, I. Takeuchi, K. Wang, L.A. Bendersky, and R.G. Polcawich, "Optimization of PbTiO<sub>3</sub> Seed Layers and Pt Metallization for PZT Based PiezoMEMS Actuators," *J. Mater. Res.*, **28** (14), 1920-1931 (2013).
  9. L.M. Sanchez, D.M. Potrepka, G.R. Fox, I. Takeuchi and R.G. Polcawich, "Improving PZT Thin Film Texture Through Pt Metallization and Seed Layers," in *Microelectromechanical Systems – Materials and Devices IV*, (Mater. Res. Soc. Symp. Proc., Vol. 1299, Cambridge University Press, 2011) pp. 53-58, DOI: 10.1557/opl.2011.254
  10. D.M. Potrepka, G.R. Fox, L.M. Sanchez, and R.G. Polcawich, "Pt/TiO<sub>2</sub> Growth Templates for PZT Films and MEMS Devices", in *Microelectromechanical Systems – Materials and Devices IV*, (Mater. Res. Soc. Symp. Proc., Vol. 1299, Cambridge University Press, 2011) pp. 67-72, DOI: 10.1557/opl.2011.53.
  11. G.R. Fox, "Ferroelectric Integration and Contamination Control Methods Developed For Ferroelectric Memories," Proceedings of the Government Microcircuit Applications and Critical Technology Conference 2010, (The Office of Naval Research, Arlington, VA) pp. 253-256.
  12. G.R. Fox, X. Han, T.M. Maitland, and M.D. Vaudin, "Nanometer Scale Crystallographic Texture Mapping of Platinum and Lead Zirconate Titanate Thin Films by Electron Backscatter Diffraction," *J. Mat. Sci.*, **45**, 2991-2994 (2010), DOI 10.1007/s10853-010-4299-5.
  13. K.R. Udayakumar, T.S. Moise, S.R. Summerfelt, K. Boku, K.A. Remack, J. Gertas, A. Haider, Y. Obeng, J.S. Martin, J. Rodriguez, G. Shinn, A. McKerrow, J. Eliason, R. Bailey, G.R. Fox, Full-Bit Functional, High-Density 8 Mbit One Transistor-One Capacitor Ferroelectric Random Access Memory Embedded Within a Low-Power 130 nm Logic Process," *Jpn. J. Appl. Phys. Part 1*, **46** (4B), 2180-2183 (2007).
  14. N. Setter, D. Damjanovic, L. Eng, G. Fox, S. Gevorgian, S. Hong, A. Kingon, H. Kohlstedt, N.Y. Park, G.B. Sphenson, I. Stolitchnov, A.K. Tagantsev, D.V. Taylor, T. Yamada, and S. Streiffer, "Ferroelectric Thin Films: Review of Materials, Properties and Applications," *J. Appl. Phys.*, **100** (10), 051606 (2006).
  15. K.R. Udayakumar, T.S. Moise, S.R. Summerfelt, F.G. Celii, G. Shinn, K. Boku, K. Remack, A. Haider, D. Anderson, J. Gertas, Y. Obeng, G. Albrecht, J.S. Martin, J. Rodriguez, B. Khan, S. Aggarwal, N. Schauer, H. McAdams, S. Madan, A. McKerrow, J. Eliason, J. Groat, R. Bailey, G.R. Fox, E. Jabillo, and J. Walbert, "Full-Bit Functional, High Density 8Mb 1T-1C FRAM Embedded Within a Low-Power 130 nm Logic
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- Process," *Proceedings 2006 International Conference on Solid State Devices and Materials*, (Yokohama, Japan, 2006) pp. 122-123.
16. J. Eliason, S. Madan, H. McAdams, G. Fox, T. Moise, C. Lin, K. Schwartz, J. Gallia, E. Jabillo, B. Kraus, S. Summerfelt, "An 8Mb 1T1C Ferroelectric Memory with Zero Cancellation and Micro-Granularity Redundancy," *Proceedings IEEE 2005 Custom Integrated Circuits Conference*, (IEEE, Piscataway, NJ, 2005) pp. 427-430.
  17. S.R. Summerfelt, K.R. Udayakumar, K. Boku, K.A. Remack, J. Rodriguez, F.G. Celii, S. Aggarwal, G. Albrecht, Y. Obeng, J.S. Martin, L. Hall, L. Matz, B. Rathsack, H. McAdams, K.J. Taylor, R. Yonemoto, T.S. Moise, R. Bailey, M. Depner, G. Fox, J. Eliason, "Bit Distribution and Reliability of Production-Worthy 1.5V FRAM Embedded with 130nm, 5LM Copper CMOS Logic," *Proceedings 12th US-Japan Seminar on Dielectric and Piezoelectric Ceramics*, (2005).
  18. J.A. Rodriguez, K. Remack, K. Boku, K.R. Udayakumar, S. Aggarwal, S.R. Summerfelt, F.G. Celii, S. Marting, L. Hall, K. Taylor, T. Moise, H. McAdams, J. McPherson, R. Bailey, G. Fox, and M. Depner, "Reliability Properties of Low-Voltage Ferroelectric Capacitors and Memory Arrays," *IEEE Trans. Dev. and Mater. Rel.*, **4** (3), 436-449 (2004).
  19. J. Rodriguez, K. Remack, K. Boku, K.R. Udayakumar, S. Aggarwal, S. Summerfelt, T. Moise, H. McAdams, J. McPherson, R. Bailey, M. Depner, G. Fox, "Reliability Properties of Low Voltage PZT Ferroelectric Capacitors and Arrays," *42<sup>nd</sup> Internat. Rel. Phys. Symp. Proc.* (IEEE, Piscataway, NJ, 2004) pp. 200-208.
  20. G.R. Fox, R. Bailey, W.B. Kraus, F. Chu, S. Sun, and T. Davenport, "The Current Status of FeRAM," in *Ferroelectric Random Access Memories, Topics Appl. Phys.*, ed. by H. Ishiwara, M. Okuyama, and Y. Arimoto, **93**, (Springer-Verlag, Berlin Heidelberg, 2004) pp. 139-148.
  21. C.E. Rice, J.D. Cuchiaro, S. Sun, L.G. Provost, G.S. Tompa, T. Davenport, G. Fox, S. Sun, F. Chu, "Development of Low Temperature Al<sub>2</sub>O<sub>3</sub> MOCVD for Ferroelectric Film Passivation on 8" Wafers," *Integrated Ferroelectrics*, **59**, 1453-1463 (2003).
  22. Y. Horii, J.S. Cross, N. Sato, S. Ozawa, K. Matsuura, M. Fujiki, T. Saito, S. Mihara, T. Eshita, S. Sun, F. Chu, G. Fox, T. Davenport, and T. Yamazaki, "New Multi-layer Top Electrode of SRO/IrO<sub>x</sub> for 0.35 μm FRAM," *Proc. Solid State Devices and Materials* (2002).
  23. F. Chu, G. Fox, T. Davenport, Y. Miyaguchi, and K. Suu, "The Control of Pb Loss for PZT Based FRAM," *Integrated Ferroelectrics*, **48**, 161-169 (2002).
  24. T.S. Moise, S.R. Summerfelt, H. McAdams, S. Aggarwal, K.R. Udayakumar, F.G. Celii, J.S. Martin, G. Xing, L. Hall, K.J. Taylor, T. Hurd, J. Rodriguez, K. Remack, M.D. Khan, K. Boku, G. Stacey, M. Yao, M.G. Albrecht, E. Zielinski, M. Thakre, S. Kuchimanchi, A.
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