The 3rd China-Russia Workshop on Dielectric and Ferroelectric Materials

Oct. 12-14, 2017, Wuhan, China

Sponsored by State Key Laboratory of Advanced Technology for Materials Synthesis and Processing (Wuhan University of Technology, China), International School of Materials Science and Engineering (Wuhan University of Technology, China), and Key Lab of Ferro & Piezoelectric Materials and Devices of Hubei Province (Hubei University, China), the 3rd China-Russia Workshop on Dielectric and Ferroelectric Materials will be held on Oct. 12-14, 2017 in Wuhan.

General Chairs:

Haoshuang Gu (Hubei University, China)

Wen Chen (Wuhan University of Technology, China)

A.S. Sigov (Moscow State Technical University of Radio-engineering, Electronics and Automation, Russia)

Organizing Committee:

Chairs of Organizing Committee:

Yunbin He (Hubei University, China)

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Yongming Hu (Hubei University, China)

Jing Zhou (Wuhan University of Technology, China)

Topics:

1. High-performance piezo-/ferroelectric materials and devices
2. Thin films, single crystals, interfaces and nanoscale materials
3. Multiferroic materials and devices
4. New Mechanisms/Materials/Devices

Abstracts and Proceedings:

The abstracts, including title, authors, affiliation, mailing address, abstract text, and figures if any, should be submitted by email to *shenjie@whut.edu.cn* by Aug. 15, 2017. Each invited speaker is advised to submit a manuscript to be included in the Proceedings of the Workshop, which will be published in the *Journal of Advanced Dielectrics* (*JAD*) as a special issue. This manuscript could be submitted on-site or by the online system within TWO months after the Workshop (by Dec. 15, 2017). The instructions for preparation of manuscripts could be found in http://www.worldscientific.com/page/jad/submission-guidelines.

Accommodation:

Wuhan Laisi International Hotel, No. 259 Zhongbei Road Wuchang District, Wuhan, Hubei Province, China

The organizing committee has already booked rooms for each invited speaker.

Workshop Location:

Wuhan Laisi International Hotel

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Tentative Schedule:

	Oct 12	Oct 13	Oct 14	Oct 15
Morning	Registration and Reception	Invited Talks and Discussion	Invited Talks and Discussion	City and Culture Tour
Afternoon		Invited Talks and Discussion	Invited Talks and Discussion	

Important Dates:

Abstract submission deadline:	Aug 15th, 2017
Final announcement:	Sep 1st, 2017
Workshop dates:	Oct 12th - 14th, 2017
Manuscript submission:	On site or by Dec 15th, 2017

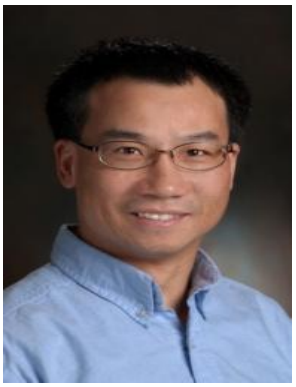
Professor Jun-Ming Liu, Nanjing University, China

Professor Liu received his doctorate of materials science from Northwestern Polytechnic University in 1989, and then joined Nanjing University as a post-doctor where he was an associate professor of physics from 1992 and a full professor of physics in 1999. Prof. Liu has made seminal contributions to the synthesis and characterization of multiferroic materials and other complex transition metal oxides, and to the understanding of physics of rare-earth manganites with multiferroicity and colossal magnetoresistance. His current research of focus includes the physics of ferroelectrics, magnetoelectric coupling in multiferroic systems, and statistical physics computations. Prof. Liu received several awards including the National Science Fund for Distinguished Young Scholars (NSFC) in 1997 and the Chang-Jiang Professorship (MOE, China) in 2004. He is a fellow of American Physical Society (2015).

Professor Alexander Sigov, Moscow Technological University (MIREA) , Russia

Alexander Sigov is the President of Moscow Technological University (MIREA), Russia, Doctor of Physics, Full Member of the Russian Academy of Sciences.

Professor Sigov (born 1945) has attained a worldwide reputation as a prominent expert in Solid State Physics and Solid State Electronics. During the course of his scientific career he contributed extensively to the phenomenology of magnets, ferroelectrics and multiferroics, physics of ferroic-based heterostructures, thin films, etc. The results of his scientific activity are reflected in more than 300 papers, reviews, book chapters, as well as 15 monographs and textbooks, including the most well-known "Defects and Structural Phase Transitions". For many years he heads the Department of Nanoelectronics in Moscow Technological University. He created his own school and inspiring and mentoring many talented scientists. In 2006 Alexander Sigov was elected a Member of the Russian Academy of Sciences. He is the head of the Russian Academy Council on Dielectrics and Ferroelectrics, member of numerous scientific societies, Associate Editor of Ferroelectrics and Integrated Ferroelectrics, Editor and Board Member of about ten Russian national journals, Chair of the Council on Physics and Astronomy of Russian Foundation for Basic Research.



Professor Zuo-Guang Ye, Simon Fraser University, Canada and Xi'an Jiaotong University, China

Zuo-Guang Ye received his Ph.D. degree from l'Université de Bordeaux I, France, and did post-doc research at l'Université de Genève, Switzerland. He joined the faculty of Simon Fraser University, Burnaby, British Columbia, Canada, in 1997, and has been a full professor with tenure since 2003. He has served a 5-year term as the chair of the Department of Chemistry and is a funding director of the 4D LABS, an interdisciplinary materials research centre. Ye was named "Info-Tech Oulu Lecturer" at the University of Oulu, Finland (2010, 2014), and is currently a "Qian-Ren Scholar" with the International Centre for Dielectric Research at Xi'an Jiaotong University, China.

Ye's research interests include (i) growth and characterization of high-performance piezo- and ferroelectric single crystals, (ii) multiferroic and magnetoelectric materials, (iii) lead-free piezo- and ferroelectrics, and (iv) relaxor ferroelectricity and its microscopic mechanism. He has been an active contributor to the ONR and DARPA research programs on high-performance piezoelectric single crystals. He has published over 310 peer-reviewed SCI research papers (with over 7700 SCI citations by others and an H-Index of 49, as of June 2017) and 10 review articles and book chapters, and was editor of the book entitled "Handbook of Advanced Dielectric, Piezoelectric and Ferroelectric Materials" (Woodhead Publications Ltd./Elsevier).

Professor Tatiana R. Volk, Shubnikov Institute of Crystallography of Federal Scientific Research Centre "Crystallography and Photonics" of Russian Academy of Sciences, Russia

Tatiana R. Volk graduated from Moscow State University and received her Ph.D and Docrorate degrees in the Shubnikov Institute of Crystallography of Russian Academy of Sciences (ICRAS), Moscow and has been a full professor since 2002. Now she is the head of the crystal-optics laboratory in ICRAS.

T. Volk's interests include: (i) ferroelectricity, with special reference to ferroelectric domains and related problems of optical frequency conversion, (ii) optical memory with an emphasis on photorefraction and related topics, (iii) radiation defects in solids, (iiii) relaxor ferroelectricity, (iiiii) atomic-force microscopy. She has published over 150 papers in peer-reviewed journals, (with over 2500 SCI citations by others and an H-Index of 24, as of June 2017) and 5 review articles and book chapters. She has published in co-authorships two monographs: "Lithium Niobate" by N. V. Sidorov, T. R. Volk, B. N. Mavrin and V. T. Kalinnikov, M., Nauka, 2003 (in Russian), and "Lithium Niobate: Defects, Photorefraction and Ferroelectric Switching" by Tatyana Volk and Manfred Woehlecke, Springer Series in Material Science 115, 2008.

Prof. T. Volk is the vice-chairman of the RAS Scientific Council on the Physics of Ferroelectrics and Dielectrics and a member of the European Meeting on Ferroelectricity (EMF) Steering Committee. She has served in the international advisory board of several conferences and symposia on ferroelectricity and related problems. Since many years she is the Chair of the Program Committees of Russian National Conferences on Ferroelectricity.

She is a member of the Editorial Board of Ferroelectrics and Integrated Ferroelectrics and several times served as a Guest-Editor of Ferroelectrics.

Oct.12, 2017	
08:00~23:00	Registration Wuhan Laisi International Hotel
18:00~20:00	Dinner (Buffet) Laisi International Hotel: Cafeteria, (Second Floor)
Oct.13, 2017	
08:00~08:10	Welcome and Introductory Remarks **Prof. Haoshuang Gu** Laisi International Hotel: Multifunctional Hall, (Fifth Floor）
08:10~08:20	Welcome and Introductory Remarks **Prof. Xi Yao**
Session Chairs	**Prof. Zhuo Xu and Prof. Leonid. Korotkov**
08:20~09:05	Plenary Session I Complex multiferroicity in $GdMn_2O_5$ **Prof. Junming Liu** Nanjing University
09:05~09:50	Plenary Session II "The validity of the Imry-Ma approach in the systems with defects of the "random local field" type" **Prof. Aleksandre. Sigov** Moscow Technological University
09:50~10:15	**Photo and Coffee Break**
10:15~11:00	Plenary Session III Understanding the Structural Origins of High Piezo-/ferroelectricity in Complex Perovskite Solid Solutions **Prof. Zuoguang Ye** Simon Fraser University
11:00~11:45	Plenary Session IV Studies in thin $LiNbO_3$ films by AFM methods **Prof. Tatiana. Volk** Shubnikov Institute of Crystallography of FSRC "Crystallography and Photonics" RAS
11:45~13:30	Lunch (Buffet) Laisi International Hotel: Cafeteria, (Second Floor)
Session Chairs	**Prof. Junming Liu and Prof. Tatiana. Volk**
13:30~14:00	(invited) Soft Mode Condensation in Raman Spectra of (Pb-La)(Zr-Sn-Ti)O_3 Ceramic **Alexander. Vtyurin** Kirensky Institute of Physics Federal Research Center KSC of the Siberian Branch of the Russian Academy of Sciences
14:00~14:30	(invited) Eletro-optical and nonlinear optical properties of $PbTiO_3$ Based Single Crystals **Zhuo Xu** Xi'an Jiaotong University
14:30~15:00	(invited) Grand design of novel functional materials and physical properties **Xiaolin Wang** University of Wollongong

15:00~15:30	(invited) Enhanced piezoelectric properties of KNN-based ceramics: from doping to multiphase co-existed **Jianguo Zhu** Sichuan University
15:30~16:00	(invited) Mode coupling and formation of the incommensurate structures in $PZr_{1-x}Ti_xO_3$ crystals **Sergey Vakhrushev** Ioffe Physical Technical Institute, Russian Academy of Sciences
16:00~16:10	**Coffee break**
16:10~16:40	(invited) Investigation of PMN-PT single crystals for medical ultrasonic transducers **Haosu Luo** Shanghai Institute of Ceramics, Chinese Academy of Sciences
16:40~17:10	(invited) Progress in piezoelectric micromotors and applications **Shuxiang Dong** Beijing University
17:10~17:40	(invited)Field-induced Phase Transition and Domain Configuration in PMN-PT Single Crystals around MPB **Qiang Li** Tsinghua University
17:40~18:10	(invited)Multilayered Ceramic Devices Based on Low Temperature Cofired Ceramics (LTCC) Process **Zhifu Liu** Shanghai Institute of Ceramics, Chinese Academy of Sciences
18:10~20:00	Reception Dinner Laisi International Hotel: No. 3 conference room, (Fifth Floor)

Oct.14, 2017

Place	**Laisi International Hotel: Multifunctional Hall, (Fifth Floor）**	**Laisi International Hotel: No. 3 Conference Room, (Fifth Floor)**
Topic	**Lead-free Ferro/Piezoelectrics**	**New Mechanism/Materials/ Devices**
Session Chairs	**Prof. Wei Huang and Prof. Aleksandre. Krylov**	**Prof. Haosu Luo and Prof. Vladimir. Shur**
08:00~08:30	(invited) Ferroelectric Transition in $Ba_4R_2Zr_4Nb_6O_{30}$ (R=La, Nd, Sm) Tetragonal Tungsten Bronze New Systems **Xiangming Chen** Zhejiang University	(invited) Ferroelectric-Graphene Heterostructures and Field-Effect Transistors **Jianhua Hao** The Hong Kong Polytechnic University
08:30~09:00	(invited) Processing and characterization of lead-free ceramics on the base of sodium-bismuth titanate and sodium-potassium niobate **Ekaterina. Politova** Karpov Institute of Physical Chemistry	(invited) Tailoring strains and physical properties of epitaxial thin films on vicinal substrates **Yuan Lin** University of Electronic Science and Technology of China

09:00~09:30	(invited) Duplex structure in $K_{0.5}Na_{0.5}NbO_3$ based ferroelectric ceramics with wide temperature-stable dielectric properties **Huiqing Fan** Northwestern Polytechnical University	(invited) Dielectric Relaxation and Photoluminescence of Lanthanide-Doped Bismuth Titanate Pyrochlore Thin Films **Dinghua Bao** Sun Yat-sen University
09:30~10:00	(invited) Large Electrocaloric Effect in Relaxor Ferroelectrics, Antiferroelectrics and Multilayer Ceramic Capacitors **Shengguo Lu** Guangdong University of Technology	(invited) From "material" to "device"----LTCC and millimeter wave antenna **Wenzhong Lv** Huazhong University of Science and Technology
10:00~10:10	**Coffee Break**	
10:10~10:40	(invited) Ionic Liquid gating control of Magnetism **Ming Liu** Xi'an Jiaotong University	(invited) Optical properties of mesoporous photonic crystals, filled by dielectrics, ferroelectrics and piezoelectrics **Vladimir. Gorelik** Lebedev Institute for General Physics of the Russian Academy of Sciences
10:40~11:10	(invited) Dielectric properties of $Ba_{1-x}Ca_xZr_yTi_{1-y}O_3$ ceramics under strong electric field **Qing Xu** Wuhan University of Technology	(invited) Mechanism of High Performance Piezoelectrics of Pb-Based Perovskites **Jun Chen** University of Science & Technology Beijing
11:10~11:40	(invited) A Comparative Study of High Temperature Performance and Depolarization of Piezoceramics **Dong Guo** Beihang University	(invited) Dielectrics in AlGaN /GaN HEMTs **Xingzhao Liu** University of Electronic Science and Technology of China
11:40~12:10	(invited) Giant Electrostrictive Effects and Defects in Lead-Free Fe^{3+}-doped $0.5Ba(Zr_{0.2}\ Ti_{0.8})O_3$-$0.5(Ba_{0.7}Ca_{0.3})TiO_3$ Ferroelectric Ceramics **Li Jin** Xi'an Jiaotong University	(invited) 2D electronic and photoelectronic devices driven by ferroelectrics **Minghua Tang** Xiangtan University
12:10~13:30	Lunch (Buffet) Laisi International Hotel: Cafeteria, (Second Floor)	
Topic	**Multiferroics/Single Crystal/Ceramic**	**Nanomaterials**
Session Chairs	**Prof. Xiangming Chen and Prof. Alexander. Vtyurin**	**Prof. Yuan Lin and Prof. Vladimir. Gorelik**

13:30~14:00	(invited) Mircro-structure and Diffuse Phase Transition of $xP(Zn_{0.5}Te_{0.5})O_3$-(1-x)PZT Ferroelectric Ceramics **Guorong Li** Shanghai Institute of Ceramics, Chinese Academy of Sciences	(invited) Electrophysical properties of nanocrystalline $BaTiO_3$ **Leonid. Korotkov** Voronezh State Technical University
14:00~14:30	(invited)Raman Scattering Study of Phase Transitions in Multiferroics with Huntite Structures **Aleksandre. Krylov** Kirensky Institute of Physics Federal Research Center KSC of the Siberian Branch of the Russian Academy of ciences	(invited) Creating crystallographically engineered hierarchical polydomain nanostructures in perovskite ferroelectric films with improved electrical performance **Jinbin Wang** Xiangtan University
14:30~15:00	(invited) Multi-state and Magnetoelectric Coupling Effects in Multiferroic Tunnel Junctions **Yuewei Yin** University of Science and Technology of China	(invited) Formation of dendrite micro- and nano-domain structures in uniaxial ferroelectrics **Vladimir. Shur** Ural Federal University
15:00~15:30	(invited) The exploration on the origin of enhanced piezoelectric properties in metal-ion doped (K, Na)NbO_3 based lead-free ceramics **Yunbin He** Hubei University	(invited) Hydrothermal Synthesis of Nd doped Barium Titanate Fine Particles **Kongjun Zhu** Nanjing University of Aeronautics and Astronautics
15:30~15:40	**Coffee break**	
Topic	**Multiferroics/Single Crystal/Ceramic**	**Energy**
15:40~16:10	(invited) Energy storage properties in ferroelectric & antiferroelectric ceramics **Genshui Wang** Shanghai Institute of Ceramics, Chinese Academy of Sciences	(invited) Ferroelectrics for Energy-Related Applications **Haitao Huang** The Hong Kong Polytechnic University
16:10~16:40	(invited) The Dielectric Constant of $CaCu_3Ti_4O_{12}$ Ceramics **Changping Yang** Hubei University	(invited) Controllable Preparation and Energy Storage Properties of Barium Titanate-based Polyvinylidene fluoride Composites **Jiwei Zhai** Tongji University
16:40~17:10	(invited) Domain structure kinetics in single crystals of potassium titanyl-phosphate **Andrey. Akhmatkhanov** Ural Federal University	(invited) Perovskite dielectric materials for high temperature capacitor application **Hua Hao** Wuhan University of Technology

17:10~17:40	(invited)Ferroelectric domain in multiferroic hexagonal manganites **Xueyun Wang** Beijing Institute of Technology	(invited)Atomic Layer Engineering of High‑κ Dielectric Response in 2D Perovskite Nanosheets **Baowen Li** Wuhan University of Technology
17:40~18:00	High performance piezoelectric ceramics and their composites for high-power application **Jie Shen** Wuhan University of Technology	Highly Flexible Electrocaloric Ceramic Nanowire Array **Guangzu Zhang** Huazhong University of Science and Technology
18:00~18:20	Voltage Control of Magnetism in Multiferroic Heterostructures **Zhongqiang Hu** Xi'an Jiaotong University	Giant Energy Density of Polymer Nanocomposites Dielectrics Induced by Interfaces-Engineering **Xin Zhang** Wuhan University of Technology
18:20~20:00	Dinner (Buffet) Laisi International Hotel: Cafeteria, (Second Floor)	

Poster Session

Poster ID.	Presenter	Title
P-01	Haibo Zhang*, Peiwei Xu, Fangzhou Yao, Ke Wang, Jinqiang Huang, Jing-feng Li	Textured $(Bi_{1/2}Na_{1/2})TiO_3$-$BaTiO_3$-$AgNbO_3$ lead-free piezoceramics and multilayer actuators
P-02	Zixing Wang, Jie Shen, Jing Zhou, Wen Chen	Study on optical properties of complex perovskite ceramics
P-03	Quan Wei, Jie Shen, Jing Zhou, Wen Chen	Influence of interdigital electrode structure on electric field distribution of MFC
P-04	Meng Shen, Shenlgin Jiang, Guangzu Zhang*	Giant electrocaloric effect of free-standing $Pb_{0.85}La_{0.1}(Zr_{0.65}Ti_{0.35})O_3$ thick fil ms fabricated by the self-lift-off screen printing method
P-05	Xin Jiang, Ningjing Zheng, Shengwei Jia, Dan Wang, Mingze Sun, Dongxu Zhang, Huanhuan Liu, Wei Li*	Microstructure and dielectric properties of BCZT thin films with alternative seed layers
P-06	Yong Li, Ningning Sun, Xiaowei Li, Jinhua Du, Liming Chen, Hongcheng Gao, Xihong Hao*, Maosheng Cao	Multiple electrical response and enhanced energy storage induced by unusual coexistent-phase structure in relaxor ferroelectric composites
P-07	Sheng Zhu, Wanping Chen*	High performance $BiFeO_3$ multiferroic ceramics prepared through sequential doping of Ba and Ti
P-08	Huifen Tong, Gang Chang, and Yunbin He*	Synthesis of g-C_3N_4/{001} TiO_2 composite with enhanced UV- and visible-light photocatalytic activity for MB degradation
P-09	Jian Chen, Qingfeng Zhang*, Yunbin He*	Ferroelectric photovoltaic effect of $[KNbO_3]_{0.9}[BaNi_{0.5}Nb_{0.5}O_{3-\sigma}]_{0.1}$ lead free thin film with narrow band gap

P-10	Hui Xie, Yijie Zhang, Hao Yang, Taosheng Zhou, Xunzhong Shang	Effect of rare earth doping on the properties of BSPT piezoelectric ceramics
P-11	Bing Zhao, Jian Guo, Xuejiao Gu, Hui Xie, Hao Yang, Yijie Zhang, Taosheng Zhou, Xunzhong Shang	Effect of Mixture of different Calcination T emperature on Piezoelectric Properties of PZT Piezoelectric Ceramics
P-12	Yahua He, Wenchao Jin, Zhao Wang, Haoshuang Gu	Annealing dependent piezoelectricity and high-performance energy harvesting of lead-free (K, Na)NbO_3 nanorod arrays
P-13	Wenchao Jin, Yahua He, Zhao Wang, Haoshuang Gu	High-Performance Piezoelectric Energy Harvesting of Vertically Aligned PZT Nanorod Arrays
P-14	Lun Tan, Xumin Pan, Zhao Wang, Haoshuang Gu	Self-powered vibration and microfluidic sensors based on flexible PVDF nanofibers
P-15	Juan Xiong, Weihai Zhang, Jinhua Li, Fangcheng Wan, Haoshuang Gu	Research of AZO hybrid transparent electrodes and its applaication of perovskite solar cells
P-16	Xianghui Zhang, Xiaoliang Ren, Yihua Gao	Ga-Doped n-ZnO & Sb-Doped p-ZnO Nanowire Arrays Grown on GaN Film for Advanced Light Emitting Diodes
P-17	Yaxuan Cai, Shijun Luo,Zhao Wang, Yahua He, Haoshuang Gu	Theoretical calculation study on the polarization properties of KNN, Croconic acid and TCAA ferroelectrics

BOOK OF ABSTRACTS

ORAL PRESENTATION

ABSTRACTS

Understanding the Structural Origins of High Piezo-/ferroelectricity in Complex Perovskite Solid Solutions

Zuo-Guang Ye[1,2]

[1] *Department of Chemistry and 4D LABS, Simon Fraser University, Burnaby, British Columbia, V5A 1S6, Canada*

[2] *Electronic Materials Research Laboratory & Intl. Center for Dielectric Research, Xi'an Jiaotong University, Xi'an, 710049, China*

Solid solution of lead zirconate-titanate, $PbZr_{1-x}Ti_xO_3$ (PZT), has been extensively studied over the past decades for both industrial applications and fundamental research, but almost exclusively in the forms of ceramics and thin films because of the difficulties encountered in the growth of PZT single crystals. On the other hand, the mesoscopic domains, the microstructure and the atomistic mechanisms that cause the outstanding piezoelectric performance of this class of materials near the morphotropic phase boundary (MPB) remain poorly understood. Therefore, it is of particular interest to grow large single crystals of PZT, which are not only necessary for thorough characterization of the anisotropic properties of this prototype ferroelectric solid solution system, but are also expected to exhibit superior piezo- and ferroelectric performance over the PZT ceramics, and a higher depoling temperature (T_d) and higher coercive field (E_c).

Recently, thanks to our capability to grow PZT single crystals and the availability of advanced characterization and analytical techniques, such as piezoresponse force microscopy, spherical aberration-corrected transmission electron microscopy, high-resolution neutron total scattering and diffuse scattering and pair-distribution function (PDF) analysis, we have gained new insights into the complex local structure, atomic scale polarization rotation, nano-scale domain structure, intricate phase transition, polarization structure, and tri-critical points in PZT. These results have provided a better

understanding of the relationship between meso-/nanoscopic structure and macroscopic functional properties not only for this important class of materials, but also for other piezo-/ferroelectric materials in general.

Keywords: PZT Single Crystals, High-T_C Piezoelectriccs, Meso-to-nanoscopic domain Structure, Local Structure, Phase Transitions, Polarization Rotation & Mapping

The work was supported by the United States Office of Naval Research (Grants No. N00014-12-1-1045 and N00014-16-1-3106) and the Natural Sciences & Engineering Research Council of Canada (NSERC). Part of this work was conducted at the International Centre for Dielectric Research at Xi'an Jiaotong University, China, with the support from the «Qianren Program» of the Chinese Goverment.

Micro- and Nanodomain Patterning in $LiNbO_3$-Based Optical Waveguides and Thin Layers.

Tatyana Volk

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Micro- and nanodomain patterns serve as an effective medium for optical-frequency conversion based on the quasi-phasemetching (QPM) principle. In the context of integrated optics, an interest arose in creation of domain patterns in $LiNbO_3$-based optical waveguides. We report on our recent results on writing and investigations of micro- and nanodomain patterns in $LiNbO_3$ thin layers. Domains were written by AFM-tip dc-voltages and an electron beam (EB) of SEM. These methods make it possible to create domain patterns up to the submicro- and nanoscale and are especially attractive for application in thin layers.

In optical waveguides fabricated by Ti-indifffusion and He-ion implantation, microdomain gratings with periods up to several microns were created. 2D-patterns of specified design were written in novel sandwich structures LNOI (thin ion-sliced $LiNbO_3$ films embedded on an insulator), which are regarded as high-index-contrast optical waveguides. All written patterns were completely stable. The mechanism of ferroelectric switching in these conditions was analyzed. Specificity of domain formation in thin $LiNbO_3$ layers was found. In particular, a contribution from the domain-wall conductivity was shown to determine the characteristics of written domain patterns. The dependence of domain dynamics on the intrinsic defects serving as

domain-wall pinning centers was found. Fabricated patterns were examined using SHG confocal microscopy.

The dataset on ferroelectric and nonlinear-optical properties of written patterns pave the way for development of the used microscopic methods in $LiNbO_3$-based integrated structures.

These researches are supported by the grants from Russian Foundation for Basic Researches projects Nos. 16-29-11777_ofi_m and 16-02-00439a). The equipment of the Shared Research Center supported by the Ministry of Education and Science (Project No. RFMEFI62114X0005) was used in experiments.

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Soft Mode Condensation in Raman Spectra of (Pb-La)(Zr-Sn-Ti)O_3 Ceramics

Alexander N. Vtyurin[1], Alexander S. Krylov[1], Sletlana N. Krylova[1],
Xiaoyong Wei[2], Yujun Feng[2], Ran Xu[2] and Tian Zhao[2]

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Since their discovery in 1950s, PZT-type materials have been the most widely used piezoelectric ceramics. With increasing Ti content above $x = 0.06$, the solid solution changes from antiferroelectric to ferroelectric. The six structural phases in the solid solution $Pb(Zr_xTi_{1-x})O_3$ have been observed at ambient pressure are an antiferroelectric phase for compositions near $PbZrO_3$, ferroelectric low-temperature and high-temperature rhombohedral phases for most Zr-rich alloys, a monoclinic ferroelectric phase near (50% Zr)/(50% Ti) composition, a tetragonal ferroelectric phase for Ti-rich alloys, and a cubic paraelectric phase for all compositions at sufficiently high temperature. Recently it was found by inelastic and diffuse X-ray scattering techniques that in pure lead zirconate phase transition from cubic into antiferroelectric phase is driven by phonon soft mode condensation. Here we report low frequency Raman scattering study of phase transition from cubic into ferroelectric phase in $(Pb_{0.97}La_{0.02})(Zr_{0.864}Sn_{0.04}Ti_{0.096})O_3$ composition.

The spectrum of higher temperature cubic phase consists of extremely wide bands, as assumed to be in a highly disordered lattice. Under cooling a set a new lines appears; their frequencies do not show any anomalies aside from normal temperature drift, while their widths drop very quickly. In particular low frequency mode at about 50 cm^{-1} exhibits strong maximum of its damping above 400 K.

Results are discussed in terms of overdumped soft mode at order-disorder phase transition.

Enhanced Piezoelectric Properties of KNN-based Ceramics: From Doping to Multiphase Co-Existed

Jie Xing, Xiang Lv, Ting Zheng, Jiagang Wu, Dingquan Xiao and Jianguo Zhu*

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In this review the enhanced piezoelectric properties of KNN-based ceramics are discussed and compared with the properties of other kinds of perovskite lead free piezoelectric ceramics. It is very important to understand the physical origin of high piezoelectricity in order to investigate the relationships between the phase boundaries, phase compositions, and piezoelectric properties of KNN materials. Most of the researchers are concentrated on designing and controlling the orthorhombic–tetragonal transition temperature ($T_{O–T}$) of KNN-based ceramics down to around room temperature, and the properties obtained are still inferior compared to PZT system.

The objective of this study is to discuss the origin of high piezoelectricity of KNN-based lead-free piezoelectric ceramics and to investigate the effect of new phase boundary on the piezoelectric properties of KNN-based ceramics. It was found that shifting the orthorhombic-rhombohedral transition temperature of KNN-based ceramics above room temperature would be accompanied with the increasing of d_{33} of the ceramics to more than 400 pC/N or better, due to the formation of the new phase boundary and microdomains in the KNN-based ceramics.

Mode coupling and formation of the incommensurate structures in $PZr_{1-x}Ti_xO_3$ crystals

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In the last decades, the interest to the PZT solid solution has grown sharply. The most contradictory is information about the structure of the PZT with Ti concentration below 6% [1]. In our combined inelastic and diffuse scattering study of PZT we have addressed the critical instability close to the Γ-point and to the BZ boundary. In the first case, in contrast to the Ref.1 we found lattice instability at q ≈ (0.2 0.2 0) in some cases resulting in the formation of the incommensurate structure. For the BZ vicinity, we found that the temperature dependent diffuse scattering is observed aside of the M-point. Also it is extinct at h = k (Q=(1.5 1.5 0)). Such extinction rule indicates that this component is related to the oxygen octahedra tilts. Our IXS measurements have revealed strong asymmetry of the scattering intensity in respect to the Brillouin zone boundary. Intensity of the central peal (CP) at Q1 = (1.55 0.45 0) is very low, while at Q2 = (1.45 0.55 0) it is high. This is similar to the results reported in the Ref. [3]. Observed scattering pattern can be tentatively described as the result of the coupling of the M3 and M2' modes. Interference term in this case can suppress the scattering at the one side of the zone boundary and enhancing it at the other side.

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Multilayered Ceramic Devices Based on Low Temperature Co-fired Ceramics (LTCC) Process

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Low temperature cofired ceramics (LTCC) process allows to fabricate multilayer ceramic circuits, modules or components by laminating green tapes with printed conductor lines on the surface on top of each layer and, then, fire them all together in one step at a relative low temperature. LTCC technology has been widely used MCM packaging substrate, microwave filter, inductor, coupler, and other passive components/modules for its robust, excellent high frequency performance, and ability of realizing 3D integration. In this presentation, we would like to present some of our recent results in multilayered ceramic devices development using the LTCC process.

1) Wireless gas sensors and pressure sensors: LC antennas were designed and fabricated using the LTCC process. For gas sensor application, the gas sensing material was integrated with the LC antenna. The gas sensing performance was investigated by monitoring the impedance phase angle changes of the antenna in response to different gas types including EtOH, NH_3 and NO_2. The testing results showed that the sensor had selectivity for gas detection. For pressure sensor application, a cavity capacitor with a pair of bottom and top electrodes was integrated with the LC antenna.

2) Ka-band bandpass filter: Bandpass filter with center frequency of 27.93 GHz was designed based on the dielectric material developed by Shanghai Institute of Ceramics. The proposed filter scheme consists of substrate integrated waveguide (SIW) cavities with coupling slots and coplanar waveguide (CPW) transition parts. The filter

has a -20 dB bandwidth of 2.6 GHz and the minimum insert loss of about -0.85 dB. These SIW bandpass filters were fabricated using the LTCC process. Simulation results and measurement results are in good agree with the bandwidth of interest. The excellent performance of the Ka-band bandpass filter confirms that the LTCC material is suitable for millimeter application.

Processing and characterization of lead-free ceramics on the base of sodium-bismuth titanate and sodium-potassium niobate

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Lead-free piezoelectric materials are among the most intensively studied in order to replace widely used Pb-based ones. In this work, effects of modification of compositions by various donor and acceptor dopants in the A- and B-sites of perovskite lattice and influence of nonstoichiometry on structure, dielectric and ferroelectric properties of ceramics from Morphotropic Phase Boundaries (MPB) in the $(Na_{1/2}Bi_{1/2})TiO_3$ - $BaTiO_3$ (NBT-BT) and $(K_{0.5}Na_{0.5})NbO_3$ – $BaTiO_3$ (KNN-BT) systems have been studied.

Ceramic samples were prepared by the two-step solid-state reaction method at high temperatures of 920 – 1500 K. The samples NBT-BT and KNN-BT were additionally modified by Ni^{2+}, Fe^{3+}, and Mn^{4+} cations. The samples were characterized by the X-ray Diffraction, Scanning Electron Microscopy, Second Harmonic Generation (SHG), Dielectric Spectroscopy and Piezorespone Force Microscopy (PFM) methods.

Changes in the unit cell volume of the KNN- and NBT-based ceramics were observed depending on the A- and B-cation substitutions. Ferroelectric phase transitions marked by steps at ~ 300 - 400 K (NBT) and by peaks at ~ 550 K (NBT) and at ~700 K (KNN) were revealed in the dielectric permittivity versus temperature curves of the

compositions studied. Ferroelectric phase transitions near 300-400 K revealed typical relaxor-type behavior attributed to the presence of polar nanoregions in a nonpolar matrix.

Increase in the spontaneous polarization value was proved for modified ceramics using the SHG method. At the room temperature, non monotonous changes of the dielectric parameters ε_{rt} and $\tan\delta_{rt}$ and maximum effective d_{33} values were observed in modified BNT- and KNN-based compositions, thus confirming their prospects for new lead-free materials development.

Acknowledgment

The work was supported by the Russian Foundation for Basic Research (Project 16-53-48009).

The Dielectric Constant of $CaCu_3Ti_4O_{12}$ Ceramics

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The dielectric properties of $CaCu_3Ti_4O_{12}$ (CCTO) ceramics were studied using AC and DC electrical measuring methods in order to understand the origin of the colossal dielectric constant, including impedance spectra analysis, frequency and temperature spectrum, electrical conditioning treatment and capacitance – biased voltage curves measuring. The experimental results indicate that the constant is very strongly correlated with defects in CCTO, especially oxygen vacancy, which is the main contribution for the dielectric polarization at low frequencies and high temperatures.

Giant Electrostrictive Effects and Defects in Lead-Free Fe^{3+}-doped $0.5Ba(Zr_{0.2}Ti_{0.8})O_3$-$0.5(Ba_{0.7}Ca_{0.3})TiO_3$ Ferroelectric Ceramics

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Electrostrictive effect has some advantages over the piezoelectric effect, including temperature-stability and hysteresis-free character. In the present work, we report the diffuse phase transitions and electrostrictive properties in lead-free Fe^{3+}-doped $0.5Ba(Zr_{0.2}Ti_{0.8})O_3$-$0.5(Ba_{0.7}Ca_{0.3})TiO_3$ (BZT-0.5BCT) ferroelectric ceramics. The doping concentration was set from 0.25 mole % to 2 mole %. It is found that by introducing Fe^{3+} ion into BZT-0.5BCT, the temperature corresponding to permittivity maximum Tm was shifted toward lower temperature monotonically by 37 ^{o}C per mole % Fe^{3+} ion. Simultaneously, the phase transitions gradually changed from classical ferroelectric-to-paraelectric phase transitions into diffuse phase transitions with a weak relaxor characteristic. Purely electrostrictive responses with giant electrostrictive coefficient Q_{33} between 0.04 m^4/C^2 and 0.05 m^4/C^2 are observed from 25 ^{o}C to 100 oC for the compositions doped with 1 mole %~2 mole % Fe^{3+} ion. The Q_{33} of Fe^{3+}-doped BZT-0.5BCT ceramics is almost twice higher than the Q_{33} of other ferroelectric ceramics. These observations suggest that the present system can be considered as a potential lead-free material for the applications in electrostrictive area and BT-based ferroelectric ceramics would have giant electrostrictive coefficient over other ferroelectric systems.

Ferroelectric-Graphene Heterostructures and Field-Effect Transistors

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The shrinking of the geometrical dimensions of current semiconductor devices has required the adoption of new materials and new device geometries. Graphene-based field effect transistor (GFET) has been among the breakthrough results of nanoscale electronic devices. The materials integrated with graphene are expanded from traditional oxides to a versatile range of functional dielectrics and semiconductors. Among the functional dielectrics, ferroelectrics not only possess high dielectric constant, but also exhibit non-volatile memory behaviours due to their unique feature of spontaneous polarization. In our study, we found that the electronic and optical properties of graphene and two-dimensioal (2D) materials could be tuned by the ferroelectric polarization and piezoelectricity. We have characterized the microstructure, ferroelectric and electrical properties of various ferroelectric/2D heterostructures. However, a fundamental problem of conventional GFET is that the device remains conducting even when switched off, ascribed to the absence of an energy gap in graphene. Therefore, we have developed a novel FET with the complementary vertical tunneling heterostructure possessing the features of both ferroelectricity and conventional GFET. We realize ultrahigh current on/off ratio of the FET. Such a tunnel device also inherently provides an opportunity to overcome the intrinsic limit of subthreshold swing (SS) for conventional metal-oxidesemiconductor FET (MOSFET). The research was supported by the grants from Research Grants Council of Hong Kong

(GRF No. PolyU 153031/15P) and National Natural Science Foundation of China (Grant No. 11474241).

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Dielectric Relaxation and Photoluminescence of Lanthanide-Doped Bismuth Titanate Pyrochlore Thin Films

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Pyrochlore structure $Bi_2Ti_2O_7$ has recently attracted considerable attention in both crystal structure and dielectric properties. It has a relatively high dielectric constant, a low loss, and a wide band gap which are desirable for integrated capacitor application including dynamic random access memory and metal oxide semiconductor devices. Due to the similarities both in structure and dielectric properties between $Bi_2Ti_2O_7$ and other complex bismuth pyrochlore compounds, $Bi_2Ti_2O_7$ can also act as a model material for bismuth-based pyrochlore. However, the phase instability in $Bi_2Ti_2O_7$ at a higher temperature limits its uses. It has been confirmed that modification of $Bi_2Ti_2O_7$ by rare earth ions is an effective way to stabilize the cubic pyrochlore phase structure. For example, doping of La, Ce, or Nd ions into $Bi_2Ti_2O_7$ can stabilize the pyrochlore structure and suppress the formation of $Bi_4Ti_3O_{12}$ at a higher temperature.

On the other hand, some rare earth ions (for example, Er^{3+} ions) have been extensively used as luminescence centers over the past few decades due to their potential applications in solid-state lasers, three-dimensional color displays, low-intensity infrared imaging, and so on. Pyrochlore $Bi_2Ti_2O_7$ has a relatively low phonon energy and its maximum phonon energy is about 710 cm^{-1}. This will help decrease the nonradiative relaxation probability and increase the quantum yield of luminescence. Furthermore, $Bi_2Ti_2O_7$ has a high refractive index (n = 2.1 at 550 nm) and a wide band

gap (3 eV). Therefore, $Bi_2Ti_2O_7$ can be a potential host candidate for lanthanide ion activators.

Herein we reported the dielectric and photoluminescent properties of lanthanide doped bismuth titanate pyrochlore thin films. The doping lanthanide ions included Eu^{3+}, Er^{3+}, Ho^{3+}, and Tm^{3+} ions. The thin films were prepared on (111) $Pt/TiO_2/SiO_2/Si$ substrates and fused silica substrates by chemical solution deposition method. The thin films exhibited a relatively high dielectric constant and a low loss as well as good bias voltage stability. Dielectric relaxation has been confirmed through temperature and frequency dependent dielectric measurements. In addition, the down-conversion or up-conversion photoluminescence with different colors in these thin films have been studied. The photoluminescence can be further enhanced by codoping with different ion combinations such as Eu/Gd, Er/Yb, and Ho/Yb. The emission mechanisms were discussed. Our results suggest that the lanthanide-doped bismuth titanate pyrochlore thin films can find applications in new multifunctional photoluminescence dielectric thin-film devices.

Keywords: Photoluminescence, dielectric relaxation, pyrochlore bismuth titanate, thin film, lanthanide

Optical properties of mesoporous photonic crystals, filled by dielectrics, ferroelectrics and piezoelectrics

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At present, it is very important to create new types of mirrors and optical filters with controlled optical properties. In this connection, it is of great interest to study photonic crystals. Their dielectric permittivity varies periodically in space with a period permitting Bragg diffraction of light. A known example of photonic crystals is the mesoporous three dimensional opal matrices, constructed from highly packed amorphous silica nanoglobules. In the last years, a new method has been developed for production of mesoporous one-dimensional photonic crystals by electrochemical etching of aluminum [1-3]. The period of the crystal lattice depends on the etching regime and may vary in the range of 100-500 nm. Thus a number of stop bands in infrared, visible and ultraviolet region, corresponding to strong light reflectance, have been observed in such types photonic crystals. Such mesoporous photonic crystals may be saturated by different dielectrics, ferroelectrics and piezoelectrics. In this paper, we posed the problem of studying the optical properties of mesoporous three dimensional opal-type and one-dimensional anodic alumina photonic crystals, filled by different dielectrics (water, ethanol, glycerin), ferroelectrics ($NaNO_2$, KJO_3) and piezoelectrics ($LiIO_3$). We have compared the optical properties of initial mesoporous photonic crystals and filled by different substances. The comparison of experimentally measured

reflection spectra with the theoretical dependence was carried out in different spectral regions, including infrared. The possibility of mesoporous photonic crystals using as selective narrow-band light filters in Raman scattering experiments and as nonlinear mirrors was analyzed. The electromagnetic field enhancing in the case of exciting light frequency close to the stop band edges have been discussed. The possibility of an optical harmonics generation in mesoporous crystals, filled by $NaNO_2$, KJO_3 ferroelectrics and $LiIO_3$ piezoelectrics was considered.

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The Performance Modulation of GaN Power Devices by Dielectrics

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GaN-based high electron mobility transistors (HEMTs) are promising candidates for power electronics. However, because it is difficult to deplete the two-dimensional electron gas (2DEG) at the interface of AlGaN/GaN heterostructure, the threshold voltage (V_{th}) of GaN HEMTs tend to be negative, which means the GaN HEMTs are depletion-mode (D-mode). Enhancement-mode (E-mode) devices with a moderate positive threshold voltage (V_{th}) are more desirable than D-mode ones in power electronic applications because they provide the advantages of fail-safe operation. Much efforts have been devoted to E-mode GaN HEMTs with high V_{th}.

In the present talk, fluorinated Al_2O_3 thin films was used as gate dielectrics of GaN HEMTs. The threshold voltage of the GaN HEMTs shifted from conventional D-mode HEMTs to E-mode HEMTs. And it was found that not the surface potential but rather the negative charges in the fluorinated Al_2O_3 gate dielectrics are primary factors responsible for conversion from D-mode HEMTs to E-mode HEMTs. With a blocking oxide layer, a threshold voltage of 2.6 V was achieved to well meet the power electronic devices application.

To further improve operation safety of GaN HEMTs, polyimide (PI)/Cromium (Cr) composite thin films with high-permittivity was used as passivation layer to prevented the occurrence of strong electric fields at the drain side edge of the gate electrode in the present talk. The breakdown voltage was improved to be double by using the PI/Cr thin film passivation while maintaining good DC performance of the

HEMTs. As PI is widely used in the packaging of electronic devices, a practical way to improve reliability of GaN power devices is demonstrated.

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2D electronic and photoelectronic devices driven by ferroelectrics

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During the past decades, because of their unique properties, 2D materials have draw more and more attention for future applications on electronic and photoelectronic devices. Transition metal dichalcogenides (TMDs) are important members in the 2D material family, different from graphene, which have band gap and huge potential in low-dimensional electronics. Such as molybdenum disulfide (MoS_2), its band gap is from 1.2 eV to 1.8 eV with the thickness decreased from bulk to monolayer. As electronics, MoS_2 FET has a large current ON/OFF ratio and a high mobility [1]; as photoelectronics, it has a strong visible light response [2]. However, these two-dimensional material photodetectors are limited to background carrier concentration, the dark current is too large, and the band gap determines the infrared detection can not be achieved, restricting its application in the field of infrared detection. Ferroelectric materials have unique polarization characteristics and superior local polarization electric field. In FeFET, the carrier concentration of semiconductor channel can be completely depletd and accumulated by polarization electric field. Based on this idea, we combined the ferroelectric materials and 2D semiconductors to prepare high performance electronics and photoelectronics.

In our designs, a $MoSe_2$ memory and a MoS_2 photodetector which both driven by the organic ferroelectric polymer polyvinylidene fluoride (P(VDF-TrFE)) were achieved. For the $MoSe_2$ memory, it exhibits excellent memory performance, including large write/erase ratios ($>10^5$), long retention ($>2\times10^3$ s), and eximious endurance ($> 10^4$ cycles) [3]. For the MoS_2 photodetector, it shows excellent optical response because of

the polarization of ferroelectric materials, high photoresponsivity 2570 A/W and high detectivity 2.2×10^{12} Jones in visible detecting are achieved. Moreover, the large local electric field introduced by ferroelectric polarization can make MoS_2 atomic lattice rearrangement then its band gap becomes smaller, so that the detecting wave length can be extend to near-infrared (1550 nm) [4].

This new method for controlling the electrical and optical properties of the 2D materials by the field of ferroelectric polarization provides a new way for applying the 2D materials in electronic and optoelectronic devices.

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Robust High‐κ Ferroelectricity in 2D Perovskite Nanosheets

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Atomic-scale control of intriguing physical properties in ultrathin perovskites is an important challenge for exploring new physics and device functionality at atomic dimensions. Here, we demonstrate atomic-scale engineering of dielectric responses using two-dimensional (2D) homologous perovskite nanosheets ($Ca_2Na_{m-3}Nb_mO_{3m+1}$; m = 3–6),[1, 2] which are synthesized by delaminating Dion-Jacobson layered perovskites via soft-chemical method.[3, 4] In this homologous 2D material, the thickness of perovskite layers can be incrementally controlled by changing m, and such atomic layer engineering enhances the high- dielectric response and local ferroelectric instability. The end member (m = 6) attains a high dielectric constant of ~470, which is the highest among all known dielectrics in the ultrathin region (< 10 nm). The stable high- dielectric response and highly insulating nature ($J < 10^{-7}$ A cm^{-2}) remained substantially unchanged in a wide temperature range of -50 to 600 °C.[5, 6] These results suggest that 2D perovskite nanosheets could act as a building block to construct high- ferroelectrics and multiferroics for use in ultra-scaled high-density capacitors and post-graphene technology. [7, 8]

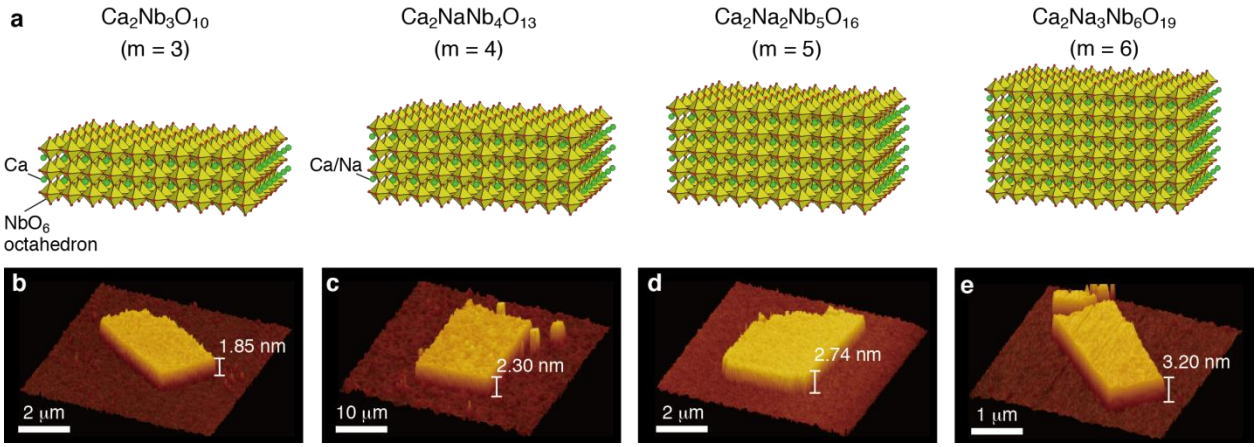

Figure 1. 2D dielectric perovskites. (a) Structures of $Ca_2Na_{m-3}Nb_mO_{3m+1}$ (m = 3 ~ 6) nanosheets. (b-e) AFM images of individual nanosheets.

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Raman Scattering Study of Phase Transitions in Multiferroics with Huntite Structures

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Multiferroic materials showing the coexistence of at least two ferroic orders ((anti)ferroelectric, (anti)ferromagnetic and (anti)ferroelastic) are expected to find potential applications in many devices. Amongst these properties the coexistence of ferroelectricity and ferromagnetism is highly desired. Besides their coexistence, of utmost importance is a strong coupling between the two ferroic orders. In multiferroic materials, the coupling interaction between the different order parameters can produce additional functionalities. The application of multiferroics will make possible to significantly enlarge the functional possibilities of spintronics.

Crystals of the RFe3(BO3)4 family (R is rare earth ion) were reported to possess multiferroic features, demonstrating both structural and magnetic phase transitions [1-4], where transition points may be varied by rare earth composition. In this work we used Raman spectroscopy to study $Ho_{1-x}Nd_xFe_3(BO_3)_4$, $HoFe_xGa_{3-x}(BO_3)_4$ and $Sm_{1-y}La_yFe_3(BO_3)_4$ single crystals.

Temperature measurements were performed in the temperature range 10–400 K. The aim of this study is to investigate the possible existence of a soft mode related to structural order parameter and effects of magnetic transitions on Raman spectra. Structural transitions manifest clearly by soft mode restoration and new Raman lines appearance below 366 K and 203 K for $x = 0$ и $x = 0.25$ compositions respectively for Ho–Nd system. In Nd-doped crystals significant modification of Raman scattering was

induced by magnetic ordering below the Neel temperature (about 40 K), that include both magnon scattering and strong intensity redistribution of high frequency lattice modes. Analysis of vibrational spectra and its numerical simulation demonstrate that bigger cell volume of Nd-containing solid solutions provides bigger displacements of oxygen ions in BO_3 groups below the Neel temperature that results in stronger magnetoelastic interactions.[5] This leads to the appearance of additional lines in the Raman spectra and rapid increase of their intensity with increasing magnetic order.

Raman spectra of Sm–La system has no changes associated with a structural phase transition in the entire temperature range. Raman spectra changes at low temperatures T = 10÷55 K, including the area of the magnetic phase transition has been analyzed. Anomalies corresponding to the phase transition of the second order has been detected at temperatures T_N = 32 K (x = 0), and T_N = 31 K (x = 0.75) in the spectra of the studied compounds. These temperatures correspond to temperatures of magnetic phase transitions and are consistent with previously reported results of a study of the magnetization. Analysis of the experimental Raman spectra, temperature dependences of the provisions of the centers of lines, their width and relative intensity was carried out, as well as theoretical temperature approximation for a number of lines.[6] A number of anomalies in the temperature dependences of the spectral lines associated with the occurrence of magnetic order. It was found that major changes are observed in the spectrum of low-frequency range (below 100 cm^{-1}) - there is a mode corresponding to two-magnon scattering (see Fig. 1). Detailed studies have shown that this mode has the internal structure, - there are a number of unstable oscillations (40-80 cm^{-1}). But otherwise, the nature of the changes relevant to the phase transition for crystals with different quantity Sm and La is different. There, as the offset lines below the temperature of the magnetic phase transition similar to that previously observed in

$TbFe(BO_3)_4$, as well as the emergence of new lines below the temperature of the magnetic phase transition in the solid solutions $(Nd_{1-x}Ho_x)Fe_3(BO_3)_4$.

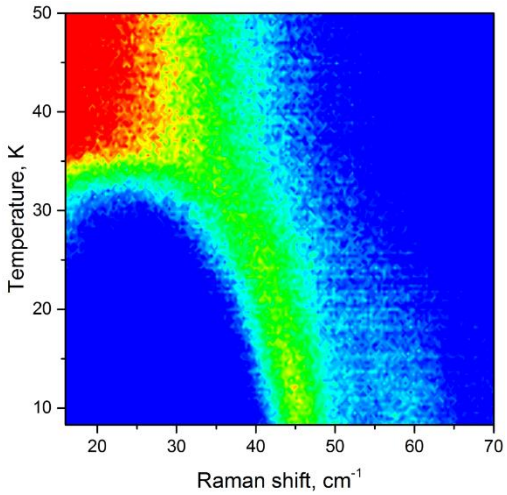

Fig. 1. Temperature begaviour of Raman spectra of the $Sm_{0.25}La_{0.75}Fe_3(BO_3)$ crystal in range corresponding to the two-magnon scattering

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Multi-state and Magnetoelectric Coupling Effects in Multiferroic Tunnel Junctions

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Although the basic concept was proposed only about 10 years ago, multiferroic tunnel junctions (MFTJs) with a ferroelectric barrier sandwiched between two ferromagnetic electrodes have already drawn considerable interests, driven mainly by its potential applications in multi-level memories and electric field controlled spintronics. Here, our recent results on multi-state and magnetoelectric coupling effects in MFTJs will be introduced. The ferroelectric memristive behaviors in $La_{0.7}Sr_{0.3}MnO_3/BaTiO_3/La_{0.7}Sr_{0.3}MnO_3$ multiferroic tunnel junctions have been observed and ten non-volatile magneto-electric resistance states were demonstrated to show its potential in high density memories. Interestingly, the ferroelectric domain switching for parallel magnetic state is relatively easier than that at antiparallel magnetic state, demonstrating the existence of magnetoelectric coupling effect. By evaluating the plasticity of resistances upon voltage pulse durations, we found that the memristor device at antiparallel magnetic state exhibits a relatively longer plasticity characteristic time than that at parallel magnetic states. Furthermore, a control of the spin polarization by purely electrical method was obtained in MFTJs employing a thin organic croconic acid ($C_5H_2O_5$) as ferroelectric barrier sandwiched between two ferromagnetic electrodes ($La_{0.7}Sr_{0.3}MnO_3$ and Co). Not only the magnitude but also the sign of the tunneling magnetoresistance effect is controlled by the ferroelectric polarization reversal. Possible mechanisms based on ferroelectricity controlled band alignment and interfacial redox of Co will be discussed.

Mircro-structure and Diffuse Phase Transition of $xP(Zn_{0.5}Te_{0.5})O_3$-(1-x)PZT Ferroelectric Ceramics

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The complex perovskite Pb(B',B'')O3 compounds perform high piezoelectric and electro-mechanical properties. Many studied on complex pervskite compositions are PMN-PT, PZN-PT, PNN-PZT. The Te^{6+}, which has the smaller ionic radius, has rarely few reported in complex perovskite compounds owing to the low melting point (733^{o}C) of tellurium oxides (Te_2O_3), and lower volatile temperature (450^{o}C), however, the Te^{6+} ion (ion radius 56pm) substitution in B site of Zr^{4+} (72pm) or Ti^{4+} (60pm) causes a large lattice distortion, which affects the ferroelectric and the piezoelectric properties.

In this work, the $xPb(Zn_{0.5}Te_{0.5})O3$-(1-x)PZT (PZnTe-PZT) solid solutions with x=0, 0.02, 0.04, 0.06, 0.08 and 0.12 are prepared by solid state reaction. High density PZnTe-PZT can be sintered in an optimized sintering process: ceramics with lower x (lower than 0.12) compositions can be sintered density and grain size decreases as the Te^{6+} content increase. XRD and SEM results show that the lattice structure are changed with the Te^{6+} content increase, indicating that substion of the Te^{6+} ion in the B site of PZT ceramics, but, it is difficulty to sinter a high density as composition is x=0.12. For x lower than 0.12. It is found that PZnTe sufficiently decrease Tc than other complex perovskite. Diffuse phase transition and flat thermal expansion coefficient up to Tc are observed. The affect of Te^{6+} ion is discussed for the PZnTe-PZT compositions.

Domain structure kinetics in single crystals of potassium titanyl-phosphate

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The domain shape and domain kinetics has been studied by experimentally in potassium titanyl phosphate ($KTiOPO_4$, KTP) using complementary experimental methods. The KTP crystals with periodical ferroelectric domain structure are one of the most promising materials for nonlinear optics, in which the main types of nonlinear optical interactions have been demonstrated. Despite the crucial importance of the in situ visualization of domain structure kinetics for creation of high quality periodical domain gratings there are only few works concerning KTP. The studied KTP samples representing 2-mm-thick plates cut perpendicular to polar axis were grown by top-seeded solution method.

The optical microscopy without selective chemical etching has been used for in situ visualization of domain structure evolution with high temporal resolution [1]. The obtained contrast was attributed to local change of the refractive index in the vicinity of the domain wall caused by residual depolarization field. The wide range of wall velocities with two orders of magnitude difference was observed for switching in uniform electric field. The kinetic maps allowed analyzing the spatial distribution of wall motion velocities and classifying the walls by velocity ranges. The distinguished slow, fast, and superfast types of domain walls differed by their orientation. It was

shown that the fast and slow domain walls provided the smooth input to the switching current, whereas the short-lived superfast walls resulted in short current peaks. The mobility and the threshold fields for all types of the domain walls were estimated. The domain shape stability effect representing the fast restoration of the rhombus shape just after merging of small isolated rhombus was demonstrated.

The model of domain growth by generation of elementary steps and kink motion was presented [1]. The revealed polarization reversal induced by chemical etching was attributed to action of the residual depolarization field appeared after partial removing of the screening charge layer.

The obtained results are important for further development of domain engineering in KTP required for creation of high power, reliable, and effective coherent light sources.

The research was made possible in part by Government of the Russian Federation (Act 211, Agreement 02.A03.21.0006) by RFBR (grant 16-02-00724), and by President of Russian Federation grant for young scientists (Contract 14.Y30.17.2837-MK). The equipment of the Ural Center for Shared Use “Modern nanotechnology” UrFU was used.

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Electrophysical properties of nanocrystalline $BaTiO_3$

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Influence of thermal treatment on crystalline structure, FTIR spectra and dielectric properties of initially cubic perovskite $BaTiO_3$ nanoparticles with average size of 100 nm (Sigma–Aldrich, USA) was studied. It was found that annealing leads to formation of ferroelectric tetragonal phase and increasing of tetragonal distortion of crystalline cell.

For the experiments the samples in the form of discs (diameter and thickness were 10mm and 1 mm, respectively) were used. The electrodes were made by silver paste coating. Before experiments the sample was placed in a thermostat where the temperature was varied from 20 to 300 ^{o}C and measured with an error less than ± 1 ^{o}C.

Experimental results show that an appearance of ferroelectricity in the nanostructured $BaTiO_3$ and its dielectric permittivity variation (ε) is caused by the decrease of lattice defects concentration owing to thermal annealing. Such defects lead, in particular, to the specific dependence of T_C on d.c. field.

Observed dispersion of dielectric permittivity (ε) and dielectric nonlinearity of the material under study within the ferroelectric phase are caused by the domain mechanism mainly. It was found that anomalous hysteresis of ε observed at cycle temperature variation in the vicinity of Curie temperature (T_C) is due to interaction of interphasic boundaries with lattice defects.

Studies of d.c. electrical conductivity revealed that charge transport is realized mainly through the granule volume. Considerable contribution to a.c. conductivity gives displacement currents which are caused by both the domain wall motion and the Maxwell–Wagner polarization. The last one supposedly due to a migration of charge carries in granule interfaces.

Dependences of magnetization on magnetic field strength were studied for both the nanostructured and the bulk ferroelectric $BaTiO_3$. It was found that nanostructured barium titanate demonstrates ferromagnetic and diamagnetic properties simultaneously. The annealing of nanostructured $BaTiO_3$ in H_2 atmosphere under experimental conditions leads to a significant increase of the spontaneous magnetization and decrease of the diamagnetic response. Analysis of experimental results shows that defects in grains surfaces of the the nanostructured $BaTiO_3$ (probably oxygen vacancies) are mainly responsible for electron states, which produce ferromagnetic and diamagnetic responses.

Formation of dendrite micro- and nanodomain structures in uniaxial ferroelectrics

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The formation of the domain shape instabilities and self-similar domain structures during polarization reversal in several uniaxial ferroelectrics in highly non-equilibrium switching conditions has been studied in details [1-3]. The complementary methods of domain structure visualization have been used for investigation of micro- and nano-scale static domain structures and domain kinetics in model uniaxial ferroelectrics: lithium niobate and lithium tantalate.

Modifications of the surface layer and spontaneous backswitching have been used for realization of the highly non-equilibrium switching conditions. Various manifestations of the discrete switching process through formation of the nanodomain arrays have been demonstrated. Original scenarios of the domain evolution including growth of the fractal, finger and dendrite domain structures were revealed experimentally and discussed within unified kinetic approach accounting for the decisive role of the retardation of the screening process. Various scenarios of the dendrite domain growth were realized. Thus the evolution of the domain structure in uniaxial ferroelectrics can be considered as the model object for investigation of the dendrite growth. The obtained knowledge can be used for development of the domain wall engineering for creating of the domain structures with very high wall concentration.

The formation of the isolated micro- and nanoscale domains with snowflake shape has been revealed for the first time in single crystals of uniaxial ferroelectrics. The

evolution of the snowflake domains during polarization reversal in uniform field have been observed in lithium niobate and lithium tantalate crystals with artificial dielectric surface layers. Similar shapes appeared also in lithium tantalate during cooling after pulse heating above transition point by laser irradiation. Domain visualization with high spatial resolution and in situ observation of the structure evolution allowed to study in details the formation and growth of the dendrites with snowflake shape during polarization reversal. All obtained results have been discussed in terms of the original approach based on the analogy between motion of the domain walls during polarization reversal and phase boundaries during first order phase transitions.

This work was supported by Russian Scientific Foundation (grant 14-12-00826). The equipment of the Ural Center for Shared Use “Modern nanotechnology” UrFU was used.

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Controllable Preparation and Energy Storage Properties of Barium Titanate-based Polyvinylidene fluoride Composites

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Ferroelectric (Ba,Sr)TiO_3 nanofibers prepared via electrospinning were used to fabricate PVDF composites. The use of paraelectric $Ba_{0.6}Sr_{0.4}TiO_3$ or $SrTiO_3$ fillers can provide a high dielectric constant while eliminating Maxwell–Wagner–Sillars interfacial polarization and reduces the energy loss and improved the energy discharged density of the composites compared to the composites with ferroelectric fillers. In this article, the inorganic/polymer nanocomposites, using the one-dimensional (1D) core-shell structure $BaTiO_3$@Al_2O_3 nanofibers (BT@Al_2O_3 nfs) as fillers and poly(vinylidene fluoride) (PVDF) as polymer matrix, has been prepared. The core-shell structure BT@Al_2O_3 nfs have been synthesized via coaxial electrospinning. The breakdown strength (E_b) and discharged energy density of the nanocomposites can be significantly improved by creating the insulating Al_2O_3 shell layer of moderate dielectric constant on surfaces of BT nanofibers to form moderate interfacial area. The Al_2O_3 shell layer could effectively confine the mobility of charges carriers, which reduces energy loss by reducing the Maxwell–Wagner–Sillars (MWS) interfacial polarization and space charge polarization between the fillers and the polymer matrix. As a result, the nanocomposite films filled with 5 vol.% BT@Al_2O_3 nfs exhibits excellent discharged energy density of 12.18 J cm^{-3} at 400 MV m^{-1}, which is ≈ 254% over the bare PVDF (4.8 J cm^{-3} at 350 MV m^{-1}) and ≈ 1015% greater than biaxially oriented polypropylenes (BOPP) (≈ 1.2 J cm^{-3} at 640

MV m^{-1}). The work here indicates that the promise of state-of-the-art method of preparing high energy density nanocomposites can be used in next generation of dielectric capacitors.

Keywords: Nanofiber, Composites, Electric Storage Property.

Giant Energy Density of Polymer Nanocomposites Dielectrics Induced by Interfaces-Engineering

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Electrostatic capacitors are the only type of energy storage device capable of delivering an ultrahigh power density, lowest loss and highest operating voltage compared to any other energy storage devices. They have been the major enabler for a number of modern electronic and electrical applications. However, the energy density of current dielectric materials is rather limited by the paradox between dielectric constant and breakdown strength. Large-aspect-ratio $BaTiO_3$@TiO_2 nanofibers (where $BaTiO_3$ nanoparticles are embedded in TiO_2 nanofiber) with interior hierarchical interfaces is employed to break the adverse coupling of electric displacement (D) and breakdown strength (E_B) in highly flexible PVDF/P(VDF-HFP)-based nanocomposite films. The large aspect ratio leads to remarkable high breakdown strength, and the hierarchical interfaces inside the nanofibers induce substantially enhanced interfacial polarization hence higher electric displacement. Finally, a small loading of 3 vol% $BaTiO_3$@TiO_2 nanofibers gives rise to an unprecedented giant energy density of 31.2 J/cm^3, this is by far the highest energy density ever achieved in polymer nanocomposites dielectrics, and an enhancement of 1500% over the bench-mark BOPP (2 J/cm^3). More importantly, a high discharge efficiency of ~ 78% is also achieved even at an ultrahigh electric field of 800 kV/mm. The mechanism of interfacial polarization enhancement is identified by theoretical results of both ab initio density functional theory (DFT) method and phased

field method. The concept of hierarchical interface provides a new design paradigm as well as a new toolbox for high energy density of polymer nanocomposites.

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POSTER PRESENTATION ABSTRACTS

Textured $(Bi_{1/2}Na_{1/2})TiO_3$-$BaTiO_3$-$AgNbO_3$ lead-free piezoceramics and multilayer actuators

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$(Bi_{1/2}Na_{1/2})TiO_3$ (BNT) based lead-free incipient piezoceramics are promising candidates for actuator applications due to their giant electromechanical strains originating from the reversible relaxor-ferroelectric phase transition. To decrease the electric field required for this large strain, the templated grain growth method was employed to prepare <100> oriented $0.91Bi_{1/2}Na_{1/2}TiO_3$-$0.06BaTiO_3$-$0.03AgNbO_3$ piezoceramics using plate-like BNT templates. Textured samples provided a high unipolar strain of 0.38 % and a corresponding large signal piezoelectric coefficient, d_{33}^* of 766 pm/V at 5 kV/mm, which are 78% higher than the values of the randomly oriented ones. The enhanced electric-field-induced strain at relatively lower field was attributed primarily to the facilitated phase-transition to form a long range ferroelectric order along the <100> direction. It was also found that the textured piezoceramics exhibited significantly reduced frequency dependence in the unipolar strain behavior at room temperature, resulting from the decreased driving electric field for the relaxor-ferroelectric phase transition.

Multilayer piezoelectric actuator based on BNT-BT-AN ceramics with Pt inner electrode are fabricated by tape casting method. The actuator exhibited a large strain around 0.30% under 6 kV/mm between 25°C and 150°C. This large strain is due to a

field-induced ferroelectric-relaxor phase transition. Remanent polarization and strain measurements in the non-fatigued state and after different numbers of unipolar fatigue cycles are provided, representing the comparison of the fatigue resistance of BNT-BT-AN lead-free bulk ceramics and the corresponding multilayer actuators. The results also show the multiayer actuator exhibits relatively high fatigue-resistance up to 10^7 cycles.

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Study on optical properties of complex perovskite ceramics

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Compared to the glass and single crystal, transparent ceramics not only have high transparency and corrosion resistance, but also can work in extreme condition. High permittivity and low dielectric loss of the complex perovskite ceramics provide the application potential as a high refractive index material with good intrinsic transmittance. Furthermore, with outstanding structure tolerant, transparent complex perovskite ceramics can be a good matrix candidate for Re doped luminescent material to improve the quenching concentration. In this study, Sn^{4+} doped $Ba(Mg_{1/3}Nb_{2/3})O_3$ (BMN) transparent ceramics were synthesized by a solid state reaction and investigated with using of first-principle method calculation. Additionally, Sm^{3+} doped BMN luminescent ceramic was also synthesized and investigated.

Sn^{4+} doped BMN transparent ceramics were fabricated via the solid state reaction with using active powders and isostatic cool pressing. The transmittance of the Sn^{4+} doped BMN transparent ceramic is 30–53% in the visible region, and its refractive index is 2.09–2.22 in the wavelength range of 400 to 1000 nm. The cut-on wavelength shifts with doping to the edge of the visible region (410 nm), leading to effective ultraviolet absorption.

The phase structure of Sn^{4+}: BMN was determined by Rietveld refinement. Based on the structural analysis, the electronic structure and optical properties of the material were calculated, analyzed and predicted. The theoretical analysis results show that the band gap of Sn^{4+}: BMN is gradually widening with the increasing of additive amount of

Sn^{4+}, the absorption edge being blue-shift, and the transparent area expanding, which are consistent with experimental results.

Sm^{3+} doped BMN luminescent ceramic were synthesized by the same method as Sn^{4+}: BMN. Structural analysis shows that Sm^{3+} enters the A-sites of BMN crystal structure. Sm^{3+}:BMN ceramic shows obvious absorption peaks at 407 nm, 465 nm and 478 nm. The emission spectrum excited by 407 nm shows characteristic emission peaks from f-f orbital transitions of Sm^{3+} at 564 nm, 600 nm, 647 nm, 708 nm. Because of the structure tolerant of BMN matrix, quenching concentration of the materials were improved to 2% mol, which were nearly 25% higher than most materials of literatures. All the above results show that doped BMN is an excellent candidate for the functional optical application.

Keywords: Complex perovskite ceramics; Transparent ceramics; Luminescent ceramic; Quenching concentration

Influence of interdigital electrode structure on electric field distribution of MFC

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With its good flexibility and outstanding piezoelectricity, Macro Fiber Composite (MFC), has attracted many researchers' attention, and many of them investigated the the electromechanical coupling behavior of MFC by simulation method, trying to improve perform of MFC by optimizing the design of fiber arrangement and interdigital electrode structure. These works were carried out with the precondition that the piezoelectric ceramic fibers in MFC have uniform expected electric properties. Actually, electric properties of fibers come from the processing progress such as polarization. The intensity and distribution of polarization electric field, which depend on the interdigital electrode structure, determines the uniformity and amplitude of fiber's electric properties. That means the design of MFC determines not only both the performance of MFC in the phase of application, but the properties in the phase of material processing. Unfortunately , the latter one has been ignored for a long time, leading to the gap between the simulation results and practical MFC performances. Here, we simulated the electric field distribution in fibers with various interdigital spacing and width respectively by FEM method with using COMSOL Multiphysics software, to find out the influence of interdigital electrode structure on electric field distribution of MFC. The calculation results show that with the increasing of the electrode spacing (from 0.25mm to 1.00mm), the uniformity of polarization electric field distribution in the fiber will be improved, which may benefit the polarization effect of MFC. While the electrode spacing can not increase infinitely, since the electric field strength of the

electrode edge is also increased with it sharply, which may breakdown the ceramic fiber. It is also predicted that with the electrode width increasing (from 0.1mm to 0.5mm), the volume of the dead zone of the fiber is bigger, which will dilute the polarization effect. To verify these predictions, experiments were also carried out. We prepared MFC specimens with changing electrode spacing and width under the same polarizing electric field (3kV/mm), and then tested their electrostrictive strains at low electric field (1/10 polarized electric field intensity) and calculated their dynamic piezoelectric coefficient d^*_{33}. The experimental results show that the d^*_{33} is increases gradually with the increase of electrode spacing. In spite of that, when the spacing is larger than 1.0 mm, extrema electric field at the edge of the electrode will breakdown the fiber. Considering the influence of electrode width, with its increases, the d^*_{33} is decreasing gradually. All these experimental results are consistent with calculation predictions. To summarize, both of simulation and experiment indicate that the electrode should be designed with a relatively moderate electrode spacing and as smaller as possible electrode width to improve the polarization effect and achieve optimized performance MFC.

Keywords: MFC; Polarization; Electric field distribution; FEM method

Microstructure and dielectric properties of BCZT thin films with alternative seed layer

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The lead free $Ba_{0.99}Ca_{0.01}Ti_{0.98}Zr_{0.02}O_3$ (BCZT) thin films were prepared by using sol–gel processing technique. The seed layers, ranging from 10 nm to 40 nm, were introduced between the films and the substrates to control microstructure of the BCZT thin films. The effects of seed layer thickness on structure and dielectric properties were investigated. With the increase of seed layers thickness, the grain size of the BCZT thin films increase accordingly, the dielectric properties become more sensitive to frequency. The seed layer thickness dependence of the dielectric properties of the films is attributed to lacking the dipole polarization. It demonstrate the possibility to control the microstructure and improve certain properties of BCZT thin films, which can be exploited for functional devices that demand high quality.

Keywords: Piezoelectric materials; Thin films; Sol-gel; Dielectrics

Multiple electrical response and enhanced energy storage induced by unusual coexistent-phase structure in relaxor ferroelectric composites

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$0.2Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.8Pb(Sn_xTi_{1-x})O_3$ composites show multiple electric response and enhanced energy storage properties. The PFM results demonstrate that a coexistent-phase structure exists in a single grain of PMN-PST with x = 0.44 and 0.48, which is composed of independent the R_p and F_p with different electrical properties. The coexistent-phase structure is the origin of the multiple relaxation and plays a crucial role in enhancing energy storage. The energy storage is obtained based on a high voltage pulse measurement, reflecting more actual charge-discharge process. The maximum current amplitude is 5.2 A under the electric field of 70 kVcm when x is 0.48, and the corresponding energy density is up to 0.85 J/cm^3. The enhanced energy storage is from the contributions of domain switching and dielectric associated with PNRs and the interfaces between the R_p and F_p, respectively. The study provides a feasible strategy for the development of high energy storage materials in the future.

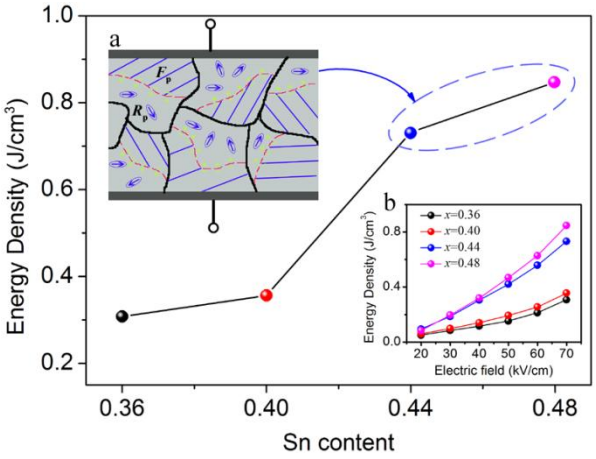

Figure 1. The structure and energy storage of PMN-PST composites.

Synthesis of g-C_3N_4/{001} TiO_2 composite with enhanced UV- and visible-light photocatalytic activity for MB degradation

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Anatase TiO_2 nanosheets with {0 0 1} facets have attracted various attentions in energy and environmental fields during the past 20 years. However, a property that restricts the widespread use of anatase TiO_2 in many cases, which is its large band gap of 3.2 eV that can only be excited by ultraviolet (UV) light [1-2]. Graphitic-C_3N_4 (g-C_3N_4), are a new type nonmetal semiconductor with outstanding mechanical, electrical, thermal, and optical properties [1], which has been used as a narrow band gap semiconductor for coupling with other photocatalysts.

Herein, we introduced an integrated design and synthesis of direct contact Z-scheme with an emphasis on synergistic promotion on charge separation. The metal-free g-C_3N_4 and environment-friendly TiO_2 with {001} facets exposed are employed to fabricate the direct contact Z-scheme by a facile calcination route utilizing a certain amount of bulk g-C_3N_4 and TiO_2 nanosheets as the precursors.

It was shown that the photocatalytic activity of the prepared Z-scheme photocatalysts was highly dependent on the g-C_3N_4 content. At the optimal g-C_3N_4 content (sample $TCN_{0.1}$ in this study), the apparent reaction rate constant was 3.26×10^{-2} min^{-1} for MB decomposition, which exceeded that of pure TiO_2 (1.44×10^{-2} min^{-1}) by a factor of 2.3. Comparison of the photocatalytic activity of the TiO_2, g-C_3N_4, $TCN_{0.075}$, $TCN_{0.1}$, $TCN_{0.3}$ samples for the photocatalytic decomposition of MB was shown in Fig. 1. The enhanced photocatalytic activity could be ascribed to the formation of g-

C_3N_4/TiO_2 Z-scheme photocatalyst [3], which results in efficient space separation of photo-induced charge carriers.

Acknowledgement. This work was financially supported by the National Natural Science Foundation of China (No. 51572073).

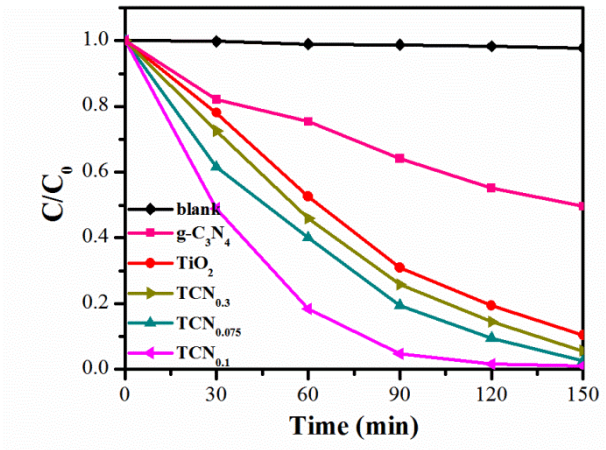

Fig.1. Comparison of the photocatalytic activity of the TiO_2, g-C_3N_4, $TCN_{0.075}$, $TCN_{0.1}$, $TCN_{0.3}$ samples for the photocatalytic decomposition of MB

Keywords: *calcination • {001} TiO_2 • g-C_3N_4• photocatalyst*

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Ferroelectric photovoltaic effect of $[KNbO_3]_{0.9}[BaNi_{0.5}Nb_{0.5}O_{3-\sigma}]_{0.1}$ lead free thin film with narrow band gap

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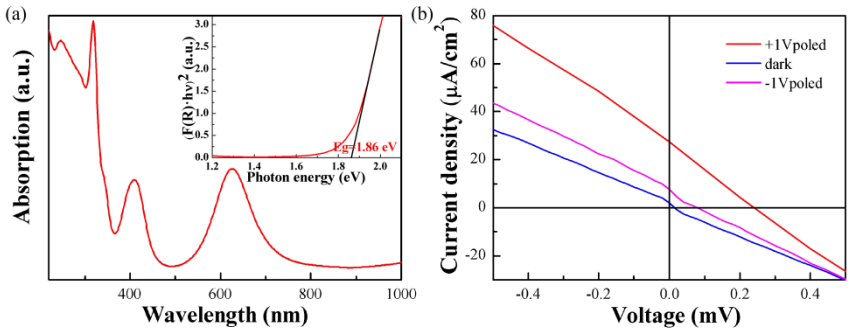
Ferroelectrics have received considerable attentions as a candidate class of materials for use in photovoltaic and other multifunctional devices since abnormal photovoltaic effect was found in $BaTiO_3$ and Pb(Ti, Zr)O_3 in 1970s.[1] However, most of ferroelectrics have wide band gaps of 2.7-4.0 eV, accounting for more than about 80% of the solar spectrum cannot be absorbed by ferroelectric materials. So, there is a big challenge for ferroelectrics to have a more sufficient light absorbing in the visiblelight range and exploration of narrow band gap ferroelectric materials is the key.[2] In 2013, Grinberg et al. have reported a perovskite solid-solution: $[KNbO_3]_{1-x}[BaNi_{0.5}Nb_{0.5}O_{3-\sigma}]_x$ (KBNNO), which exhibit a tunable direct bandgaps in the range 1.1-3.8 eV. However, their work only concentrated on the study of Ferroelectric photovoltaic effect on the 20-μm KBNNO thick film, which is too thick to separated photogenerated electrons and holes. In this work, a 483-nm KBNNO thin film was deposited on Pt(111)/Ti/SiO_2/Si(100) substrate with Transparent indium tin oxide(ITO) top electrodes of 500 μm diameter coated on it by pulsed laser deposition(PLD). Structural, ferroelectric and optical properties as well as photovoltaic properties and photocurrent responses of the KBNNO film were investigated.

It was shown that a high-quality, narrow-band gap(~1.83 eV) and high-ferroelectricity(~0.1 μC/cm^2) KBNNO lead-free thin film was successfully prepared on Pt(111)/Ti/SiO_2/Si(100) substrate by PLD. The photocurrent density(27.3 μA/cm^2) is

two orders of magnitude bigger than what is reported by Ilya Grinberg *et al*. who reported a J_{sc} of 0.1 μA/cm^2 and V_{oc} of 0.7 mV at room temperature while the V_{oc}(~0.24 mV) is almost the same.



(a) UV-vis-NIR absorption spectra and a plot of $(\alpha h\nu)^2$ versus hν for the absorption spectra (inset). (b) J-V characteristics for the KBNNO device.

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Effect of Mixture of different Calcination Temperature on Piezoelectric Properties of PZT Piezoelectric Ceramics

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In recent year, domestic and foreign experts and scholars has done a lot of research about doping modification of the PZT piezoelectric ceramic,to have a more e -xcellent, more stable performance, so that PZT ceramic into a new development stage. However, there is not much research on the calcination temperature of PZT ceramics[1-2]. In this article, $Pb(Zr_{0.53}Ti_{0.47})O_3$ piezoelectric ceramics doped with 0.3wt%La_2O_3 and 0.2wt%Nb_2O_5 were fabricated by a conventional solid-state reaction method.It was investigated that the effects of calcination temperature and the ratio of materials calcined at 830℃、860℃ and 890℃ on the phase structures and piezoelectric properties.The results show that the piezoelectric properties is better that calcination temperature is 890℃and the piezoelectric properties of ceramic samples when the ratio of materials calcined at 1.5:1:0.5 and 0.5:1:1.5 is better than those of the ratio are 1:1:1 and 0.5:1:0.5.

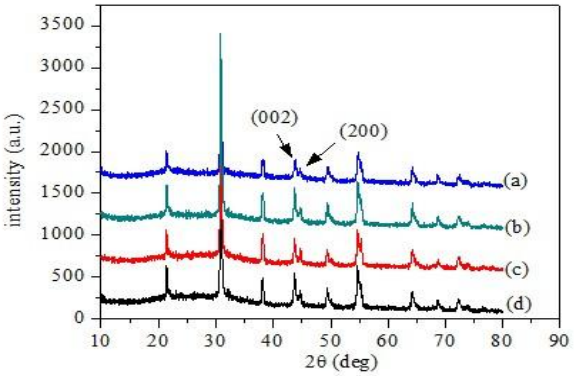
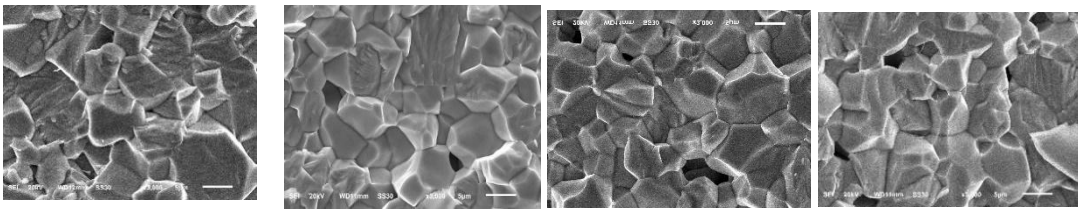


Fig.1. X-ray diffraction patterns of different ratio of material calcined at 830℃、860℃、890℃.(the ratio of materials calcined at 1:1:1(a),at 0.5:1:1.5(b), at 0.5:1:0.5(c)，at 1.5:1:0.5(d).)



(a) (b) (c) (d)

Fig. 2. SEM images of different ratio of material calcined at 830℃、860℃、890℃. (the ratio of materials calcined at 1:1:1(a),at 0.5:1:1.5(b), at 0.5:1:0.5(c)，at 1.5:1:0.5(d).)

Key Words: piezoelectric ceramics；PZT；calcination temperature；piezoelectric properties.

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High performance $BiFeO_3$ multiferroic ceramics prepared through sequential doping of Ba and Ti

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In this work, Ba and Ti codoped $Bi_xBa_{1-x}Fe_yTi_{1-y}O_3$ (x, y≤0.15) ceramics were successfully fabricated by using a solid state reaction method. In this two-step doping method, Ba and Ti were doped in calcination and sintering, respectively. The XRD diffraction patterns show some slight differences in the lattice of the perovskite phase, the *E-J* characteristics, dielectric loss curves and *M–H* loops show a high resistivity of 4×10^{12} Ω·cm, a low dielectric loss of 0.05 at 10^3 Hz, and a large remnant magnetization of 1.5 emu/g. Compared with samples prepared with single-step doping, the two-step doping samples have a diff erent lattice distortion, reduce grain size, decrease dielectric loss, as well as increasing resistivity and remnant magnetization at the same time. The contrast between these two doping strategies clearly reveals the importance of establishing a proper doping strategy when two or more elements are co-doped to $BiFeO_3$.