一軸性タングステンブロンズ構造の無鉛リラクサー強誘電体の電場効果

Electric Field Effect on Lead Free Relaxor Ferroelectrics with Uniaxial Tungsten Bronze Structure

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派遣先　International Conference on Technologically Advanced Materials and Asian Meeting on Ferroelectricity (ICTAM-AMF10)
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海外における研究活動状況

研究目的

At present, ferroelectric materials are used in micro- and nano-electromechanical systems and electro-optical devices to design very high efficiency sensors, actuators, very high capacity non-volatile ferroelectric random access memories (FeRAMs) and high density multilayer capacitors. Most of the used materials are lead-based. The $Sr_xBa_{1-x}Nb_2O_6$ are crucial materials for investigations due to their unique combination of physical properties, simple structures and lead free nature. An advanced research on these ferroelectric materials is obviously required to explore the insight mechanism which will create new ideas in the field of ferroelectricity for the device application.

海外における研究活動報告

Conference overview

The International Conference on Technologically Advanced Materials and Asian Meeting on Ferroelectricity (ICTAM-AMF10) was held during November 7-11, 2016 at University of Delhi, New Delhi, India. Total 694 delegates across the globe attended from 30+ countries including USA, UK, Japan, South Korea, China, Thailand, Germany and many more. Among them 12 plenary lectures, 127 invited talks, 82 oral lectures and 473 poster presentations. There were six parallel sessions in six large hall room and several interesting topics including (i) Dielectric, Piezoelectric, Ferroelectric and Related Materials, (ii)Nanomaterials and Applications, (iii) Carbon materials:Graphene, Lead Free Materials, Oxides and Composites, (v)Electronic and Spintronic Materials, (vi)Piezoelectric Materials and Sensors, (vii)Multiferroic and magnetic Materials, (viii)Advanced and Smart Materials and Electronic Device Applications, (ix)Energy

Harvesting and Thermoelectric Materials and Devices, (x)Bio-inspired Materials and Biomedical Applications, (xi)Functional Materials Thin Films and Functional Materials, (xii)Epitaxial Grown Ferroelectrics and Characterization, and (xiii) Advanced Materials Characterization. Therefore, this conference was a unique platform for the students, young scientists and renowned researchers from different branches of materials science to interact with each other, share knowledge, and establish new collaborations.

The research presented at ICTAM-AMF10

My oral presentation was held on 7th November, 2016 entitled "Electric Field Effect on Lead Free Relaxor Ferroelectrics with Uniaxial Tungsten Bronze Structure". Now a days, ferroelectrics materials play a very important role in world of modern technology because of their exceptional physical properties. The intense interest in micro- and nano- sized piezoelectric and electrostrictive actuators, which are particularly attractive for future smart technological applications such as micromechanics, robotics, and microfluidics have made the ferroelectric materials a promising candidates in the novel research fields. Strontium barium niobate, $Sr_xBa_{1-x}Nb_2O_6$ (SBN) with a tetragonal tungsten bronze structure, are of technologically important uniaxial relaxor ferroelectrics because of its excellent dielectric, piezoelectric, pyroelectric, and photorefractive properties. From the environmental point of view, SBN single crystals are very important materials for research because of their unique physical properties and lead free nature. Therefore, we choose these materials for research and the many valuable information related to the insight mechanism and functionality have been observed. The elastic properties of uniaxial relaxor $Sr_xBa_{1-x}Nb_2O_6$ (x = 0.40, SBN40) single crystals were studied under the zero and externally applied dc electric field using broadband Brillouin scattering spectroscopy. A marked thermal hysteresis was observed below T_C in the LA shift between zero field heating (ZFH) and zero field cooling (ZFC) processes. The effect of the electric field along a [001] direction was clearly observed. On field heating (FH) under 3.0 kV/cm, an incomplete alignment of nanodomains at 50 ºC and a complete switching of nanodomains to the macrodomain state at 149 ºC were observed. On field cooling (FC) a remarkable increase of longitudinal acoustic (LA) velocity and decrease of thermal hysteresis were observed below Curie temperature, T_C. The poling effect of high electric field on static polar nanoregions (PNRs) in paraelectric phase was investigated. After applying 5 kV/cm for 60 min at 160 ºC, LA velocity during ZFC shows the similar fashion of FC due to the alignment of static PNRs along the field direction. By decreasing the poling time to 1 min, some PNRs switch back and therefore, the splitting of LA mode was observed. The high-frequency LA mode corresponding to the macrodomain induced by electric field and low-frequency LA mode corresponding to the nanodomains induced by random fields (RFs).

Discussion and Conclusions

A marked thermal hysteresis below T_C in the LA shift between ZFH and ZFC processes indicates that the SBN40 single crystal has a defused phase transition which is related to the incomplete switching of nanodomains induced

by quenched RFs.On FH under 3.0 kV/cm, an incomplete alignment of nanodomains at 50 ºC were observed due to the formation of some correlation between dipoles of PNRs.Upon heating, this correlation become weaker near T_C results a complete switching of a nanodomain to a macrodomain state at 149 ºC. On subsequent FC,the anomaly at 149 ºC was not observed because of the complete switching of nanodomains during the previous FH. Since external electric field suppresses the RFs, a significant decrease of thermal hysteresis and a remarkable increase of LA velocity were observed below T_C. Poling the sample above T_C, reveal a very important result.After poling the crystal with a high electric field for long time above T_C, all static PNRs are aligned along the field direction. As a result, the poled crystal show the same behavior as the crystal on cooling under constant electric field.By decreasing the poling time to 1 min, some of the PNRs switch back to their initial direction, and therefore a splitting of the LA mode was observed below T_C. This splitting indicates the presence of mixed state consisting of nanodomains induced by RFs and macrodomain induced by the external electric field.From the above observations it is confirmed that in SBN40,PNRs exist not only in a ferroelectric phase below T_C but also in a paraelectric phase above T_C similar to other typical relaxor ferroelectrics. All the results obtained from this research are unique and very important to understand the insight mechanism of relaxor ferroelectrics. These findings will be helpful for further research on relaxor ferroelectrics and their application in future smart devices.

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