

Energy storage: high performance material engineering

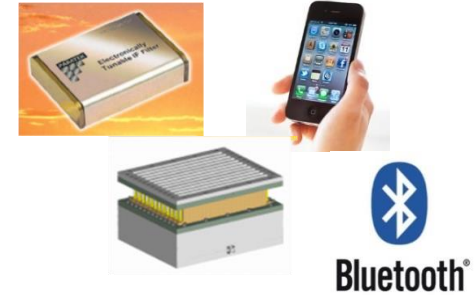
— Teranishi Group —
Faculty of Engineering

Research activities

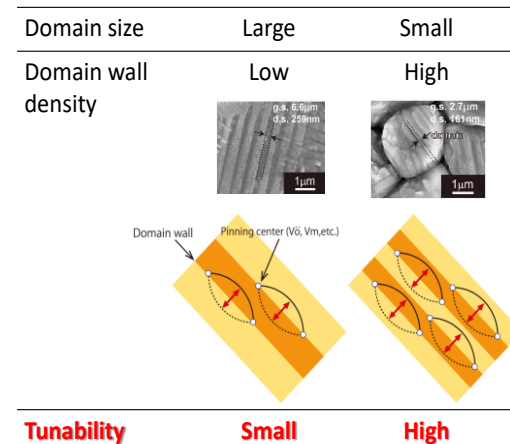
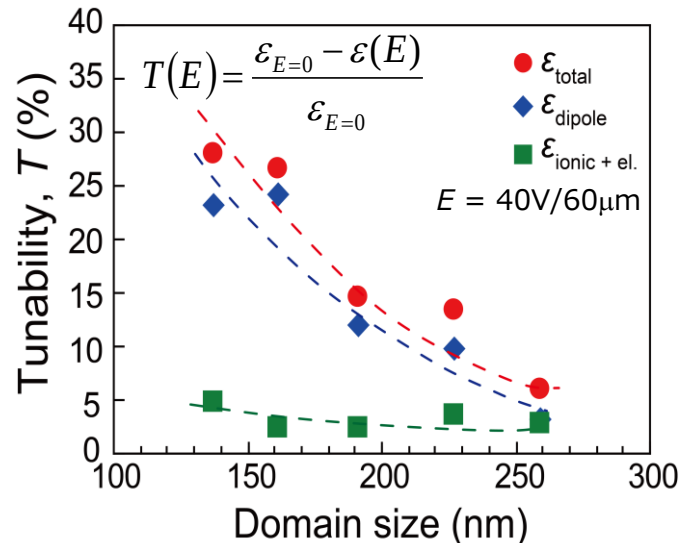
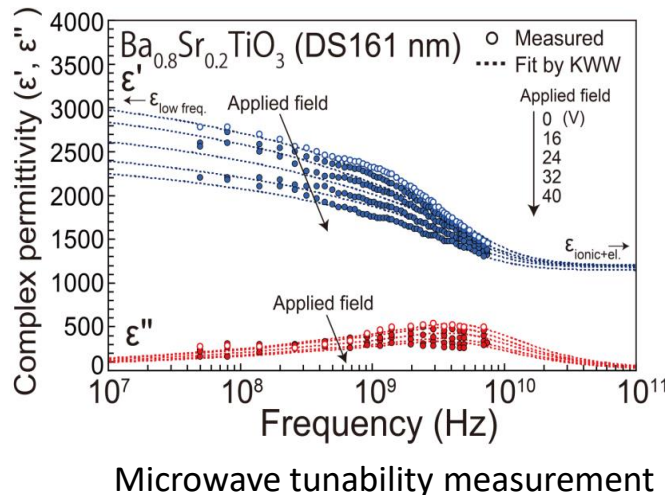
1. Polarization assisted ultrahigh rate lithium ion batteries
2. Lithium ion conductor-dielectrics nano-composite capacitor exhibiting enormous capacitance
3. Tunable ferroelectrics with controlled ferroelectric domain configuration
4. Broadband dielectric spectroscopy on oxide materials

Tunable ferroelectric oxides

Ferroelectric oxides with high nonlinearity has been widely used for microwave tunable devices, such as tunable capacitors, phase shifters and tunable antennae, attributing to the ferroelectric domains...



Objective: Enhance the tunability T for ferroelectric oxides by controlling domain structure



Down sizing of the ferroelectric domains effectively improved overall tunable property in ferroelectrics

Further we need to know the defect contribution such as oxygen and cation vacancies to the tunable property besides the ferroelectric domain size.

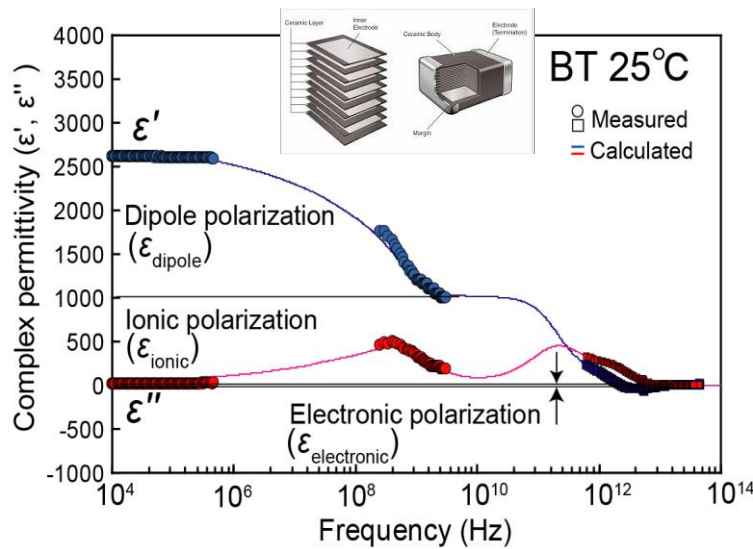
T. Teranishi et al., Jpn. J. Appl. Phys. **52** (2013) 09KF06.

Broadband spectroscopy for oxides

Broadband spectroscopy on dielectric and conductive oxides yields to understanding of the origin of polarization and conduction mechanism.

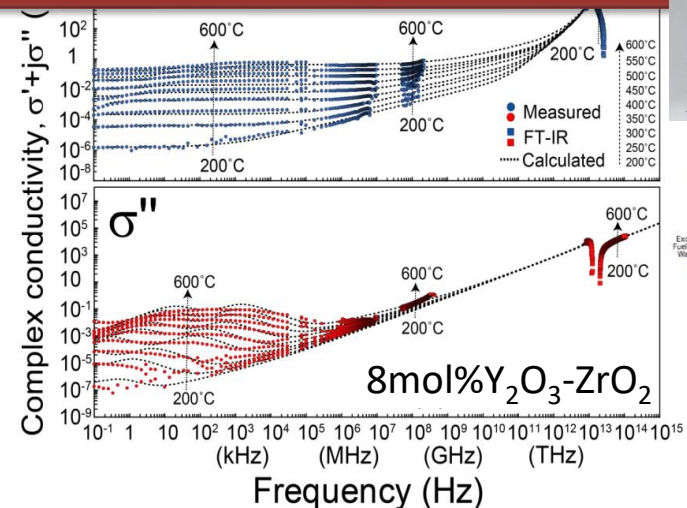
Objective: Determine the broadband dielectric / conductivity spectra from low to THz region for various oxides to analysis their polarization / conduction mechanisms.

Ferroelectrics: BaTiO₃



We'll determine broadband spectra for given dielectric and ion conductive oxides if asked.

Oxygen ion conductors: YSZ



T. Teranishi et al., Appl. Phys. Lett. **100** (2012) 24290
T. Teranishi et al., J. Appl. Phys. **105** (2009) 054111.
T. Teranishi et al., Jpn J. Appl. Phys. **51** (2012) 01110

Teranishi Gr. International Projects

ASCENT



Okayama University researcher: Pr. Teranishi

Tyndall researcher : Dr. Liam Floyd <liam.floyd@tyndall.ie>

Coordinator : Dr. Nicolas Cordero <Nicolas.Cordero@tyndall.ie>

"Nanoscale TLs for ferroelectric characterization"

*TL=transmission line

The dielectric measurement technique for ferroelectric ceramics up to 100GHz using down to 100 nm sized transmission line electrodes will be established.

The advanced metal deposition technique using EB-lithography as well as a series of facilities for microwave dielectric evaluation at Tyndall will be accessed

To understand the microscopic polarization behaviour in ferroelectric compounds

----- Performed in April 2017 ([see the ASCENT news](#))

Specific gain expected at ASCENT (Tyndall) platforms

Up to 100GHz at Tyndall – 9GHz only at Takashi's lab.

Since the dipole polarization in ferroelectrics fully relaxes up to tens of GHz at the highest, the measuring the permittivity up to 100 GHz will deliver the accurate quantification to the dipole contribution as well as the determination of the relaxation frequency of dipoles.

The analysis will thus allow us to understand the microscopic polarization behaviour in ferroelectric compounds

Teranishi Gr. members (y-2017)

1 PhD student (L-I-Batteries)

6 MD students (LIB, Ferroelectrics)

4 BD students (LIB, Capacitors, Ferroelectrics)

1 internship student (Ph.D), Canada-INRS, Duration: 2017. May- 2017. July.

*LIB: Lithium ion batteries, LIC: Lithium ion capacitor

Recent papers

- 1) T. Teranishi, S. Kajiyama, H. Hayashi, A. Kishimoto,
Polarization behavior of sol-gel-derived relaxor Ba(Zr, Ti)O₃ films",
J. Am. Ceram. Soc., in press (2017).
- 2) T. Teranishi, R. Kanemoto, H. Hayashi, A. Kishimoto,
Effect of the (Ba + Sr)/Ti ratio on the microwave-tunable properties of Ba_{0.6}Sr_{0.4}TiO₃ ceramics",
J. Am. Ceram. Soc., 100, 1037-1043 (2017).
- 3) T. Teranishi, Y. Ishii, H. Hayashi, A. Kishimoto,
"Lithium ion conductivity of oriented Li_{0.33}La_{0.56}TiO₃ solid electrolyte films prepared by a sol-gel process",
Solid State Ionics., 284, 1-6 (2016).
- 4) T. Teranishi, Y. Yoshikawa, R. Miyahara, H. Hayashi, A. Kishimoto, M. Katayama, Y. Inada,
"In situ time-resolved dispersive X-ray absorption fine structure analysis of BaTiO₃-LiCoO₂ composites for
lithium ion batteries",
J. Ceram. Soc. Jpn, 124, 659-663 (2016).

- 5) T. Teranishi, N. Katsuji, Y. Yoshikawa, M. Yoneda, H. Hayashi, A. Kishimoto, K. Yoda, H. Motobayashi and Y. Tasaki,
"High rate capability of a BaTiO₃-decorated LiCoO₂ cathode prepared via metal organic decomposition",
Jpn. J. Appl. Phys, 55, 10TB01 (2016).
- 6) T. Teranishi, Y. Yoshikawa, R. Sakuma, H. Okamura, H. Hashimoto, H. Hayashi, T. Fujii, A. Kishimoto, and Y. Takeda,
"High-Rate Capabilities of Ferroelectric BaTiO₃–LiCoO₂ Composites with Optimized BaTiO₃ Loading for Li-Ion Batteries",
ECS Electrochem. Lett., 4, A137 (2015).
- 7) T. Teranishi, Y. Yoshikawa, R. Sakuma, H. Okamura, H. Hayashi, A. Kishimoto, and Y. Takeda,
"In situ Impedance Analysis on BaTiO₃-LiCoO₂ Composite Cathodes for Lithium Ion Batteries.",
Jpn. J. Appl. Phys., 54, 10NB02 (2015).
- 8) T. Teranishi, T. Sogabe, H. Hayashi, A. Kishimoto, K. Iokibe, and Y. Toyota,
"Effect of Mg loading on the High-Frequency Tunability of Ba_{0.8}Sr_{0.2}TiO₃ Ceramics",
Jpn. J. Appl. Phys., 54, 011502 (2015).
- 9) T. Teranishi, Y. Yoshikawa, R. Sakuma, H. Hashimoto, H. Hayashi, A. Kishimoto and T. Fujii,
"High-rate performance of ferroelectric BaTiO₃-coated LiCoO₂ for Li-ion batteries",
Appl. Phys. Lett., 105, 143904 (2014).
- 10) T. Teranishi, A. Kouchi, H. Hayashi, A. Kishimoto and K. Fujimori,
"Dependence of the conductivity of polycrystalline Li_{0.33}Ba_xLa_{0.56-2/3x}TiO₃ on Ba loading",
Solid State Ionics, 263, 33-38 (2014).
- 11) T. Teranishi, N. Matsubara, H. Hayashi, and A. Kishimoto,
"Relation between phonon parameters and oxygen ion conductivity for Al-Yb Co-doped zirconia",
Key Eng. Mater., 582, 107-110, (2014)