4 Engineering Materials

Professor : Dr. Shinjiro Tashiro

Associate Professor : Dr. Yoichi Okamoto

Keywords: piezoelectric material, dielectric material, ceramic, single crystal, thermoelectric conversion, artificial superlattice thin film, low dimensional nano materials

Engineering Materials conducts research and education about the materials design, materials processing and application of functional materials.

Shinjiro Tashiro

Piezoelectric Ceramics, Dielectric Ceramics, Semiconducting Ceramics, Piezoelectric Nonlinearity, Lead-Free Ceramics, Hot-Press, Grain Orientation

---

Ⅰ Evaluation of piezoelectric nonlinearity during high-power vibration

Nonlinear phenomena are quantitatively described using a new nonlinear coefficient we defined in lead-based piezoelectric ceramics.
Detailed topics are:

(1) Nonlinear phenomena, such as generation of higher harmonic voltages, change in resonance frequency and current-jumping, were compared between lead zirconate titanate (PZT) piezoelectric and lead magnesium niobate (PMN) electrostrictive ceramics. This comparison was carried out in order to discuss the effect of domain wall motion on the nonlinear behavior that appears during high-power driving at around resonance frequency.
(2) Second-harmonic and third-harmonic voltages, appearing due to nonlinearity, was theoretically calculated in piezoelectric rectangular vibrators which were driven by a sinusoidal constant current having the resonance frequency of length-extensional vibration. The theoretical calculation was performed using the electrical equivalent circuit of a piezoelectric rectangular vibrator.
(3) In order to clarify the occurrence mechanism of nonlinear phenomena, dc-bias dependence and aging characteristics of the two nonlinear coefficients of second-higher and third-higher terms were investigated. Their two coefficients contrasted sharply in their dc-bias dependence and aging characteristics due to the mechanism of nonlinearity

Ⅱ Development of lead-free piezoelectric ceramics with high coupling coefficients

Microstructure and piezoelectric properties were investigated in potassium sodium niobate based ceramics, in anticipation of high piezoelectric properties.
Detailed topics are:

(1) The grain growth strongly depended on the A/B ratio in perovskite structure and the phenomenon was markedly similar to that of barium titanate semiconducting ceramics with donor additives. Piezoelectric properties were strongly affected by grain size.
(2) MnO additive was added to suppress grain growth anomaly, dense ceramic body formation and withstanding voltage enhancement.

The powder obtained by previously calcining the mixture Nb_2O_5 and $MnCO_3$ was used as a raw material for MnO addition, in order to obtain dense body and uniform

(1) Transport properties of artificial superlattice thin film semiconductor

Yoichi OKAMOTO

The artificial suprlattice is most practical candidate in nano-technology material. Artificial superlattice is made by alternative accumulation of different kind of atoms with few atomic layers. Therefore, we can make the "New materials which never existed in natural" with artificial design.

Results of this theme;

(a) Discovery of superconduction with Au/Ge superlattice thin film. Both of Au and Ge are normal conductor.

(b) Discovery of extremely large thermoelectric power of Si/(Ge+Au) superlattice thin film. Which has few hundreds large thermoelectric power compared with another past materials.

(2) Thermoelectric conversion of sintering semiconductor

Yoichi OKAMOTO

We have already found the extremely superior thermoelectric properties of Si/(Ge+Au) superlattice thin film. It is not possible to apply for practical usage. Because, thin film is too small to supply enough electric current for thermoelectric electric power generation and thermoelectric cooling. Therefore, the purpose of this theme is to make bulk material with keeping superior thermoelectric properties of Si/(Ge+Au) superlattice thin film.