First order reversal curve diagrams for high quality $BiFeO_3$ epitaxial films

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Ferroelectric hysteresis (spontaneous polarization *v.s.* electric field; *P* - *E*) loops have been discussed for a long period because ferroelectric polarization controls the variety of physical properties such as reflective index, piezoelectric, and magnetics in multiferroics by applied electric field. First order reversal curve (FORC) diagram rearranged by *P* – *E* loops are used for analyzing the ferroelectric properties, coercivity, imprint, switching distribution, superparaelectric, fatigue, porous anisotropy. **[1 - 4]** However, there was not so many reports using FORC diagram. One practical reason is that leakage current superposes ferroelectricity, purely switching of ferroelectric polarization can not be discussed based on leaked samples. In our previous study, [5] the leakage current of $BiFeO_3$ (BFO) epitaxial films was drastically decreased under optimized sputtering conditions. Compared with the $Pb(Zr, Ti)O_3$ (PZT) film which has mixed of crystal symmetry, [1 - 4] the *P* – *E* loops of BFO films exhibited high squareness due to single crystal symmetry. In this study, the high squareness of BFO epitaxial film with low leakage current was analyzed by FORC diagram. Figure 1 shows the *P* – *E* loop and FORC diagram of BFO film. After the positive poling, the *P* – *E* loops were measured. In the Preisach model, [6] the FORC diagram shows exchange bias for the positive electric field, and the distribution of switching had a tendency to be localized compared with PZT films owing to high squareness of BFO. We also discuss rearrangement process of FORC analysis.

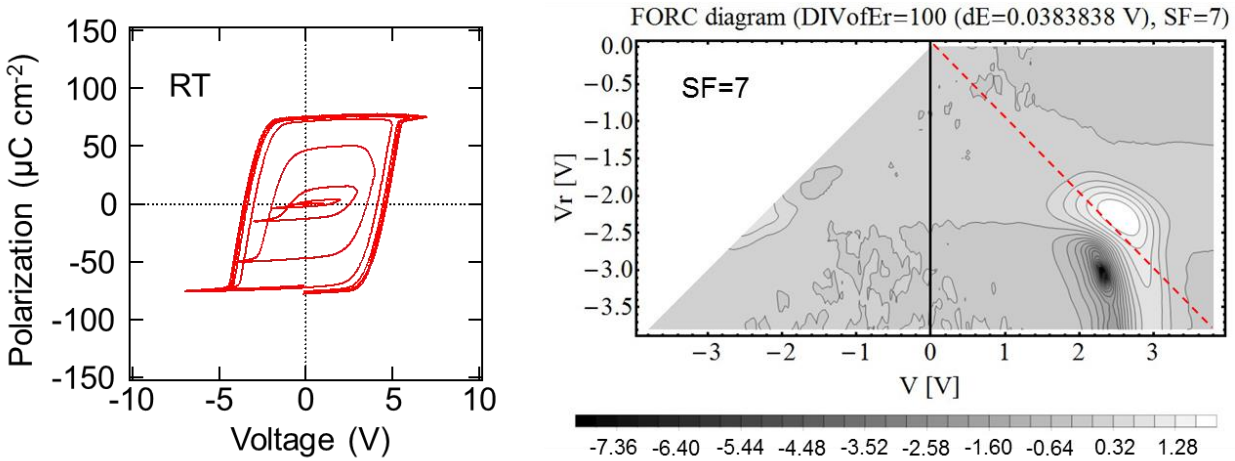

Figure 1 Ferroelectric hysteresis loop and FORC diagram of BFO epitaxial film

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