OA-19

Domain engineering in relaxor-PT ferroelectric single crystals

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Domain engineering is an important and effective technique for enhancing piezoelectric properties in ferroelectric single crystals. The <001>-oriented rhombohedral relaxor-PT ferroelectric single crystals, such as PMN-PT and PZN-PT, exhibit ultrahigh piezoelectric properties due to engineered domain configuration. This engineered-domain configuration technique makes use of the anisotropy of the ferroelectric single crystals as a function of the crystallographic orientation. For example, the [001] poled orthorhombic $BaTiO_3$ crystals with the engineered domain configurations exhibited d_{33} of over 500 pC/N and k_{33} of over 85%. For relaxor-PT ferroelectric single crystals, there are several ways to manipulate engineered-domain configuration for enhancement the piezoelectric properties, such as applying nanocomposite electrodes, modifying the pattern of electrodes and utilizing different poling methods. Recently, Yamamoto and Yamashita et al. reported an alternating current poling (ACP) method that can enhance the dielectric and piezoelectric properties of PMN-PT crystals.

The ACP method may be an effective domain engineering technique for enhancing piezoelectric properties of relaxor-PT ferroelectric single crystals. The reported work about the ACP focused on the PMN-PT crystals with low coercive field. The smaller of the coercive field is, the easier of the domain reverse. It is not clear the effect of domain engineering for relaxor-PT ferroelectric single crystals with high Curie temperature and large coercive field. In this work, PIN-PT single crystals were grown by top-seeded solution method, new poling method for domain engineering was used to enhance the piezoelectric properties of PIN-PT crystals. The d_{33} of PIN-PT single crystal is 1050 pC/N, 1450 pC/N after DCP and ACP at room temperature respectively. The d_{33} after ACP was equivalent to the value after DCP at high temperature. The d_{33} after ACP was not satisfied due to high coercive field of PINT (8-12 kV/cm, which is 3-4 times larger than that of PMNT single crystal). We modified the poling process, the optimal piezoelectric coefficient was 2350 pC/N obtained by tuning the steady-state time. The steady-state time was crucial for the poling the ferroelectric single crystals with high large coercive field.

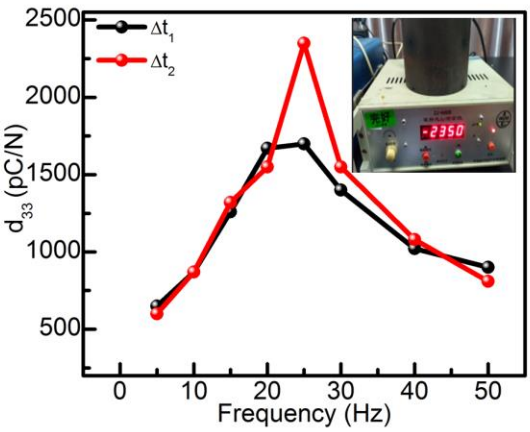

Figure 1. Frequency dependence of d_{33} of PINT ferroelectric single crystals under different steady time.

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2. Y. Yamashita, N. Yamamoto, Y. Hosono, K. Itsumi, U.S. patent: US 2015/0372219 A1.
3. J. Xu, H. Deng, Z. Zeng, et al, *Appl. Phys. Lett.* **112**, 18290 (2018).