K(Ta,Nb)O_3結晶、BaTiO_3系セラミックスの電気熱量効果

Electrocaloric Properties of K(Ta,Nb)O_3 Crystals and BaTiO_3-based Ceramics

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The electrocaloric effect(ECE) is a phenomenon in which a material shows a reversible temperature change under an applied electric field. There has been some problem in the conventional refrigerator. Since the conventional refrigerator operates by using a compressor, vibration generation is inevitable. The conventional refrigerator uses Freon as refrigerants; however, Freon acts implicated in ozone depletion. The other disadvantage includes the difficulty in down-scaling. Thermoelectric cooling using the Peltier device has been considered as a solid state cooling device; however, low efficiency has been a hindrance to the wide applications. In addition, common thermoelectric materials used as semi-conductors include bismuth telluride, lead telluride, silicon germanium, and bismuth-antimony alloys. Some of them are toxic. Although new high-performance materials for thermoelectric cooling are being actively researched, the good results have not been obtained. From the viewpoint of the refrigerator innovation, new refrigerators based on the new mechanism are expected. ECE is considered to be one of the new cooling mechanisms. By using ECE, the application to compact a high energy-effective, inexpensive, and safe refrigerator would be considered. In order to create ECE cooling devices, materials with large ECEs are required. For direct measurement of the ΔT, there are some difficulties. Most temperature changes are less than 1K. And heat dissipation from ferroelectric materials through electrode, wire, and/or the supporting jig for field application occurs. Most probably due to these difficulties, the reports on the direct measurement of ΔT are limited thus far. In this study, the electrocaloric temperature change, ΔT, due to applied ΔE, of the K(Ta,Nb)O_3 crystal and BaTiO_3 ceramics is estimated and directly measured. The comparison with the estimations from indirect approach based on Maxwell's equation will be discussed.

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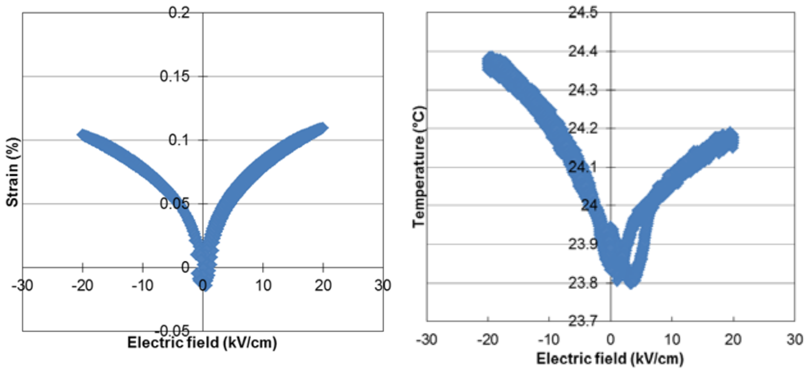

Fig. 1. Strain-electric field (S-E) loop and temperature-electric field (T-E) loops of the K(Ta,Nb)O_3 crystal.