Phase Transitions and Caloric Effects in Ferroics and Multiferroics

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In recent years much attention has been focused on ferroelectrics, ferromagnets and ferroellastics showing monocaloric effects (CE) associated with the reversible change of entropy or/and temperature under external field (magnetic, electric, mechanical stress). The main reason is that such materials are highly promising to be used as working bodies in thermodynamic cycles of the effective alternative solid-state refrigeration technologies. The greatest CE in ferroics can be realized in the temperature region near phase transitions close to the tricritical point and characterized by large values of entropy change and susceptibility to external field. Electro(ECE)- and magneto(MCE)-caloric effects are the most extensively studied compared to baro(BCE)-caloric one. However the latter effect associated with a heat emission or absorption at changing external pressure is the most universal because it can be realized in solids in spite of their physical nature.

In this paper, we present a short review of some recent studies results evidently showing that along with a searching for new effective solid refrigerants, it is profitable also to seek for the ways of caloric efficiency elevating in known ferroics not only by the increase of external field. Because phase transitions in many ferroelectrics and ferromagnets are followed by the unit cell deformation (do not obligatory associated with the symmetry change), one of the most efficient directions is to use a twofold CE (ECE + BCE, MCE + BCE) generated in the same ferroic material by two distinct external fields. Another way is associated with using the CE effects in multiferroics. Owing to magnetoelectric coupling between two monoferroic subsystems there is possibility to realize the multicaloric effect (ECE + MCE) by one of the external fields. But the monophase ferromagnet-ferroelectric materials are characterized not infrequently by rather low values of magnetoelectric coefficient. That is why it is worth to give much attention to compositional materials, especially when the transformation temperatures in ferroelectric and ferromagnetic components are close to each other. In such a case, using magnetic or electric field, one can generate the total multicaloric effect consisting of ECE, MCE and BCE. The latter effect results from the elastic mechanical interaction between magnetostrictive and piezoelectric phases introducing stress in each other.