Ultrasensitive barocaloric materials for room-temperature solid-state refrigeration

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Refrigeration is of vital importance in many fields of human society. Nowadays, conventional vapor-compression refrigeration contributes 7.8% of society's total carbon emissions and consumes 25% of society's total electricity [1]. Within this context, solid-state refrigeration technology based on the caloric effect offers a promising solution to realize sustainable development [2]. In particular, the colossal barocaloric effect discovered in plastic crystals provides a novel technological route to achieve this objective [3]. Nevertheless, one of the greatest obstacles to the real application of barocaloric effect is the huge driving fields.

Here, we report a giant barocaloric effect in inorganic NH_4I with reversible entropy changes of $\Delta S^{max}{}_{P_0 \rightarrow P} \sim 71$ J K^{-1} kg^{-1} around room temperature, associated with a structural phase transition [4]. The phase transition temperature, T_t, varies dramatically with pressure at a rate of dT_t/dP ~0.79 K MPa^{-1}, which leads to a very small saturation driving pressure of ΔP ~40 MPa, an extremely large barocaloric strength of $|\Delta S^{max}{}_{P_0 \rightarrow P}/\Delta P| \sim 1.7$ J K^{-1} kg^{-1} MPa^{-1}, as well as a broad temperature span of ~41 K under 80 MPa. Comprehensive characterizations of the crystal structures and atomic dynamics by neutron scattering reveal that the large pressure sensitivity of T_t orientates from a strong reorientation-vibration coupling, while the giant entropy change is largely contributed by the orientational disorder of the $[NH_4^+]$ tetrahedra. This work is expected to advance the practical application of barocaloric refrigeration.

References

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