Magnetocaloric effect on nanocrystalline melt spun R_2Fe_{17} (R= Pr, Nd) ribbons

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INTRODUCTION

R_2Fe_{17} intermetallic alloys, specifically those with R= Pr and Nd undergo second-order magnetic phase transition with Curie temperatures close to room temperature. These alloys exhibit a notorious broad magnetocaloric effect (MCE), rendering them exceptionally promising for diverse applications, including the burgeoning field of vibrational/mechanical energy-harvesting. The fabrication of these alloys into ribbon shape not only enhances their versatility, unlocking a spectrum of potential uses in various technological domains, but also reduces both economic and ecological processing costs by avoiding lengthy annealing processes during manufacturing.

EXPERIMENTAL/THEORETICAL STUDY

R_2Fe_{17} (R = Pr and Nd) ribbons were fabricated by melt-spinning[1]. The crystalline structure of the ribbons was determined using X-ray diffraction, while the microstructure and nanostructure of the samples were analysed using both scanning and transmission electron microscopy. Magnetic measurements were conducted in a PPMS magnetometer.

RESULTS AND DISCUSSION

The polycrystalline ribbons with the rhombohedral Th_2Zn_{17}-type crystalline structure (space group $R\bar{3}m$) consist of nanograins that form agglomerated nanocrystalline entities with an approximate average size of 15 nm. These nanograins are separated by boundaries where the crystalline order disappears. The coexistence of ordered and disordered regions gives rise to the existence of two successive magnetic phase transitions shown in the low-field magnetization vs. temperature curves. The low-temperature transition corresponds to the ferro-to-paramagnetic transition of the parent bulk alloy (290 and 326 K for R = Pr and Nd, respectively[2]); while the other one can be ascribed to occurring in the disordered boundaries (323 and 350 K for R = Pr and Nd, respectively). The contribution of the disordered phase to the MCE results in a remarkable broadening of the magnetic entropy change curve $|\Delta S_M|(T)$ accompanied by an enhanced refrigerant capacity (RC > 200 $J\cdot kg^{-1}$ for R = Pr at $\mu_0\Delta H$ = 5 T) in comparison with the parent bulk alloy[3,4]. Interestingly, a distinctive "table-like" behavior is also observed.

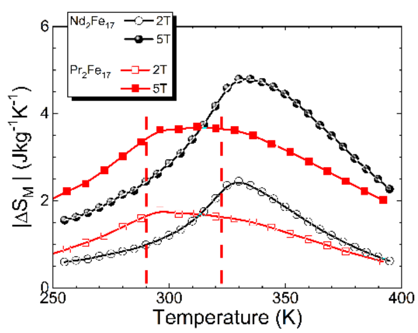

Fig. 1 Temperature dependence of the magnetic entropy changes for Pr_2Fe_{17} and Nd_2Fe_{17} melt-spun ribbons.

CONCLUSION

This work signifies progress in optimizing the magnetocaloric response at room temperature. By employing the nanostructuring of R_2Fe_{17} (R= Pr, Nd) fabricated by melt-spinning, we have successfully expanded the temperature range for the magnetic entropy change, as consequence of the existence of two successive magnetic transitions. Furthermore, we have demonstrated that a table-like behavior can be obtained under certain conditions. These findings are promising for applications such as vibrational/mechanical energy-harvesting. Our subsequent research will focus on exploring the impact of tension/pressure on the magnetocaloric effect to evaluate the performance of these ribbons in power generation from mechanical oscillations.

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