Influence of annealing treatment on magnetocaloric properties and phase structure of amorphous $Gd_{7-x}Y_xPd_3$ Ribbons (x = 1–5)

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Rare-earth-based magnetocaloric materials attract interest due to their potential application in environmentally friendly magnetic refrigeration. In this work, the influence of annealing treatment on the magnetocaloric properties and phase structure of amorphous $Gd_{7-x}Y_xPd_3$ (x = 1–5) ribbons was investigated. The alloys were prepared by melt spinning and subsequently annealed at composition-dependent temperatures for 30 minutes to induce partial crystallization. Structural and microstructural characterization was performed using X-ray diffraction and scanning electron microscopy, while magnetic measurements were carried out using a SQUID magnetometer. The magnetic entropy change ΔS_m and refrigeration capacity were calculated from magnetic isotherms. X-ray diffraction confirmed the amorphous structure of as-quenched ribbons and revealed the formation of crystalline phases after annealing. The Curie temperature of Gd_6YPd_3 increased from 115 K to 153 K after annealing, while for $Gd_4Y_3Pd_3$ it increased from 65 K to 75 K. In contrast, $Gd_5Y_2Pd_3$ exhibited a slight decrease of the Curie temperature from 90 K to 85 K. The magnetocaloric response strongly depended on thermal treatment. For Gd_6YPd_3, the maximum ΔS_m decreased from 8.18 J kg^{-1} K^{-1} in the amorphous state to 5.22 J kg^{-1} K^{-1} after annealing. A similar reduction was observed for $Gd_4Y_3Pd_3$ (6.39 to 4.76 J kg^{-1} K^{-1}). In contrast, annealed $Gd_5Y_2Pd_3$ exhibited enhanced performance, with ΔS_m increasing from 6.31 to 9.82 J kg^{-1} K^{-1} and refrigeration capacity rising from 360 to 1139 J kg^{-1}. These results demonstrate a strong correlation between phase structure, microstructure and magnetocaloric efficiency, highlighting the key role of controlled nanocrystallization in optimizing magnetocaloric performance.

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