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Meta-Magnetic Properties of $LaFe_{12}B_6$ Type Compounds

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Abstract : The antiferromagnetic itinerant-electron compound $LaFe_{12}B_6$ occupies a special place among rare-earth iron-rich intermetallic; it presents exotic magnetic and physical properties. The unusual amplitude-modulated spin configuration defined by a propagation vector k = (¼, ¼, ¼), remarkably weak Fe magnetic moment (0.43 μB) in the antiferromagnetic ground state, especially low magnetic ordering temperature TN = 36 K for an Fe-rich phase, a multicritical point in the complex magnetic phase diagram, both normal and inverse magnetocaloric effects, and huge hydrostatic pressure effects can be highlighted as the most relevant. Both antiferromagnetic (AFM) and paramagnetic (PM) states can be transformed into the ferromagnetic (FM) state via a field-induced first-order metamagnetic transition. Of particular interest is the low-temperature magnetization process. This process is discontinuous and evolves unexpected huge metamagnetic transitions consisting of a succession of steep magnetization jumps separated by plateaus, giving rise to an unusual avalanche-like behavior. The metamagnetic transition is accompanied by giant magnetoresistance and large magnetostriction. In the present work, we report on the intrinsic magnetic properties of the $La_{1-x}Pr_xFe_{12}B_6$ series of compounds exhibiting sharp metamagnetic transitions. The study of the structural, magnetic, magneto-transport, and magnetostrictive properties of the $La_{1-x}Pr_xFe_{12}B_6$ system was performed by combining a wide variety of measurement techniques. Magnetic measurements were performed up to μ_0H = 10 T. It was found that the proportion of Pr had a strong influence on the magnetic properties of this series of compounds. At x=0.05, the ground state at 2K is that of an antiferromagnet, but the critical transition field Hc has been lowered from Hc = 6T at x = 0 to Hc = 2.5 Tat x=0.05. And starting from x=0.10, the ground state of this series of compounds is a coexistence of AFM and FM parts. At x=0.30, the AFM order has completely vanished, and only the FM part is left. However, we still observe meta-magnetic transitions at higher temperatures (above 100 K for x=0.30) from the paramagnetic (P) state to a forced FM state. And, of course, such transitions are accompanied by strong magneto-caloric, magnetostrictive, and magnetoresistance effects. The Curie temperatures for the probed compositions going from x=0.05 to x=0.30 were spread over the temperature range of 40 K up to 100 K.

Keywords : metamagnetism, RMB intermetallic, magneto-transport effect, metamagnetic transitions
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