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Stabilization of Metastable Skyrmion Phase in Polycrystalline Chiral β-Mn Type $Co_7Zn_7Mn_6$ Alloy

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Abstract : The topological protected nanosized particle-like swirling spin textures, “skyrmion,” has been observed in various ferromagnets with chiral crystal structures like MnSi, FeGe, Cu_2OSeO_3 alloys, however the magnetic ordering in these systems takes place at very low temperatures. For skyrmion-based spintronics devices, the skyrmion phase is required to stabilize in a wide temperature – field (T - H) region. The equilibrium skyrmion phase (SkX) in $Co_7Zn_7Mn_6$ alloy exists in a narrow T – H region just below transition temperature (TC ~ 215 K) and can be quenched by field cooling as a metastable skyrmion phase (MSkX) below SkX region. To realize robust MSkX at 110 K, field sweep ac susceptibility χ(H) measurements were performed after the zero field cooling (ZFC) and field cooling (FC) process. In ZFC process, the sample was cooled from 320 K to 110 K in zero applied magnetic field and then field sweep measurement was performed (up to 2 T) in positive direction (black curve). The real part of ac susceptibility (χ′(H)) at 110 K in positive field direction after ZFC confirms helical to conical phase transition at low field HC_1 (= 42 mT) and conical to ferromagnetic (FM) transition at higher field HC_2 (= 300 mT). After ZFC, FC measurements were performed i.e., sample was initially cooled in zero fields from 320 to 206 K and then a sample was field cooled in the presence of 15 mT field down to the temperature 110 K. After FC process, isothermal χ(H) was measured in positive (+H, red curve) and negative (-H, blue curve) field direction with increasing and decreasing field upto 2 T. Hysteresis behavior in χ′(H), measured after ZFC and FC process, indicates the stabilization of MSkX at 110 K which is in close agreement with literature. Also, the asymmetry between field-increasing curves measured after FC process in both sides confirm the stabilization of MSkX. In the returning process from the high field polarized FM state, helical state below HC_1 is destroyed and only the conical state is observed. Thus, the robust MSkX state is stabilized below its SkX phase over a much wider T - H region by FC in polycrystalline $Co_7Zn_7Mn_6$ alloy.

Keywords : skyrmions, magnetic susceptibility, metastable phases, topological phases
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