DB07

Universal Criterion for Formation of Stable Vortex or Antivortex in Domain Wall Motions in Magnetic Thin-film Nanostripes: Two Dimensional Soliton Model

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The velocity breakdown of DW motions above a critical Walker field H_w is known to be associated with oscillatory dynamic transformations of the internal structure of a single moving DW between the transverse wall (TW) and the antivortex wall (AVW) (or vortex wall (VW)) [1]. Although 1D models developed to date have partially explained the linear increase of velocity with field strength in a low-field region as well as the Walker breakdown in an intermediate-field region, they cannot adequately explain nucleation, in-plane gyrotropic motion, annihilation of the vortex (V) (antivortex (AV)) appearing in VW (AVW), or the transformations of magnetic solitons between TW, VW, and AVW in 2D systems such as thin-film nanostripes.

In this presentation, we suggest that a 2D model of magnetic soliton dynamics in thin-film nanostripes is appropriate for interpretation and understanding of DW motions that are associated with the nucleation and motions of V- or AV-type solitons. We adopt a concept of a critical core size as the universal criterion for the stabilized formation of the V or AV during its dynamic motions inside nanostripes. An onset field of the velocity breakdown in the 1D Walker model corresponds to the threshold field by which the cores of the V or AV can be stabilized up to a critical size for its nucleation and matured formation. Moreover, when the velocity of the soliton core of a TW reaches a certain critical velocity (about 600 m/s for Py), the VW or AVW is well formed, and moving in its own gyrotropic motion. Micromagnetic simulations reveal that the estimated values of the critical core size and DW velocity for Py are approximately 10 nm and 600 m/s, respectively, which are independent of the dimensions of the nanostripes and the applied field strengths, but rely only on material parameters.

The universal criterion for the formation of VW or AVW in the repeatable changes of the internal structure of a moving DW can offer true physical insights into the apparent DW transformations as well as DW motions in a wide field range. This work indicates that at least a 2D model is absolutely instrumental to correctly understanding/describing oscillatory DW dynamics associated with the nucleation, gyrotropic motion, and annihilation of a VW or AVW.

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DC01

Control of Magnetocaloric Effects by Partial Substitution in Itinerant-Electron Metamagnetic $La(Fe_xSi_{1-x})_{13}$ for Application to Magnetic Refrigeration

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We have found that $La(Fe_xSi_{1-x})_{13}$ exhibit an itinerant-electron metamagnetic (IEM) transition [1]. These compounds are good candidate as high-performance magnetic refrigerant, because these compounds exhibit large magnetocaloric effects (MCEs) and the Curie temperature T_C can be elevated around 300K by hydrogen absorption with keeping large MCEs [2]. Recently, we have demonstrated that a partial substitution of such as Ce and Pr for La brings about a lowering of T_C, resulting in the enhancement of the magnitude of MCEs [3]. $La(Fe_xSi_{1-x})_{13}$ compounds exhibit large magnetovolume effects, therefore, the lowering of T_C is mainly attributed to the decrease of lattice parameter due to the lanthanide contraction. However, the enhancement of MCEs is not so straightforward.

In Fig. 1, to shed light on this issue, the temperature dependence of the entropy change ΔS_m of $La(Fe_xSi_{1-x})_{13}$ (x = 0.86 and 0.88) is compared with that of La1-zRz$(Fe_{0.86}Si_{0.14})_{13}$ (R = Ce: z =0.3 and Pr: 0.7), together with that for x = 0.86 under hydrostatic pressure of 0.25GPa. After the partial substitution, the maximum of the entropy change ΔS_m^{max} is increased, and ΔS_m^{max} for R = Ce is almost comparable to that of x = 0.88. It is confirmed that ΔS_m is increased by applying pressure but the increment is smaller than that by the partial substitutions. Since ΔS_m^{max} is closely correlated with the magnetization change at T_C, the existence of Pr moment of about 3.3 μ_B is one of the reasons for enhancement of ΔS_m. On the other hand, the substituted Ce is close to the tetravalent ionic state and behaves as non-magnetic element. The origin of large MCEs in $La_{1-x}Ce_x(Fe_xSi_{1-x})_{13}$ is attributed to the IEM transition influenced by 3d electron band structure, suggesting that the hybridization of 3d bands with 5d and/or 4f electrons in Ce element enhances ΔS_m.

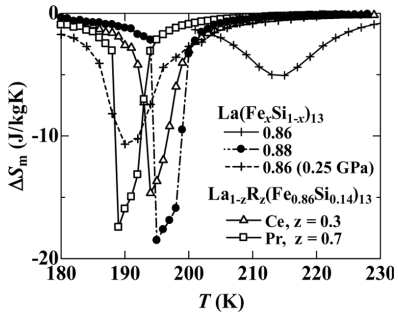

Fig. 1. Temperature dependence of ΔSm for $La(Fe_xSi_{1-x})_{13}$ and $La_{1-z}Rz(Fe_{0.86}Si_{0.14})_{13}$.

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