

第 353 回 物性セミナー

An update on a hidden treasure in conventional admixed rare earth intermetallic compounds

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The attributes of a large conduction electron polarization (CEP) and the exchange bias field have received much attention in recent times in the context of spintronics and the magnetic multi-layer devices comprising ferro-antiferro interfaces, respectively. The rare earth (RE) based isoelectronic series of ferromagnetic intermetallic compounds offer the possibility of realizing and tailoring these attributes concurrently by synthesizing admixed RE-intermetallics, wherein a given RE³⁺ ion (R₁) is partially replaced by another RE³⁺ ion (R₂), such that R₁ and R₂ belong to the different halves of the 4fⁿ series, and $x\mu_{R_1} \sim (1-x)\mu_{R_2}$, where μ_{R_1} and μ_{R_2} are the magnetic moments of R₁ and R₂. Considering that J value for the ground multiplet level for the first/second half of the RE ions is L-S/L+S, respectively, their magnetic moments get (notionally) get aligned parallel / anti-parallel to the respective 4f-spins. In the above stated pseudo-binary RE alloys derived from a ferromagnetic intermetallic series, the conduction electron mediated RKKY based exchange interaction between the 4f-spins of R₁ and R₂ remains ferromagnetic, which in turn enjoins the magnetic moments, μ_{R_1} and μ_{R_2} , belonging to the different halves of the RE-series, to couple anti-ferromagnetically. The alloys near the stoichiometry, $x\mu_{R_1} \sim (1-x)\mu_{R_2}$, are expected to imbibe the near-zero net-magnetization characteristic, and also display the magnetic compensation phenomenon as a function of temperature. The local magnetic moments of dissimilar RE ions can be made to undergo a field induced reversal in their orientations across the compensation temperature (T_{comp}). While this happens, the CEP also undergoes a field induced reversal with respect to the externally applied field, and such an occurrence assumes an accentuated importance in determining the phase of the asymmetry (i.e., the exchange bias field) in the magnetization hysteresis loops and the sign of the magneto-resistance response.

A status report on the ongoing explorations at TIFR on a wide variety of admixed rare earth intermetallics close to the zero-magnetization stoichiometry shall be presented. The recent new findings [1-7] include: (i) exemplification of the existence of exchange bias field on approaching T_{comp} and its sudden phase reversal across T_{comp}, (ii) identification of a step change in high field magnetization and its correlation with the fingerprint of field-induced entropic change in specific heat data, (iii) oscillatory character in the magneto-resistance response, including a change in its sign at T_{comp}, (iv) novel repeated magnetic compensation behavior in some specific alloys, (v) synthesis of alloys undergoing magnetic orderings close to the ambient temperature and possessing large CEP, but, near-zero bulk magnetization, and permitting easy tuning of the exchange bias field for novel applications, etc.

5 研究科共同セミナーの認定科目です

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