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Using Magnetic Proximity Effects to Stabilize Magnetic Nanoparticles[1]

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The current miniaturization trend in magnetic applications has led to a quest to suppress spontaneous thermal fluctuations (superparamagnetism) in ever-smaller nanostructures, which constitutes a clear example of the fundamental efforts of condensed matter physics to meet technological challenges (e.g., the continued growth of magnetic recording density). We have demonstrated that ferromagnetic (FM) Co nanoparticles with blocking temperature below 70 K become magnetically stable above 400 K when embedded in a high Neel temperature antiferromagnetic (AFM) NiO matrix [1]. This remarkable stabilization is due to a magnetic proximity effect between a thin CoO shell (with low Neel temperature and high anisotropy) surrounding the Co nanoparticles and the NiO matrix (with high Neel temperature but low anisotropy). This proximity effect yields an effective antiferromagnet with an apparent ordering temperature beyond that of bulk CoO, and an enhanced anisotropy compared to NiO. In turn, the Co core FM moment is stabilized against thermal fluctuations via core-shell exchange-bias coupling, leading to the observed increase in blocking temperarature. A mean-field model, corrected for thermal activation effects, closely reproduces the experimental exchange-bias data, corroborating the above interpretation and providing a semi-quantitative understanding of the nature of the proposed proximity effect. The results presented in this study constitute a striking illustration of how a subtle combination of interactions may permit the occurrence of unique magnetic properties by exploiting proximity effects in magnetism. 1. J. A. De Toro, D. P. Marques, P. Muniz, V. Skumryev, J. Sort, D. Givord, and J. Nogues, Phys. Rev. Lett. 115, 057201 (2015).

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