Institute of Magnetism of the NAS of Ukraine and MES of Ukraine

NANOSTRUCTURED MAGNETIC COMPOSITES FOR THERMOELECTRONIC CONTROL AND THERMOSTABILIZATION SYSTEMS

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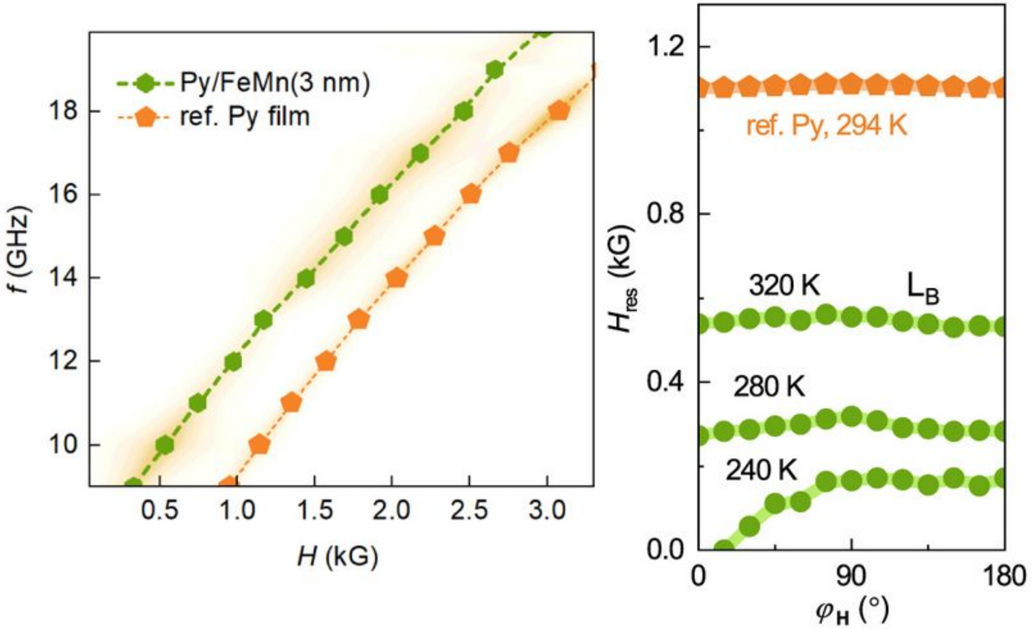
OBJECTIVES

This work aimed to develop magnetic nanostructures with controlled switching of magnetic configurations within a given temperature range, clarify how the parameters of individual nanostructure components influence magnetic transition characteristics and magnetically induced entropy change, and develop the physical basis for creating a new type of functional elements for thermal stabilization of micro-sized electronic circuit and temperature sensor components.

The study focused on three- and multilayer nanostructures containing ferromagnetic layers based on iron group elements and weakly magnetic (antiferromagnetic) spacers based on iron alloys with chromium or manganese. As an integral part of this study, we also examined single- and/or double-layer films to develop manufacturing methods and optimize the magnetic properties of each component.

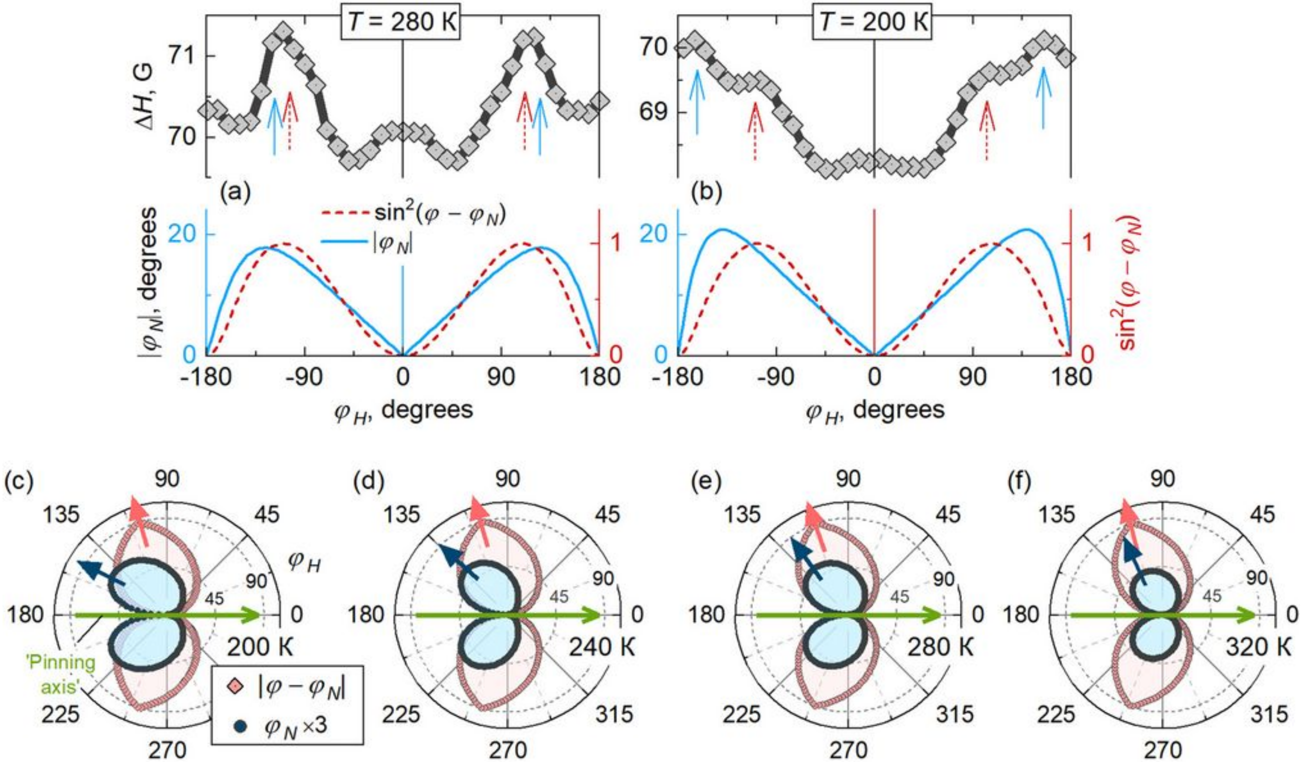
MAIN RESULTS



Left – Frequency dependence of the resonance field, measured at room temperature for the Py/FeMn(3 nm) bilayer and compared to that for the reference Py film. Right – Corresponding angular profiles of the resonance field at select temperatures.

Exchange biasing in ferromagnet/antiferromagnet bilayers is known to enhance ferromagnetic resonance frequency, but make it strongly angle dependent. We observe an ***angle-independent enhancement in frequency of ferromagnetic resonance*** in bilayers of Py/FeMn with ultrathin FeMn, which is consistent with rotatable rather than unidirectional magnetic anisotropy, linked to the ferromagnet-proximity effect. The estimated ***effective anisotropy field*** acting on the proximity-induced moment in ultrathin FeMn can be as high as ***0.5 T*** at room temperature. Our results show the potential of the ferromagnetic proximity effect combined with the inherent exchange anisotropy in antiferromagnets for high-speed spintronic applications.

MAIN RESULTS

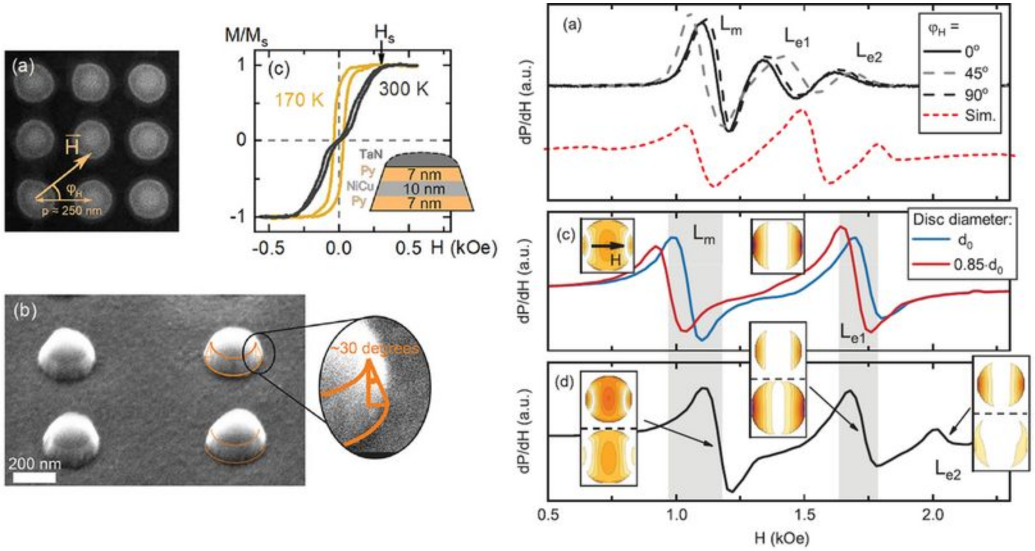


Angular dependence of the resonance linewidth ΔH for the Py/FeMn(5 nm)/Cu/Py structure and corresponding calculations of the Neel vector deviation angle at different temperatures

For the first time, we propose an approach for separating and characterizing dissipative processes occurring in the volume of an antiferromagnet and at the interface between an antiferromagnet and a ferromagnet. We determine the features of the transformation of dissipation processes when the Néel vector of the antiferromagnet deviates from the direction of exchange coupling. We have concluded that the proposed method is efficient for studying spin scattering processes in individual layers and at the interfaces between them in complex magnetic systems.

MAIN RESULTS

The collective spin dynamics of ***arrays of synthetic antiferromagnets nanodisks***, in which the spacer undergoes a ferromagnet-paramagnet phase transition, has been investigated. Above the Curie point of the spacer, when the ferromagnetic layers interact only magnetostatically, systems exhibit higher-order resonance with two spatially inhomogeneous edge modes, predominantly excited in one of the ferromagnetic layers. Experimental results demonstrate the possibility of ***effectively controlling the behavior of nanodisks thermally:*** as the temperature decreases, an exchange interaction occurs between the ferromagnetic layers. This results in the transformation of the synthetic antiferromagnets into quasi-single-layer disks, which are characterized by only one boundary mode. These results are interesting for creating new functional elements with thermal control.



SEM images of synthetic antiferromagnetic nanodots and hysteresis loops at different temperatures (left), FMR spectra and simulated spin wave mode profiles (right).

SELECTED PUBLICATIONS

1. Polishchuk D.M., Nakonechna O.I., Lytvynenko Ya.M., Kuncser V., Savina Yu.O., Pashchenko V.O., Kravets A.F., Tovstolytkin A.I., Korenivski V., Temperature and thickness dependent magnetostatic properties of [Fe/Py]/FeMn/Py multilayers, Low Temp. Phys. 47, 483 (2021).
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4. Golub V., Aseguinolaza I.R., Salyuk O., Popadiuk D., Sharay I., Fernández R., Alexandrakis V., Bunyaev S.A., Kakazei G.N., Barandiarán J.M., Chernenko V.A., Thickness dependences of structural and magnetic properties of Ni(Co)MnSn/MgO(001) thin films, J. All. Comp. 862, 158474 (2021).