Oral senior

Microwave absorption properties of two dimensional arrays of permalloy nanodots in the vortex and quasi-uniform ground states

Konstantin Gusliyenko[1,2], Gleb Kakazei[3], Yurii Kobljanskyj[4], Gennadii Melkov[4], Valentyn Novosad[5], Andrei Slavin[6]

kostyantyn.gusliyenko@ehu.es

[1] Depto. Física de Materiales, Universidad del País Vasco, UPV/EHU, Spain
[2] IKERBASQUE, The Basque Foundation for Science, Bilbao, Spain
[3] IFIMUP, IN-Institute of Nanoscience & Nanotechnology, Depto. Fisica e Astronomia, Universidade do Porto, Porto, Portugal
[4] Faculty of Radiophysics, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[5] Materials Science Division, Argonne National Laboratory, Argonne, Illinois, USA
[6] Department of Physics, Oakland University, Rochester, Michigan, USA

When the in-plane bias magnetic field acting on a flat soft magnetic particle (dot) is smaller than the saturation field, there are two stable competing magnetization configurations of the dot: vortex and quasi-uniform state [1]. To measure the microwave absorption in a two dimensional array of in-plane magnetized magnetic dots we used a technique of vector network analyzer ferromagnetic resonance (VNA-FMR) [2]. The investigated magnetic dot array (patterned film area is 5x5 mm^2) was composed of circular permalloy ($Ni_{80}Fe_{20}$ alloy) dots having the radius 150 nm and thickness 14 nm. The edge-to-edge interdot distance was 300 nm that guarantees absence of the interdot magnetostatic interaction. We measured microwave absorption properties of the dot array in the frequency range 1-8 GHz when bias magnetic field was varied in the region of the magnetization state bi-stability in the range 0 – 600 Oe (Figure 1).

It was found that the microwave absorption properties of magnetic dots existing in the quasi-uniform and vortex states are qualitatively different [3]. The frequency of the resonance microwave absorption in the quasi-uniform magnetization stable state increases with the increase of the bias field, while in the vortex magnetization stable state it remains practically constant and equal to 7 GHz. For the dots existing in a quasi-uniform and C-stable states [4] a considerable linewidth broadening (up to 2 times, from ~ 300 MHz to ~ 600 MHz, was found when the in-plane bias magnetic field is decreasing from the field of a vortex annihilation (H_{an} = 450 Oe) to the field of a vortex nucleation (H_n =50 Oe), while for the dots existing in the vortex stable state the absorption linewidth remains practically constant within the whole interval of the bias field variation. The microwave susceptibility of the dots in the quasi-uniform state has a broad maximum in the bias field interval 100-400 Oe and decreases at low and high values of the field, while in the vortex stable state the susceptibility increases with the bias field increase and reaches a maximum value at the vortex annihilation field. Due to the hysteresis in the dot magnetization stable states and substantially different microwave absorption properties in the quasi-uniform and vortex states (that can co-exist at the same value of the bias magnetic field) it would be possible to use arrays of non-interacting magnetic nanodots for the development of dynamically reconfigurable microwave absorption materials, where the microwave properties of the patterned materials depend on the magnetization history and could be changed dynamically through a fast remagnetization [5].

References

[1] K.Y. Guslienko, J. Nanosci. Nanotechn., 8 (2008) 2745.
[2] Y. Kobljanskyj, G.A. Melkov, K.Y. Guslienko, V. Novosad, S.D. Bader, M. Kostylev, and A.N. Slavin, Sci. Reports, 2 (2012) 478.

[3] K.Y. Guslienko, G.N. Kakazei, Y.V. Kobljanskyj, G.A. Melkov, V. Novosad, and A.N. Slavin, New J. Physics, in press (2014).

[4] G.A. Melkov, Y. Kobljanskyj, V. Novosad, A.N. Slavin, and K.Y. Guslienko, Phys. Rev. B, 88 (2013) 220407.

[5] R. Verba, V. Tiberkevich, K. Guslienko, G. Melkov, and A. Slavin, Phys. Rev. B, 87 (2013) 134419.

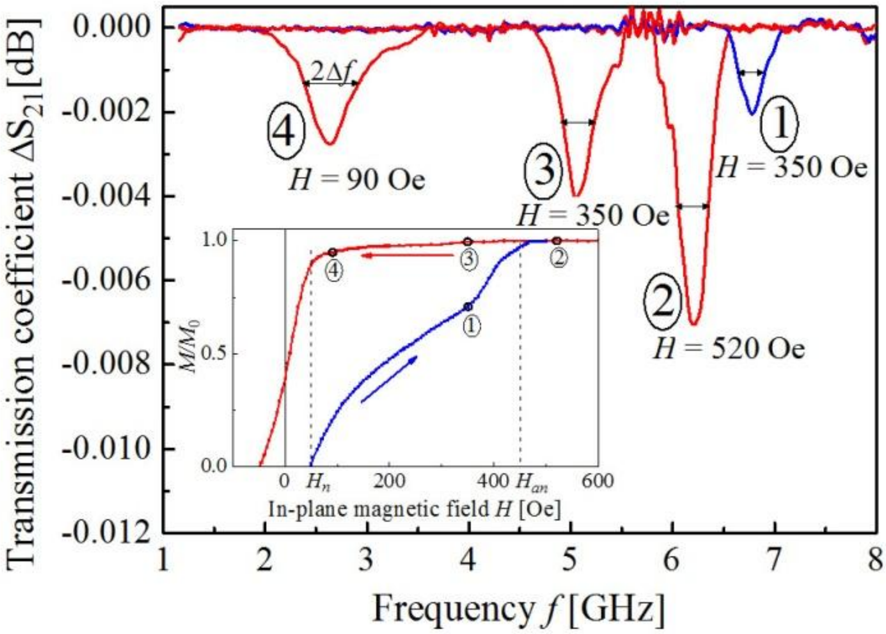

Figure 1. Experimental VNA-FMR microwave absorption lines of a square array of cylindrical permaloy dots (the dot radius is 150 nm, the dot thickness is 14 nm, edge-to-edge interdot distance is 300 nm) measured at four different points ((1)-(4)) on the static magnetization hysteresis loop of the array shown in the inset. The marked fields H_n, H_{an} are the magnetic vortex nucleation and annihilation fields, respectively. Points (2), (3), and (4) (H = 520, 350, 90 Oe) are situated on the upper branch of the hysteresis loop corresponding to the quasi-uniform stable state of the dots, while the point (1) (H = 350 Oe) is situated at the lower branch of the hysteresis loop corresponding to the vortex stable state of the dots. Note that the absorption curves corresponding to points (1) and (3) are taken at the same magnitude of the in-plane bias magnetic field H = 350 Oe.