Simulation of Remagnetization in Composite Structures

V. Sohatsky, G. Parhomchuk, V. Laichuk

Taras Shevchenko National University of Kyiv, Ukraine

Composite structures, having components with the different properties (in particular, ferromagnetic and piezoelectric or magneto-electric nanolayers) are of considerable interest for use in spintronics (or straintronics) as memory or logic devices, microwave filters or integrated photonic cells. [1]. The problems of remagnetization of such structures are the difficulties of nanosized magnetic field localization and correspondent large enough energy losses; necessity of high speed magnetization switching with a reliable arrangement of logic operations, etc. The experimental investigations confirmed the possibility of effective remagnetization of YIG film crystal structures as well as the amorphous ferromagnetic Fe nanolayers under mechanical strain while they being in a rigid contact with the piezoelectric PZT [2].

The calculations of optima parameters of such structures allowed to adjust operating characteristics of composite cells for various possible applications. The performed research are based on energy balance equations method within which the 3D diagrams of the total magnetization energy vs intensities of the applied magnetic field and/or mechanical strain were plotted. The equilibrium states of magnetization in ferromagnetics were determined from the coordinates of the energy minima and correspondent remagnetization curves (magnetic hysteresis loops) were calculated and depicted according to the sequence of these coordinates. Thus obtained curves were in a good agreement with the experimental ones, taken magnetooptically by means of Faraday and Kerr effects.

The results of simulation confirmed the possibility of variation of the hysteresis loops (operating characteristics) shape from a linear to almost rectangular by changing either the external influence (in particular, the direction of the applied magnetic field or mechanical strain), or inherent parameters of the structures (e.g. the relative orientation of uniaxial anisotropy axes in the nanolayers). The plotted energy diagrams also helped to explain the origin of the "intersecting" loops (with non-monotonic change of the magnetization vector orientation) as complex exchange/magnetostatic interaction of the magnetizations in adjusted layers with differently oriented anisotropy axes. Useful evaluations of the frequency characteristics of remagnetization were also done for some another compositions of magnetic nanolayers, such as in particular, permalloy or Eu, Tm and Dy orthoferrites.

A computer program created on JS allowed to promptly observe changes of the shape of calculated magnetic hysteresis curves in dynamics for wide variety of the specified magnetic, electric and mechanical parameters of the above composite structures.