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Multilayered Structures from Periodically Alternating Magnetic Island Layers: Magnetization Processes and Magnetoresistance

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The multilayered structures from periodically alternating of island layers of various ferromagnetic are investigated. This island structures possessed a magnetoresistance of ~1-3 % and can detect of superweak magnetic fields up to 10^{-6} Oe at room temperature that allows using them as sensors of magnetic fields. The new specific vorticose states of magnetization which arises under some conditions in island structures is offered. Magnetization of these vortical states is distributed on many islands of island structures. It is supposed, what exactly this vortical magnetization is responsible for appearance of unidirectional magnetic anisotropy too.

Keywords: Nanoislands, Magnetism, Multilayer, Kerr effect, Magnetoresistance, Tunneling.

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1. INTRIDUCTION

Now the researches directed on receiving magnetic structures with high sensitivity to superweak magnetic fields are conducted. There are a set of systems which can be used as sensor of the superweak magnetic fields functioning at room temperature. That is magnetic structures with anisotropic effect, systems with gigantic magnetoresistance (spin-valve and spin-tunneling structures), magnetic nanocomposites, some systems from the diluted semiconductors (Si-Mn, Ge-Mn). All these structures have the advantages and the disadvantages: the some of these structures have insufficient sensitivity, others are too complex in preparation, etc. In this article the new systems consisting from periodically alternating island layers of different ferromagnetic materials and some results of research of their magnetization processes are submitted.

2. SAMPLE PREPARATION

In this article the multilayered structures consisting of periodically alternating of island layers of various magnetics $(FeNi\text{-}Co)_N$, $(FeNi\text{-}CoNi)_N$, $(FeNiCo\text{-}CoCr)_N$ and other were investigated. These systems were grown by the RF-sputtering method. It was established [1] that under certain conditions very thin magnetic films (d < 2 nm) are in the island state. The sizes of islands depend on thickness of a film and lie in a range of 5-30 nm, distance between them ~ 3-5 nm. Structural parameters of islands strongly depended on a type of a substrate. The dielectric substrates were used for simplicity of researches. As substrates polycrystalline glass (sitall) and glass were more often used. The multilayered structure was grown by level-by-level deposition of island layers of some magnetics which differ by their magnetic parameters (for example, a magnetic hardness – FeNi and Co). Ten bilayers usually made. By means of measurement of x-ray low-angular reflection it was established that the prepared structures really are structures with periodic alternation of island layers without their appreciable mixing. The protective layer of Al_2O_3 (d ~ 2 nm) was deposited on the top of growing system at the end of growth process. After preparation of island structures In contacts were made on their surface.

3. RESULTS AND DISSCUSSION

Some structures with periodic alternation of island layers from different magnetics – $(FeNi\text{-}Co)_{10}$, $(FeNi\text{-}CoNi)_{10}$, $(FeNiCo\text{-}CoCr)_{10}$ were grown. The equatorial magnetooptical Kerr effect (MOKE) was used for research of magnetic properties of island structures. Besides transport properties of structures were investigated. Electrical field E were applied along a surface of structures in all electric measurements. All optical and transport researches were carried out at room temperature.

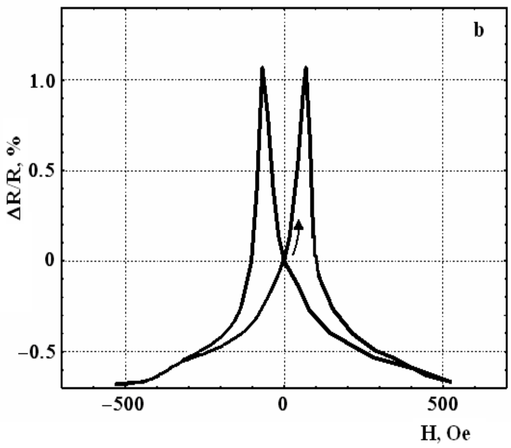

Fig. 1

The dependence of resistance on an external magnetic field which testifies about existence of a positive and negative magnetoresistance is shown on Fig.1. The value of a magnetoresistance R_M reaches ~ 1-3 %. Character of dependence of magnetoresistance on

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angle α between fields E and H ($\cos^2\alpha$) testify about a contribution of anisotropic effect in a magnetoresistance.

It should be noted a high steepness of R_M (H) dependence that allows to use island structure as sensors of weak magnetic fields. The dependence of an output signal V on an external magnetic field H is presented on Fig.2. It is mark that the island structure is capable to detect magnetic fields about and less than 10^{-6} Oe [2].

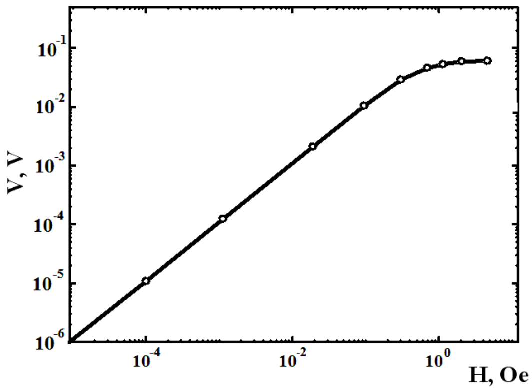

Fig. 2

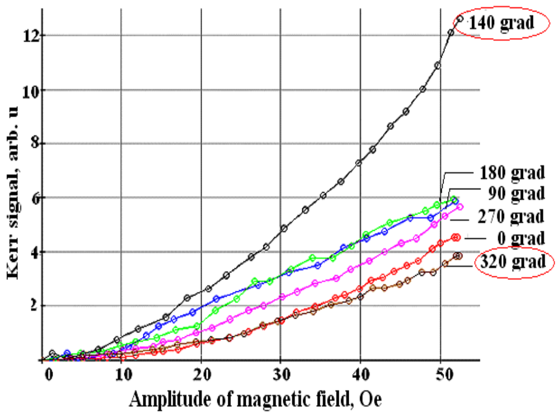

Fig. 3

The Kerr effect measurement showed that the unidirectional axis of preferred magnetization present in island structures (Fig. 3, curve 140 degree). In systems FeNi-Co there is almost never observed a unidirectional magnetic anisotropy (exchange anisotropy). Usually exchange anisotropy exists, for example, in systems of ferromagnetic - antiferromagnetic due to the exchange interaction between ferromagnetic layer and one of sublattice of antiferromagnetic layer. As a result the shift of hysteresis loops are happened in such systems. However, the expected shift of hysteresis loops are not found in multilayered island structures.

Moreover when the some of island samples are rotated in the fixed external magnetic field, the dependence of Kerr value on the direction of sample rotation (on or against an hour arrow) was sometimes observed. It is very difficult to explain of detected dependence due to weak of the hysteresis phenomena in island systems and existence of the unidirectional magnetic axis too.

It was assumed that in some multilayered island structures special vortical states of magnetization are can be appeared. In this case the unidirectional axis can be connected with a vortex kore. As also the Kerr effect value will depends on that the sample rotate in the direction or against of vortex twisting.

However, in studied island structures usual vortex can't arise because the sizes of islands are too small for formation of vortex in them. Therefore it was assumed that in multilayered island structures there can be the special vortical states. In that situation the vortical magnetization is distributed on separate islands. Numerical confirmed possibility of the similar vortical states which distributed on islands [3].

It should be noted that similar vortical states are metastable that leads to disappearance of observable features of magnetization of island structures.

In some structures, in which is absent unidirectional axes and any other magnetic anisotropy, there is a possibility to excite vorticose states. For this purpose the sample was located near conductors through which the current (~ 7A) was passed that led to appearance of a vortical magnetic field. This vortical magnetic field (value ~ 10^{-6} Oe on sample) influenced on a sample and create new magnetic anisotropy in a sample.

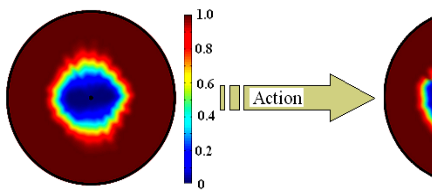

Fig. 4

Thus, multilayered structures from periodically alternating of island layers from various magnetics are investigated. This island structures possessed a magnetoresistance of ~1-3 % and can detect superweak magnetic fields to 10^{-6} Oe at room temperature that allows using them as sensors of magnetic fields. The new specific vortical states of magnetization which arises under some conditions in island structures is offered. Magnetization of these vortical states is distributed on many islands of island structures. It is supposed, what exactly this vortical magnetization is responsible for appearance of unidirectional magnetic anisotropy too.

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REFERENCES

1. A.P. Boltaev, N.A. Penin, A.O. Pogosov, F.A. Pudonin *JETP* **99** No 4, 827 (2004).
2. A.P. Boltaev, F.A. Pudonin, I.A. Sherstnev, *Phys. Solid State* **53** No5, 950 (2011).
3. K.A .Zvezdin, private report