Magnetic properties of [Pd/Co/CoO]n superlattices

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Abstract

Results of research on the magnetic properties of multilayered ferromagnetic epitaxial films with oxidized top interfaces of the ferromagnetic layer are shown. Experimental data demonstrate the presence of PMA in $[Pd/Co/CoO]_n$ films, as well as an increase in the coercivity and magnetic moments from the number of layers.

Introduction

Thin magnetic films are valuable for studying them as a material for new types of logical devices for storage, reading/writing, and information processing. Precise driving of the parameters of magnetic materials is required for the development of such devices. The Dzyaloshinskii-Moriya Interaction (DMI) and PMA are the most important properties of such systems. Interfacial DMI appears due to symmetry breaking at the interface of ultrathin films, which leads to asymmetric spin rotation, and in combination with strong PMA allows one to stabilize the topological structures as chiral domain walls and skyrmions. In our samples $[Pd/Co/CoO]_n$ films, both DMI and PMA appear. Meanwhile, with an increasing number of film layers (n), the crystal structure is preserved.

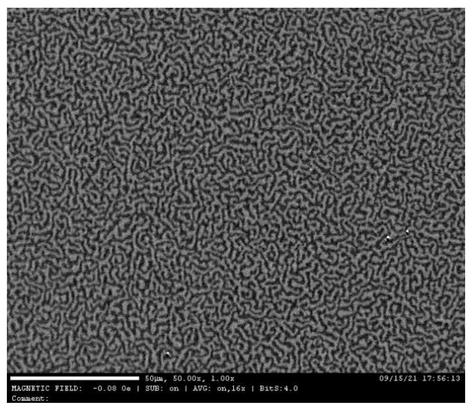
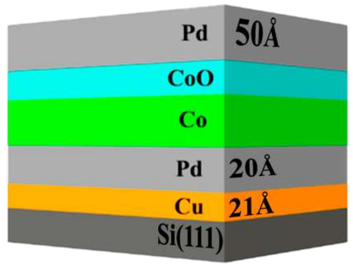


Figure. 3. *Labyrinth domain structure in the $[Pd/Co/CoO]_4$ film.*

Methods and materials

Experiment

- Samples were obtained by molecular beam epitaxy in an Omicron ultrahigh vacuum complex with a base pressure of P = $2x10^{-11}$ Torr.
- Substrate Si(111).
- Resistive heating (650 °C) and direct current annealing (1200 °C).
- Buffer layer Cu(21Å).
- Film Pd(20Å)/Co_x/CoO_{1-x}/Pd(50Å).
- Thickness Co (10Å).
- Oxidation parameters:
  P = 750 Torr,
  t = 3 min.



Research

- Vibrating sample magnetometer (VSM).
- Magneto-optical Kerr microscope (MOKE).

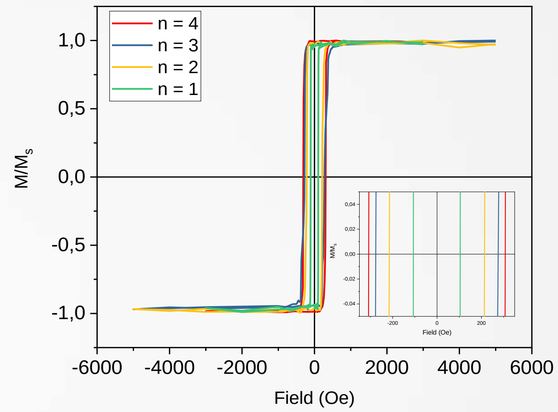


Figure 1. The hysteresis loops for $[Pd/Co/CoO]_n$ films

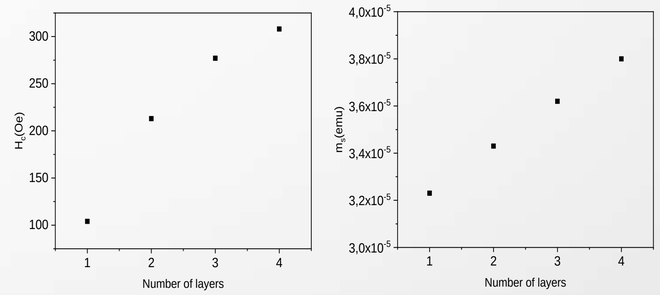


Figure 2. Change in magnetic characteristics.
(left) Dependence of the coercive force on the number of layers (n); (right). Dependence of the magnetic moment on the number of layers (n).

Results and discussions

Hysteresis loops taken perpendicularly to the plane of the sample indicate the easy magnetization axis in this orientation, which indicates the presence and preservation of PMA on each layer. (Fig. 1.). The growth of the coercive force and magnetic moment with an increasing number of trilayers was shown (Fig 2.).

The domain structure of the samples was studied by MOKE-microscopy (Fig 3). A magnetic field was applied in the range from ±100 to ±500 Oe. The structure of the labyrinth domains was observed in a demagnetized state.

Conclusions

- The dependences of the coercive force and magnetic moment on the number of layers of a $[Pd/Co/CoO]_n$ multilayer thin film were studied.
- The labyrinthine domain structure of the sample was observed.
- The ability to control the coercive force and magnetic moment will potentially allow the use of top-interface oxidation as a mechanism for controlling magnetic parameters.

References

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3. J. Feng et al., Phys. Rev. Applied, Vol. 13.4, 044029 (2020).