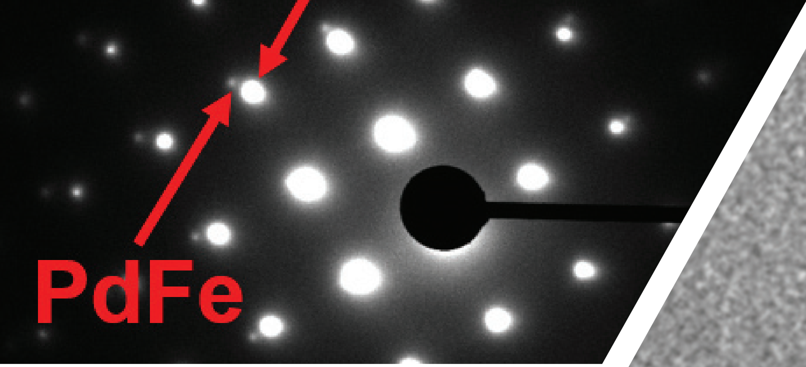

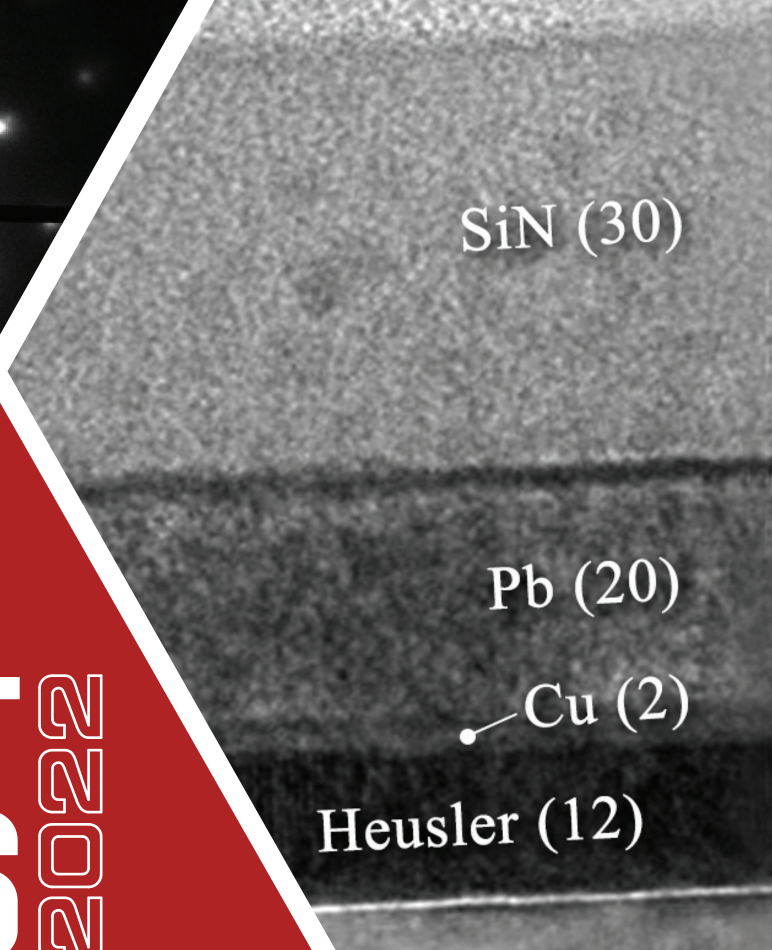

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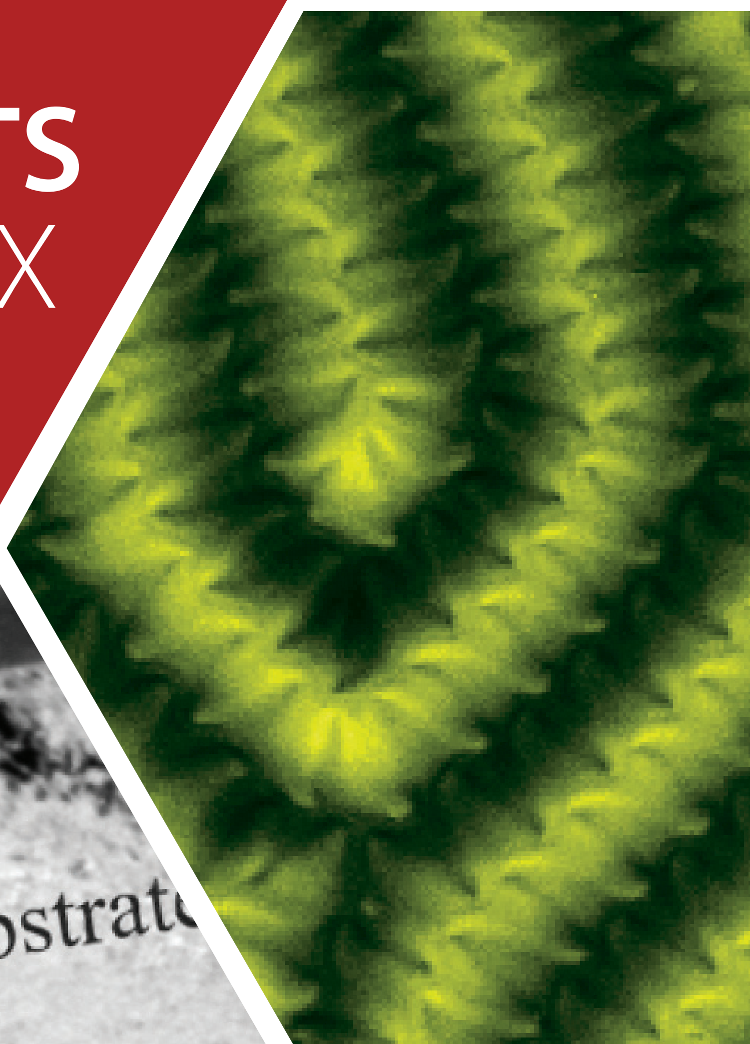

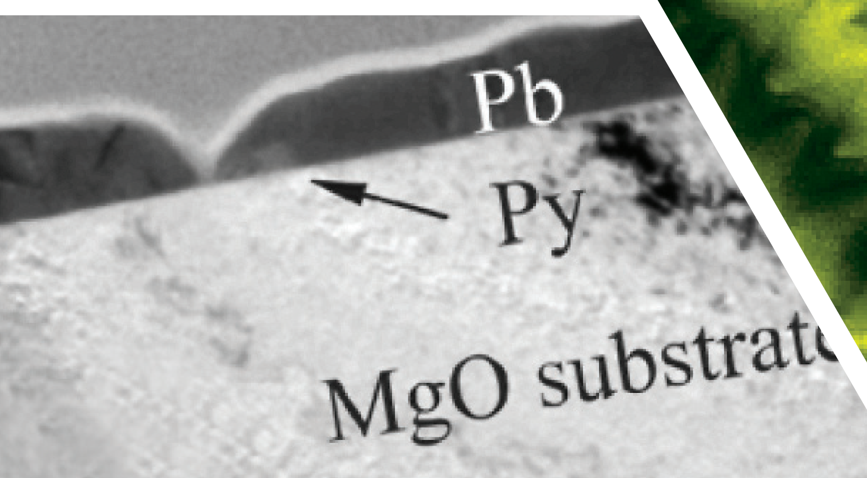

VIII Euro-Asian Symposium «Trends in MAGnetism»

August 22–26, 2022, Kazan, Russia

Zavoisky Physical-Technical Institute FRC Kazan SC RAS

Euro-Asian Symposium «Trends in Magnetism»: EASTMAG-2022

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Symposium is supported by:

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CONTROL OF DOMAIN STRUCTURE OF FERROMAGNETIC PLANAR MICROPARTICLES BY UNIAXIAL MECHANICAL STRESS

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Recently, the possibility to control the magnetic properties of planar ferromagnetic structures by applying uniaxial mechanical stresses has attracted great interest [1, 2]. The stresses can be induced in various ways: by mechanical compression (or stretching, or bending) of the substrate with microparticles; by applying an electrical potential to the piezoelectric substrate; by heating the sample if there is a difference in thermal expansion coefficients of substrate. The influence of uniaxial mechanical stress induced as by the mechanical bending of the substrate as by the difference in thermal expansion coefficients on the domain structure of microparticles made from various materials was studied in this work.

The research was performed for microparticles made from Py alloy (Fe18%, Ni82%), CoNi alloy (Co18%, Ni82%) and Ni. Substrates made of thin cover glass (0.15 mm thick) were mechanically bended for stress induction. A single-crystal substrates of lithium niobate $LiNbO_3$ (CLN) and potassium titanyl phosphate $KTiOPO_4$ (KTP) were used to induce thermal stress. For CLN substrates the in-plane thermal expansion coefficients are differ by two times (for the "*a*" axis $\alpha_1 = 15\cdot10^{-6}$ K^{-1}, for the "*c*" axis $\alpha_3 = 7.5\cdot10^{-6}$ K^{-1}). For KTP substrates the difference in in-plane thermal expansion coefficients was even higher ($\alpha_y = 9\cdot10^{-6}$ K^{-1} и $\alpha_z = 0.6\cdot10^{-6}$ K^{-1}). Thus, the induction of uniaxial stresses in microparticles by changing the sample temperature only a few tens of degrees was possible. The magnitude of this stress was comparable to the stress induced by mechanical bending and it was possible to compare results obtained by both ways.

A magnetic force microscopy (MFM) and optical setup based on magneto-optical Kerr effect (MOKE) registration were used for studying the magnetic properties of microparticles. To visualize the distribution of magnetic moments from MFM images the reverse technique was used: a set of geometrical and material parameters was used to simulate one of the possible magnetization distributions in OOMMF [3], a virtual MFM image was calculated on the base of this distribution, it was compared with the experimental one and in case of match the conclusion that the virtual magnetization distribution is equal to real one was made.

The MFM studies have shown that when applying of uniaxial mechanical stresses, it is possible to change domain's sizes and, thus, to control the domain structure of microparticles (Fig. 1). At the same time, when lateral size of microparticle was decreasing, its sensitivity to the applying mechanical stress also decreases, i.e., with size decreasing from 25 to 7.5 μm the much higher stress must be applied to particle for the same relative change in the domain's sizes. At the same time, a decrease of microparticle height reduces the stress required for same relative change of domains sizes. An increase in absolute value of the saturation magnetostriction of the material (the values for materials used in this work: Py $-3\cdot10^{-6}$, CoNi $-25\cdot10^{-6}$, Ni $-35\cdot10^{-6}$) leads to decreasing the stress required for same changes of domain structure. It was shown that applying uniaxial mechanical stresses, it is possible to achieve a quasi-homogeneous magnetization state of microparticles and, by changing the sign of the stress (i.e., by changing tension to compression), it is possible to reverse the direction of microparticle magnetization by 90°. It was also shown that changes in the domain

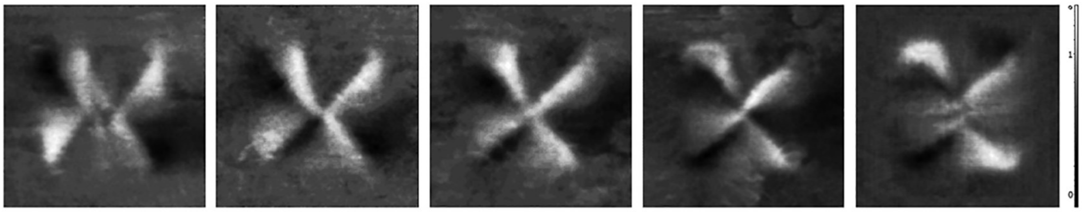

Figure 1. MFM images of CoNi microparticles 7.5×7.5×0.06 μm^3 formed on CLN substrate at temperature 60 °C. Scans were made at different sample temperatures: **a** 30 °C, equal of 47 MPa, **b** 45 °C equal of 24 MPa (direction of tension parallel to Y axis); **c** 60 °C (without of stress); **d** 75 °C, equal of 24 MPa, **e** 90 °C, equal of 47 MPa (direction of stress parallel to Y axis). Scan size 13×13 μm^2.

structure depends only on the magnitude (and the sign) of the stress applying to microparticle and do not depend on the nature of these stresses (bending or heating of the substrate).

The MOKE experiments showed that uniaxial mechanical compression of microparticles leads to appearing of easy magnetization axis (EA) coinciding with the compression axis (due to the negative sign of the saturation magnetostriction of the materials used). The EA direction can be turned by 90° by changing the sign of the applied stress (i.e. by changing from tension to compression). In the absence of mechanical stresses, two EA are observed in microparticles due to shape anisotropy.

The single-crystal substrates with different thermal expansion coefficient along different crystallographic axes are the most promising for further research. Since on these substrates the magnitude of induced mechanical stresses can be easily controlled by changing the sample temperature.

The work was support by RSF (grant №22-29-00352, investigation of Ni microparticles), and by state assignment of Zavoisky Physical-Technical Institute, FRC Kazan Scientific Center of RAS (investigation of Py and CoNi microparticles).

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APP.P02

ESR OF HETEROMETALLIC Mg-Mn WARWICKITES

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Oxiborates cause scientific interest due to their rich phase diagram and low-dimensional zigzag–chain structure. Monocrystals of $Mn_{2-x}Mg_xBO_4$ (x varies from 1 to 0.73) were synthesized by the flux method. Electron spin resonance spectra of these compounds were measured.

Angular and temperature dependencies of ESR linewidth are reported. One exchange narrowed ERP line was observed in the magnetic resonance spectrum. Angle dependence of the peak-to-peak linewidths in two orthogonal *ab* and *ac* planes are presented in Fig. 1. Temperature dependencies of ESR linewidth are shown in Fig. 2. Anisotropic exchange interactions between magnetic Mn^{2+} and Mn^{3+} ions and crystal field parameters describe the linewidth.

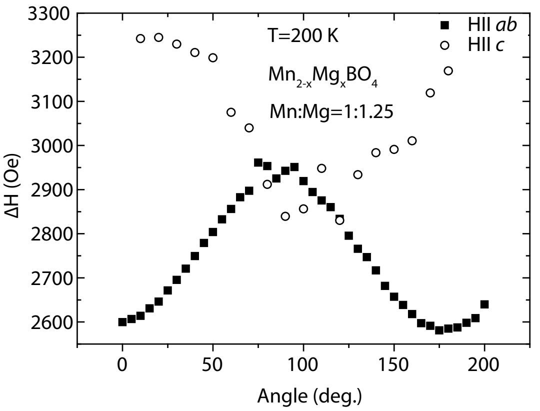

Figure 1. Angle dependences of ΔH linewidths in *ab* and *ac* planes. $Mn_{1.11}Mg_{0.89}BO_4$ sample.

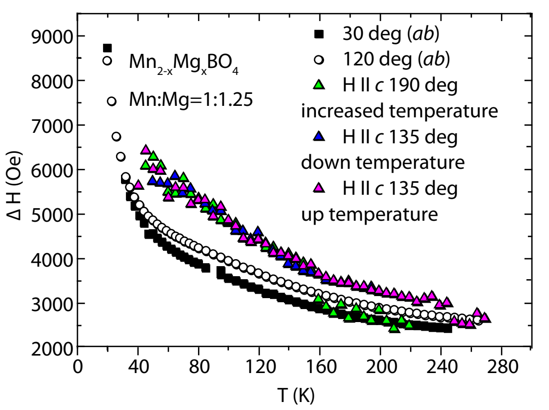

Figure. 2. Temperature dependencies of ΔH linewidths in *ab* and *ac* planes. $Mn_{1.11}Mg_{0.89}BO_4$ sample under different angles.

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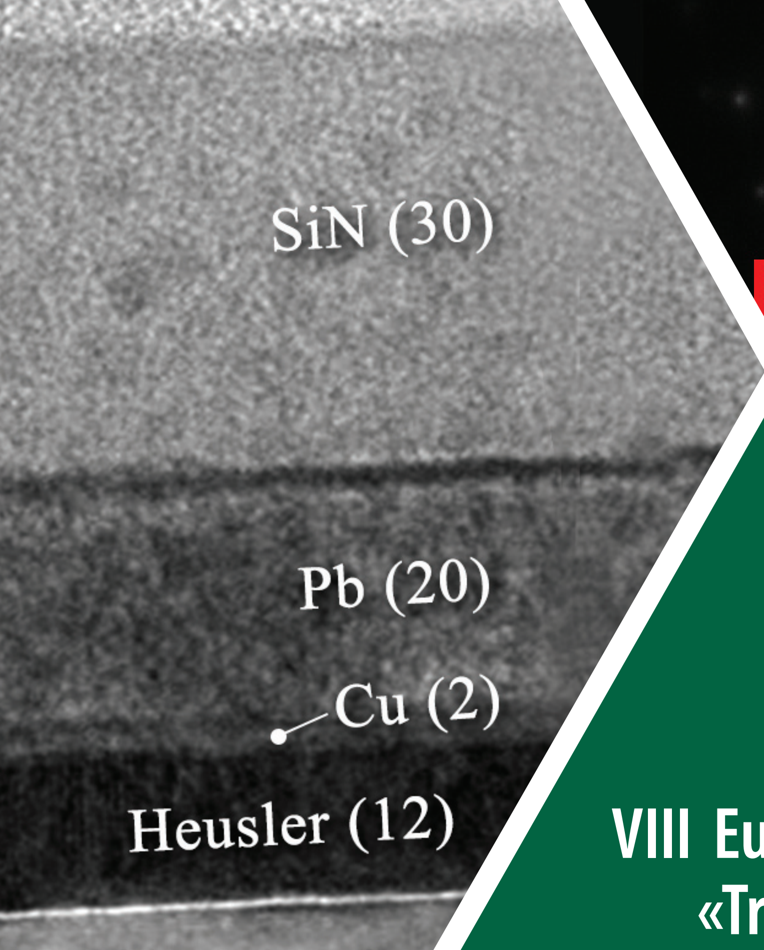
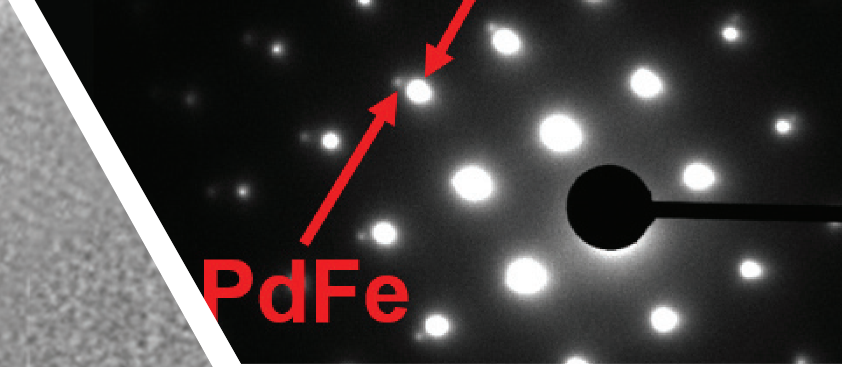
The layout and design of EASTMAG-2022 Book of Abstracts – Polina A. Agzamova
The editing of EASTMAG-2022 Book of Absracts – Sergey G. L'VOV, Olga B. YANDUGANOVA





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