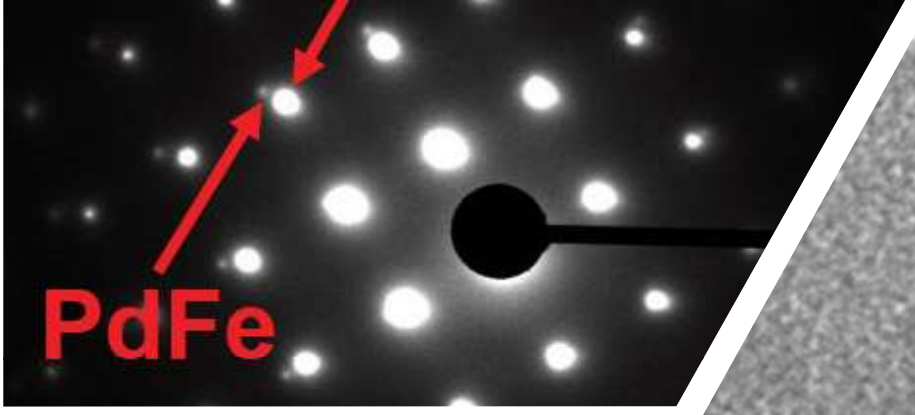

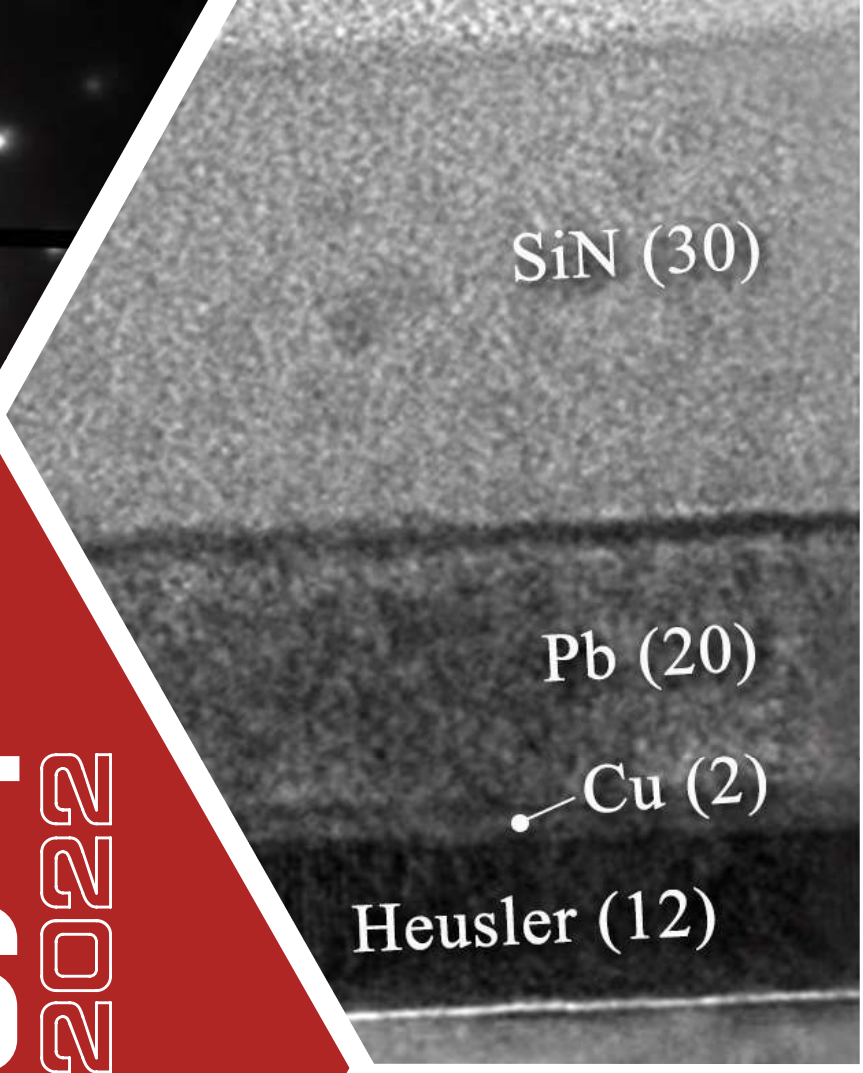

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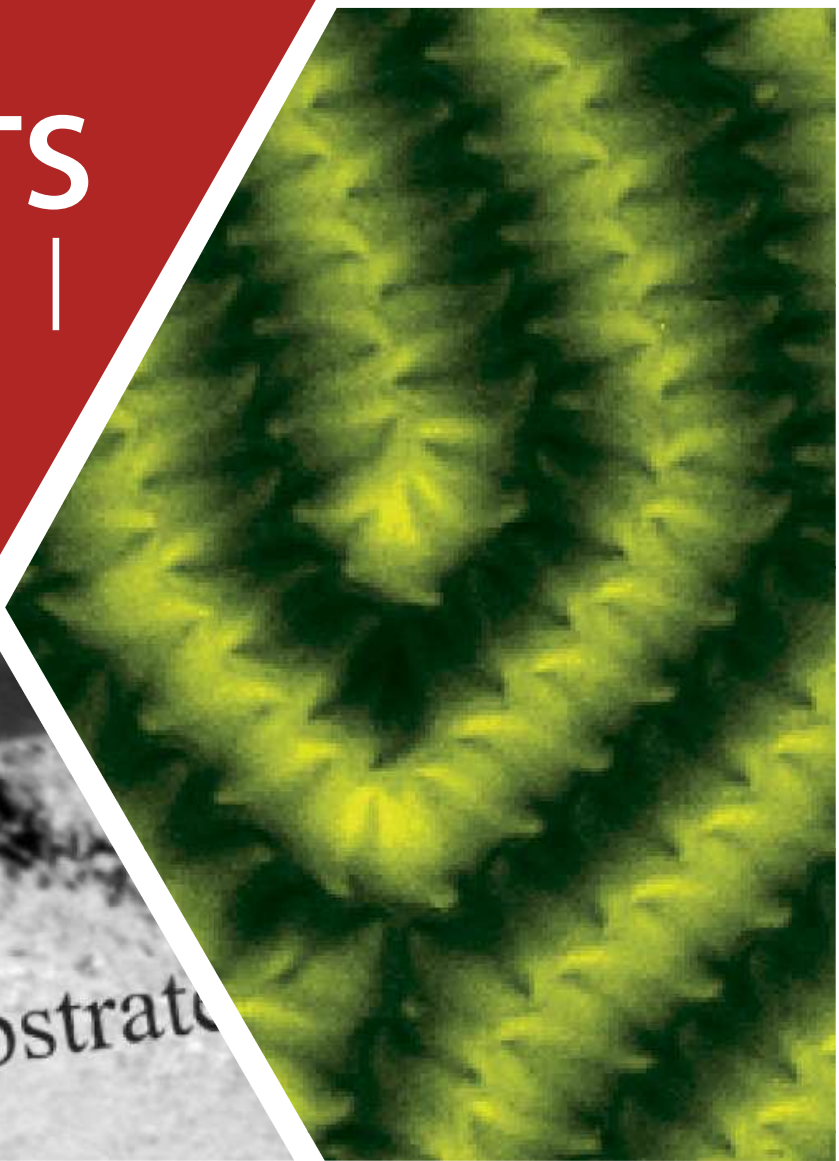

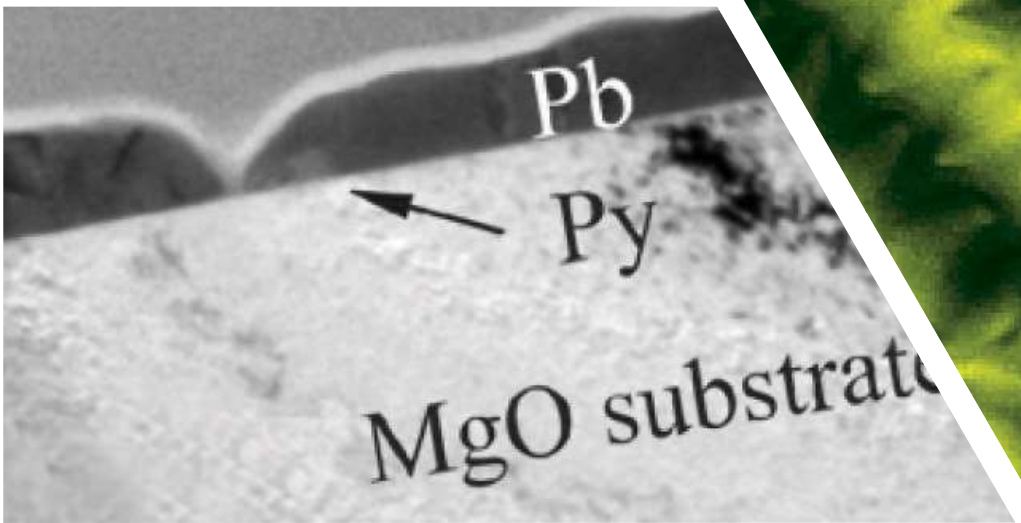

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August 22–26, 2022, Kazan, Russia

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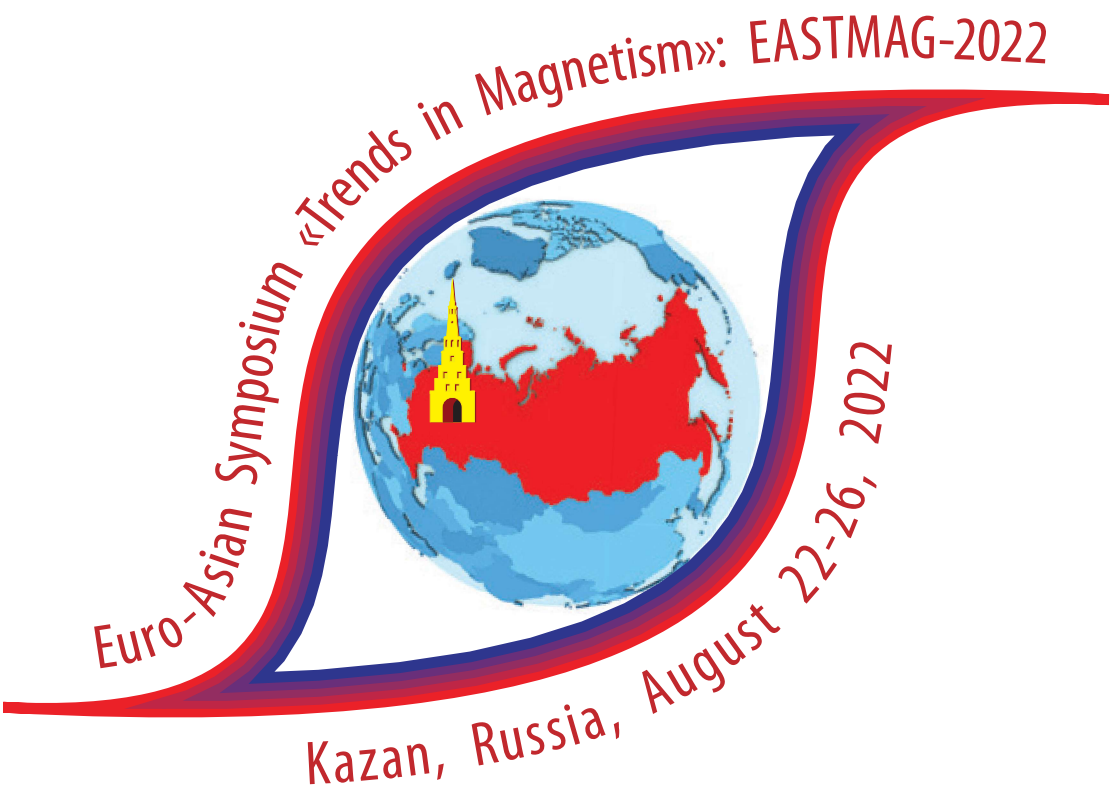

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ANGULAR AND TEMPERATURE DEPENDENCES OF FERROMAGNETIC RESONANCE IN EXCHANGE-COUPLED FeNi/Dy/FeNi PLANAR STRUCTURES

R.S. Iskhakov, I.G. Vazhenina, V.Y. Yakovchuk*

Kirensky Institute of Physics, Federal Research Center KSC SB RAS, Krasnoyarsk, Russia
*E-mail: irina-vazhenina@mail.ru

Planar three-layer structures “ferromagnetic material/interlayer/ferromagnetic material” were studied by ferromagnetic and spin-wave resonance methods in a wide temperature range. The three-layer films were obtained by the vacuum-evaporation technique (10^{-6} mm Hg). The layers $Fe_{20}Ni_{80}$ and Dy were successively sputtered on glass substrates from unrelated vapor sources with a ring-shaped cathode. The thickness of every ferromagnetic layer is about 70 nm, and the thickness of the Dy layer is about 5, 10 and 15 nm. Microwave absorption spectra were measured using the equipment of the Krasnoyarsk Regional Center of Research Equipment of the Federal Research Center “Krasnoyarsk Science Center SB RAS” (spectrometer ELEXSYS E580, Bruker, Germany). The resonator pumping frequency was f = 9.2 GHz. The angular dependences were measured with changing the angle between the direction of constant magnetic field and the film normal. When the temperature measurements in the range from 4 to 300 K were carried out, the constant magnetic field was applied in the plane of the film. Microwave absorption curves were divided into individual peaks using the differential Lorentz function.

The aim of our work is to study the effect of the magnetic state of the Dy-layer of the three-layer system on the parameters of the effective exchange coupling of the ferromagnetic layers.

The experimental FMR-spectra in the whole range of temperatures and angles show a complex structure and demonstrate an excitation of the exchange-coupled oscillations on the form of acoustic and optical modes (Fig. 1).

The temperature dependences of the interlayer exchange interaction constant J_{12}, the values of which were detected from experimental microwave spectra [1], have a set of the features. These are the sign change $J_{12}(-|J_{12}| \rightarrow |J_{12}|)$ and the extremum point on the curve $J_{12}(T)$. We believe that

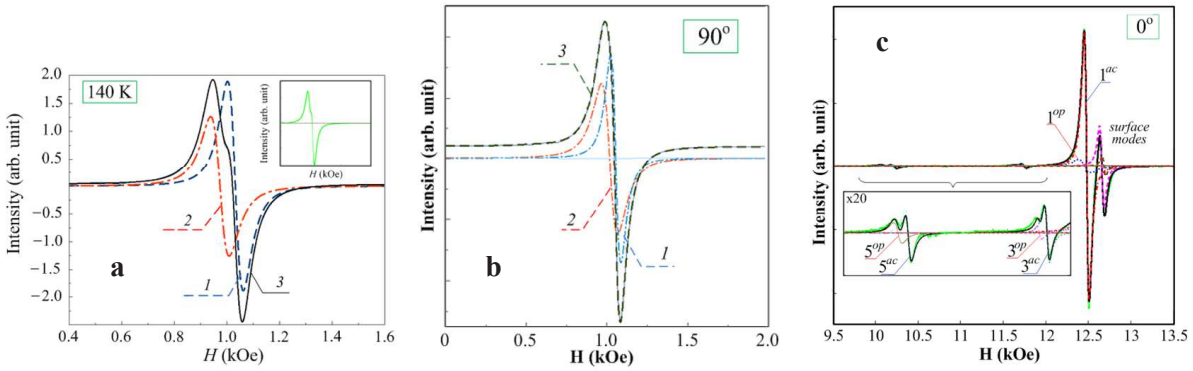

Figure 1. The experimental microwave spectra for films with the thickness of Dy equal 5 nm at 140 K (**a**), the thickness of Dy equal 10 nm at the room temperature and θ_H = 90° (**b**) and θ_H = 0° (**c**). Curves 1 and 2 are acoustic and optical modes, curve 3 is the fitting curve. The experimental curve is shown in the inset.

the behavior of the dependence $J_{12}(T)$ reflects the transformations of the magnetic structure of the Dy. The values of effective magnetization M_{eff}, exchange interaction constant A, surface anisotropy constant K_S and perpendicular anisotropy field were also defined from the angular dependences of the resonance fields.

Support by RFBR, Krasnoyarsk Territory and Krasnoyarsk Regional Fund of Science, project number 20-42-240010 is acknowledged.

1. Z. Zhang, L. Zhou, P.E. Wigen, K. Ounadjela, Phys. Rev. B **50**, 6094–6112 (1994).