INFLUENCE OF ION IRRADIATION ON THE MAGNETIC PROPERTIES AND DOMAIN STRUCTURE OF THIN CoPt FILMS

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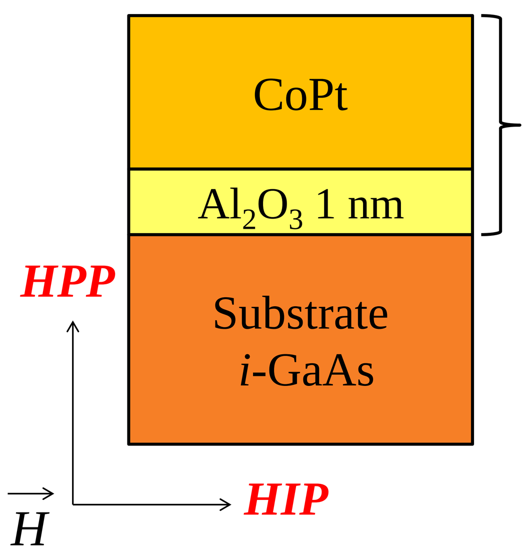
Introduction

The possibilities of controlled exposure of ion irradiation (He^+ with energy of 20 keV and a fluence in the range from 2×10^{14} to 1×10^{15} cm^{-2}) as a method for modifying the magnetic properties and domain structure of CoPt(2/5) films have been investigated. The conditions for the activation of the formation of skyrmion states in these films are established.

Preparation of samples



200°C
Electron-beam evaporation (EBE)

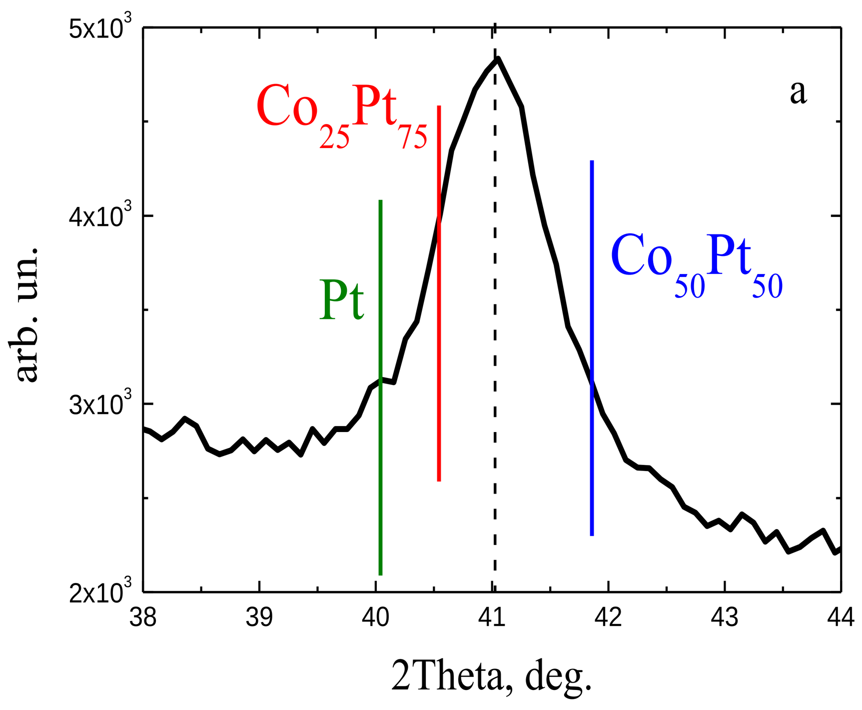
Alternately deposited layers of Pt (0.5 nm) and Co (0.2 nm) - CoPt (2/5).
Total metal film thickness: 7 nm.

Structures were irradiated on the ILU-3 accelerator with 20 keV He^+ ions, the fluence value (F) varied from 2×10^{14} to 4×10^{14} cm^{-2}.

Experimental techniques

- The magneto-optical Faraday effect $Q_F(H)$ at a laser wavelength of 980 nm was investigated.
- Magnetization M of the samples was measured by a magnetometer with a alternating field gradient in the field range of ±1700 Oe.
- The crystal structure of the films was investigated by X-ray diffraction in symmetric Bragg-Brentano geometry.
- The domain structure of the samples was studied by magnetic force microscopy (MFM) using a probe with a low magnetic moment. The changes in the domain structure, leading to the formation of skyrmions, were carried out by MFM scanning with a probe with a high magnetic moment [1].
- The value of the energy of the Dzyaloshinskiy-Moriya interaction (DMI) was estimated.

Results and discussion



The composition of the obtained alloy is $Co_{0.35}Pt_{0.65}$ (estimated using a linear approximation).

Fig.1. X-ray diffraction pattern of the original CoPt (2/5) film. The figure shows the tabular positions of the peaks for different stoichiometry.

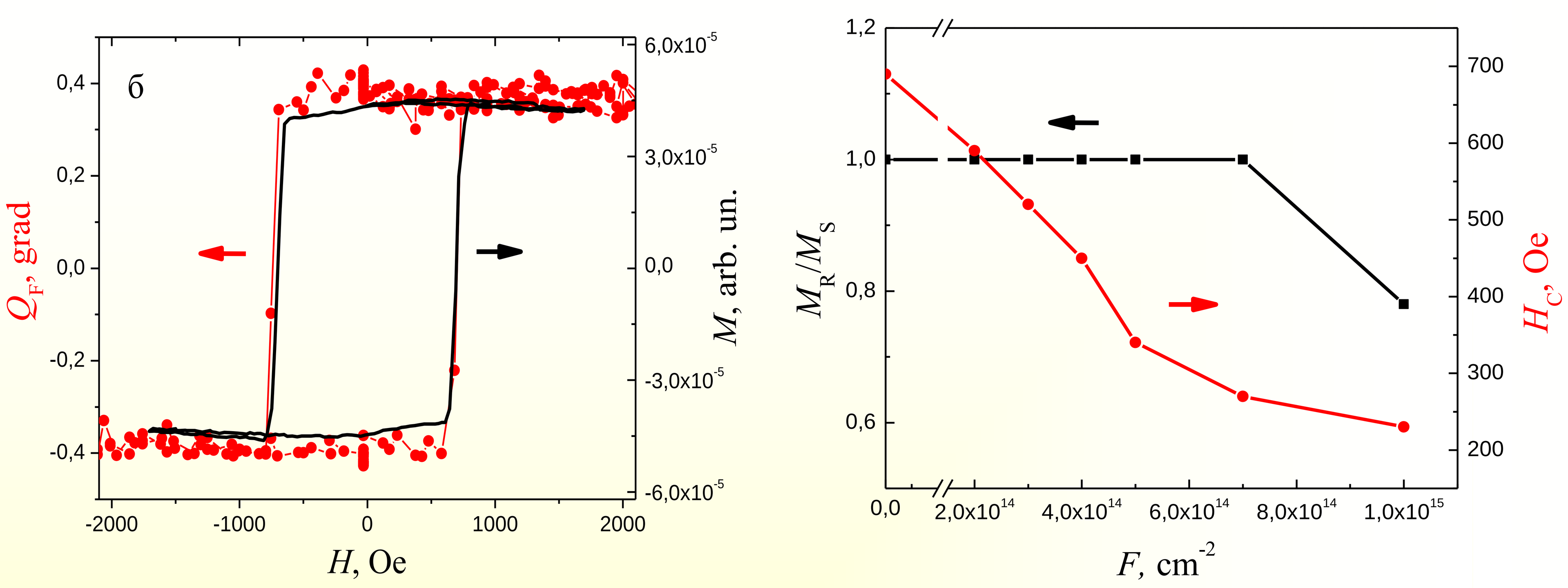
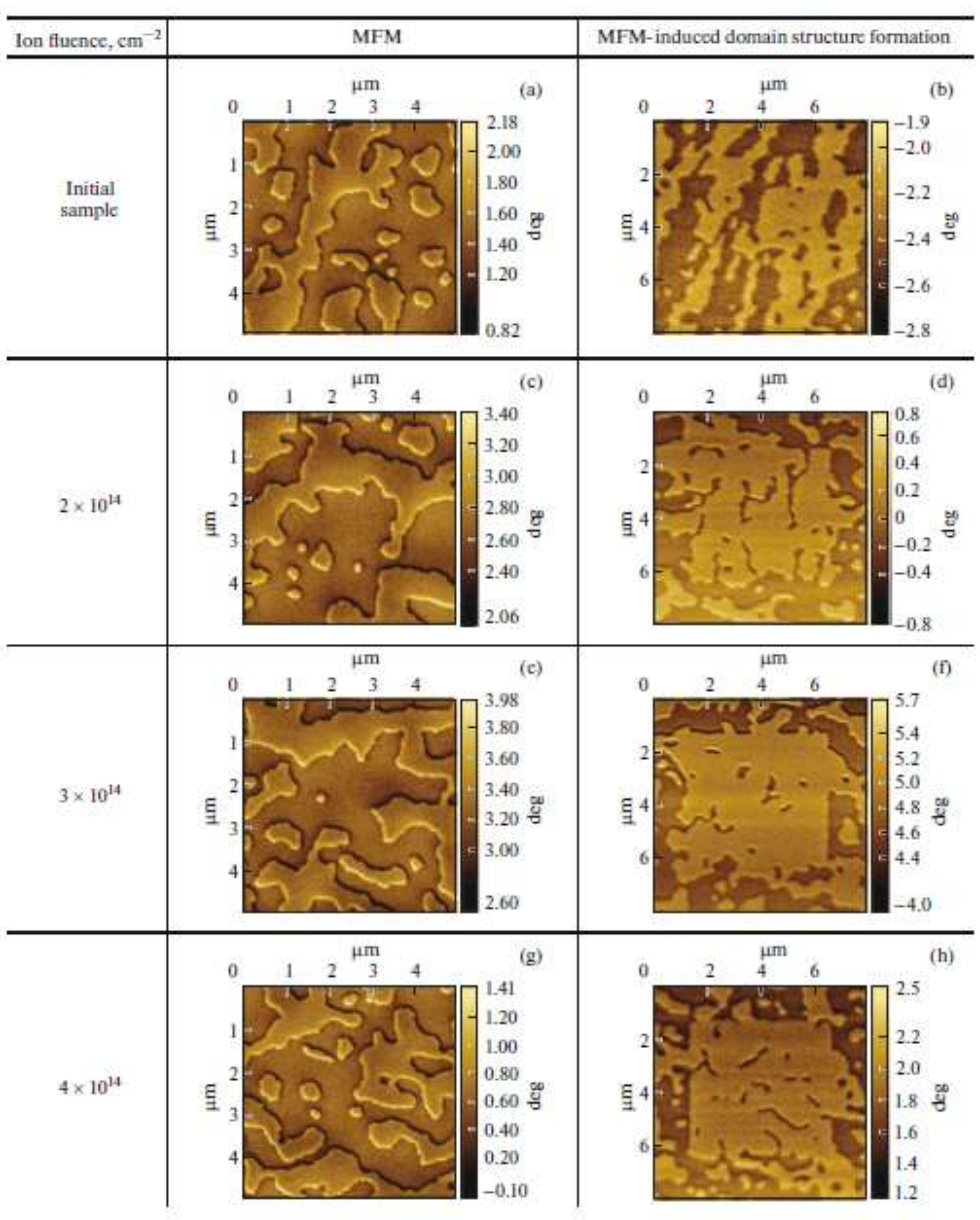


Fig.2. a) Magnetic-field dependences of the Faraday Q_F angle and magnetization M of the initial CoPt(2/5). Magnetic field applied perpendicular to the film surface. *b)* Dependences of the coercive field H_C and relative residual magnetization M_R/M_S on the helium ion fluence.

Таблица 1. Parameters of the initial and irradiated (with dose F) films (shift between the Stokes and anti-Stokes spectral components, Δ, and DMI constant) obtained by Mandelstam–Brillouin spectroscopy.

F, cm^{-2}	0	2×10^{14}	3×10^{14}	**4×10^{14}**
Δ, MHz	216	244	235	**496**
DMI, mJ/m^2	0.281	0.316	0.448	**0.644**

First, a region of 2×2 μm^2 is scanned in two passes, and the film undergoes partial magnetization reversal in the scanning region under the effect of the probe. Then a larger region (5×5 μm^2) is scanned in one pass at a distance of about 100 nm above the surface [1].



For a film irradiated with $F = 4\times10^{14}$ cm^{-2}, the MSM image shows a small number of isolated circular domains (skyrmions), and narrow (~ 100 nm) stripes with "reverse" magnetization - 360-degree domain walls (1D- skyrmions).

The most probable reason for the enhancement of DMI can be the asymmetric mixing of Co and Pt atoms due to ion irradiation, which leads to a decrease in the perpendicular anisotropy of magnetization and promotes the activation of the formation of skyrmion states.

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[1]. Темирязев А.Г. и др. // ФТТ. Т.60, Вып.11. С.2158-2165 (2018).