# PHYSICAL PROPERTIES OF Fe-Ag-Pt FILMS

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## Introduction

With the development and improvement of technology, due attention is paid to reducing the size of devices and electronic circuits. The components of the latter are replaced by thin films (objects less than 1 µm thick). Immiscible systems are of particular interest, since there are a few previously unexplored and promising systems. Purpose of the work: to study the influence of different deposition methods on the properties of the same system, as well as its behavior after heat treatment

## Materials and Methods

The object of this study were films of composition (in at.%):.%): $Fe_{69}Ag_{21}Pt_{10}$.

In immiscible systems, the energy barriers are sufficiently high for the formation of homogeneous structures. To overcome them, it is necessary that the kinetic energy of the atoms hitting the substrate exceed the value of these barriers. Therefore, the films were deposited using the method of modernized three-electrode ion-plasma sputtering (MTIPS) and the high-frequency ion-plasma sputtering method (HFIPS).The rate of energy relaxation of the deposited atoms under different modes of sputtering by the MTIPS method, according to theoretical estimates, reaches $10^{12}$–$10^{14}$ K/s. The films were deposited on sitall (glass-ceramic) substrates, as well as on a fresh cleavage of a NaCl salt single crystal. Films on sitall substrates were used to study the electrical and magnetic properties. The films on the NaCl substrate after its dissolution were studied by electron microscopy and X-ray diffraction analysis. Measurement of the electrical resistance of the films during heating was carried out in a vacuum of 13.3 mPa by the four-probe method. The coercive force $H_c$ of the films was measured using a vibrating magnetometer in a maximum magnetizing field of 0.3 T, added parallel and perpendicular to the film surface.

## Results

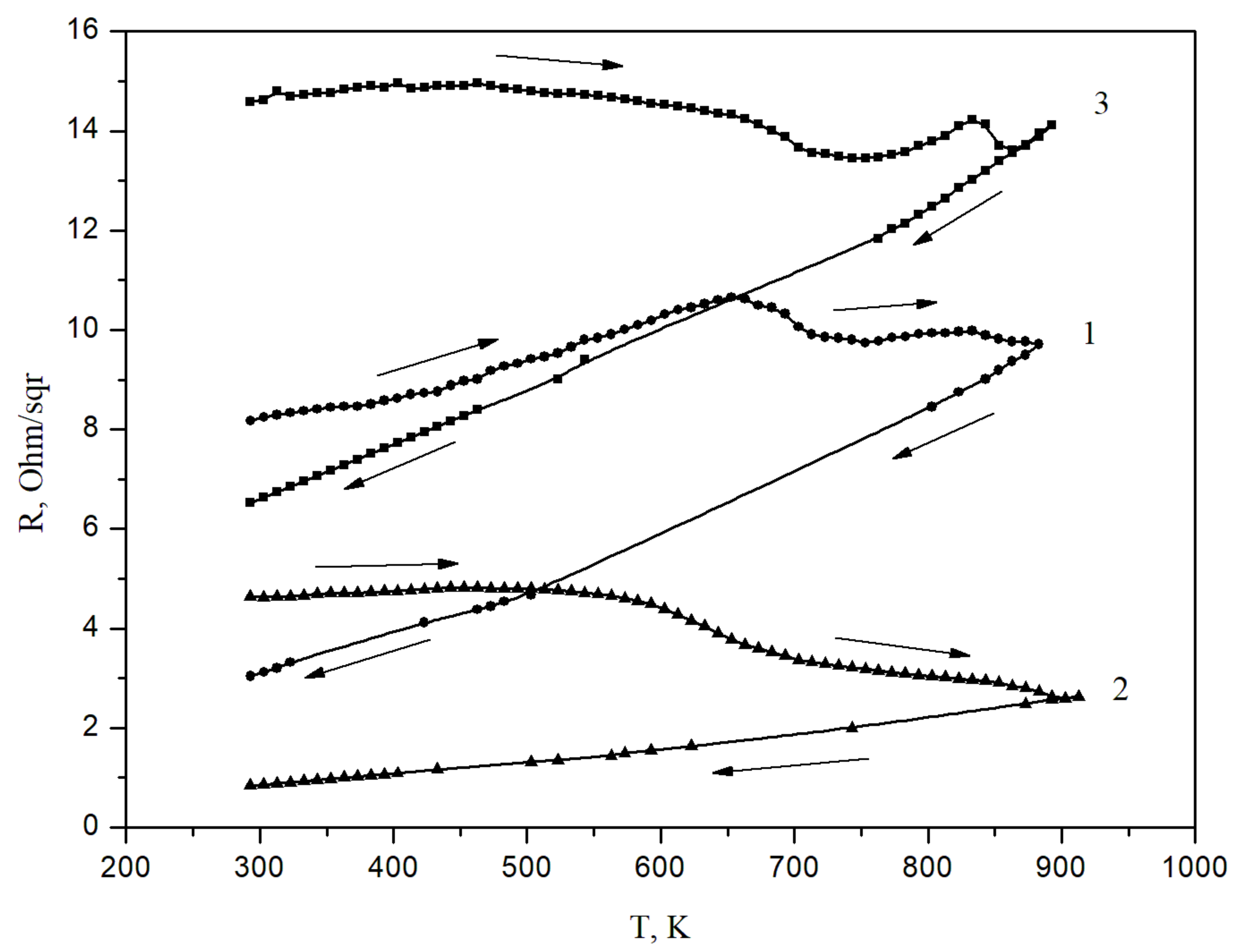


Fig.1. The temperature dependence of the resistivity of the film: 1) MTIPS ($E_a$~100 eV); 2) HFIPS; 3) MTIPS ($E_a$~20 eV)

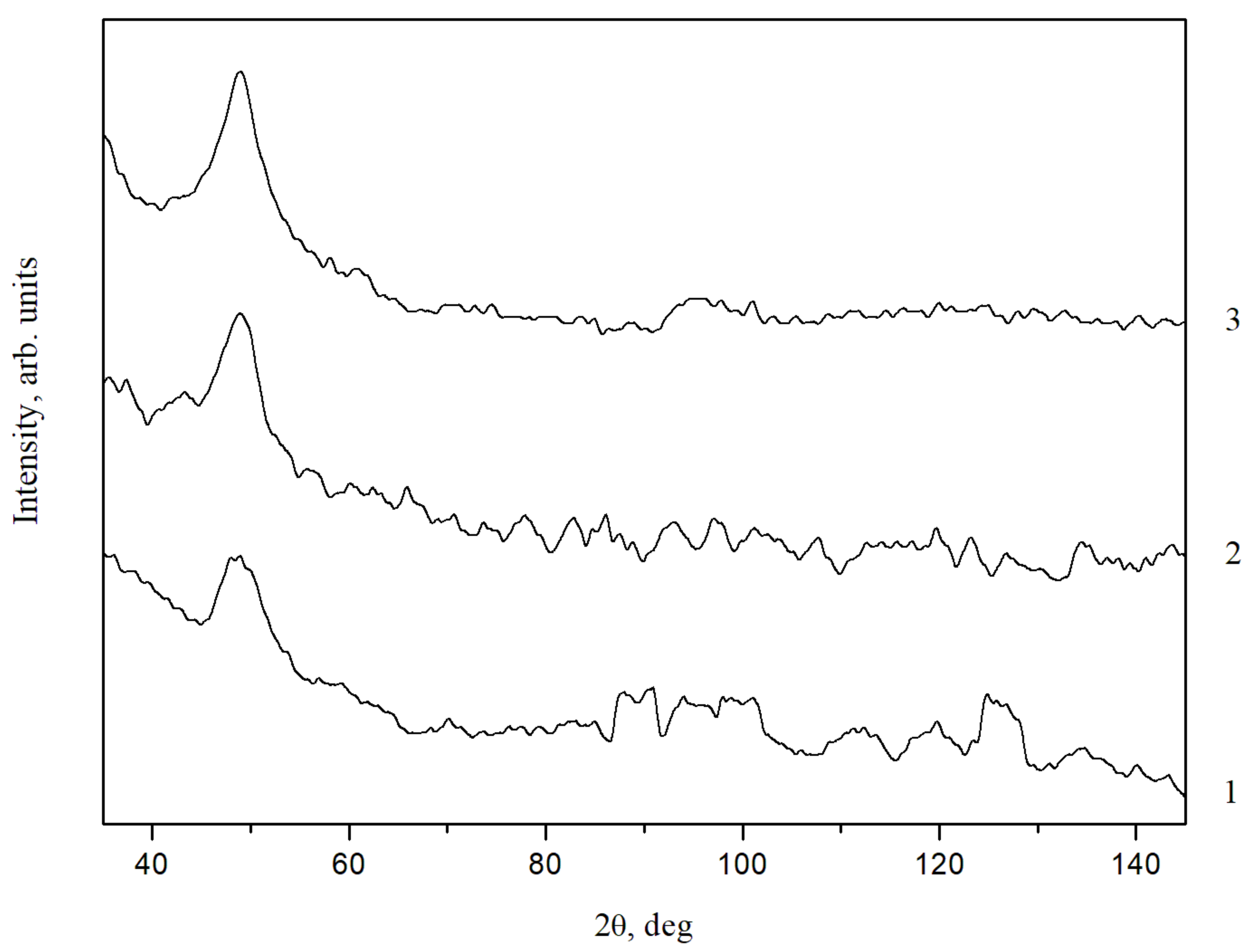


Fig.2. Photometric radiographs of films in their initial state. Estimated energies of deposited atoms and sizes of coherent scattering regions (CSR) are given in parentheses. 1) MTIPS ($E_a$~100 eV; 30Å ); 2) HFIPS (35Å); 3) MTIPS ($E_a$~20 eV; 35Å)

<u>Thermal stability and electrical properties of films.</u>

Fig. 1 shows that the FeAgPt film obtained by the HFIPS (2) method begins phase transformations at a temperature of about 473 K. In the range 303-473 K it has a rather low temperature coefficient of resistance (TRC) $\approx 0.4\times10^{-4}$ $K^{-1}$. Films obtained by the MTIPS method at a pressure P = 130 mPa (3) are characterized by the same stability, which, according to estimates, corresponds to the energy of the deposited atoms $E_a$ on the order of 20 eV. In these films (3), phase transformations begin at a temperature of about 473 K, and its TRC is $0.6\times10^{-4}$ $K^{-1}$.

Films 1 obtained by the MTIPS method at pressure P = 53 mPa. This corresponds to the highest energy of the deposited atoms, $E_a \approx 100$ eV. Structural transformations begin at a temperature of 653 K. For these films, TRC is $\approx 8.4\times10^{-4}$ $K^{-1}$.

<u>Phase composition of thin films.</u>

From fig. 2 can be seen in the freshly deposited state, at all deposition modes, a nanocrystalline phase (NCP) is formed with the sizes of the coherent scattering regions (CSR), L $\approx$ 3.0 - 3.5 nm, which differ little.

After heating to 900 K, traces of NCP decay appear (a second blurred peak and a subpeak appear, on the main halo from the side of large angles), but no noticeable increase in OCR is observed (L $\approx$ 3.5 - 4.5 nm). In this case, the weak growth of OCR may indicate the emergence of internal tensions that arise as a result of the beginning of the collapse of the NCP.

<u>Magnetic properties of films based on immiscible systems</u>.

The smallest coercive force was obtained in sample 3 (P = 133 MPa): $H_c \approx 460$ A/m, but after heating it increased to 11.7 kA/m. In the initial state, these films behave as a magnetically soft material. The coercive force of sample 2 (HFIPS method) after heating increased by 1.85 kA/m to 3 kA/m, but the saturation induction decreased by 1.7 times. The coercive force of film 1 (P = 53 MPa) remained virtually unchanged from 5 kA/m after heating. Saturation induction increased by 3.5 times.

## Conclusions

It is shown that a nanosized Fe-Pt solid solution is formed during modernized three-electrode ion-plasma sputtering and the high-frequency ion-plasma sputtering method . After heating to 900 K, the beginning of NCP decomposition is observed in the films and internal stresses appear. Films (MTIPS, P = 133 MPa) in the initial state are magnetically soft material. After heating to 900 K, the coercive force of the film increases by a factor of 25 and it becomes a hard magnetic material. It is shown that the high-frequency method of ion-plasma sputtering gives results similar to the MTIPS method at an operating pressure of 130 mPa, i.e., at an energy of deposited atoms ~ 20 eV, and can be used for sputtering in situations where MTIPS is not effective - during the deposition of dielectrics.