THE METASTABLE PHASE COMPOSITION OF FeTiB FILMS PRODUCED BY MAGNETRON SPUTTERING

E. N. Sheftel*[a], Ph. V. Kiryukhantsev-Korneev[b], V. A. Tedzhetov[a], E. V. Harin[a], and G. Sh. Usmanova[a]

[a]Baikov Institute of Metallurgy and Materials Science, RAS, Moscow, 119334 Russia
[b]National University of Science and Technology MISiS, Moscow, 119049 Russia
*e-mail: velmurad@yandex.ru

DOI: 10.24411/9999-0014A-2019-10157

The paper presents the results of the complex study of nanocrystalline $Fe_{97.8\text{-}54.5}Ti_{0\text{-}16.6}B_{0\text{-}28.9}O_{0\text{-}3.8}$ films. The films were deposited on glass and metal substrates by magnetron DC sputtering [1] of composite targets: Fe target & SHS TiB/TiB_2 chips, Fe target and hot-pressed TiB_2 chips, or SHS TiB target & Fe chips. The sputtering was performed in Ar atmosphere. The films were annealed in vacuum at temperatures of 200–500°C. The chemical composition and structure of the as-deposited and annealed films were studied using SEM, EDS, GDOES, XRD, and TEM methods. Magnetic properties were studied by the VSM method. Mechanical properties were measured by nanoindentation under loads of 1–5 mN.

The phase composition of the films depends on the concentration of C_B and C_{Ti}, their ratio C_B/C_{Ti} and the type of boride ceramic used in the target (Fig. 1):
(a) ($C_B/C_{Ti} \sim 2$) single phase – bcc solid solution α-Fe(Ti,B);
(b) ($C_B/C_{Ti} < 2$) two-phase – α-Fe (main phase) + α-Ti/Fe_2B/FeTi/TiB_2 (additional phases), target with SHS chips;
(c) ($C_B/C_{Ti} < 2$) four-phase – α-Fe + α-Ti + Fe_2B + Ti_2B_5, a target with hot-pressed chips;
(d) ($C_B + C_{Ti} > 19$) XRD amorphous phase.

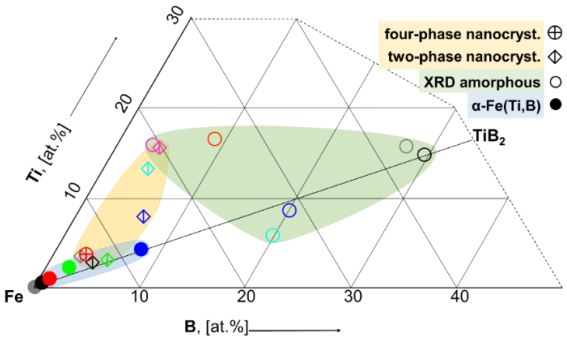
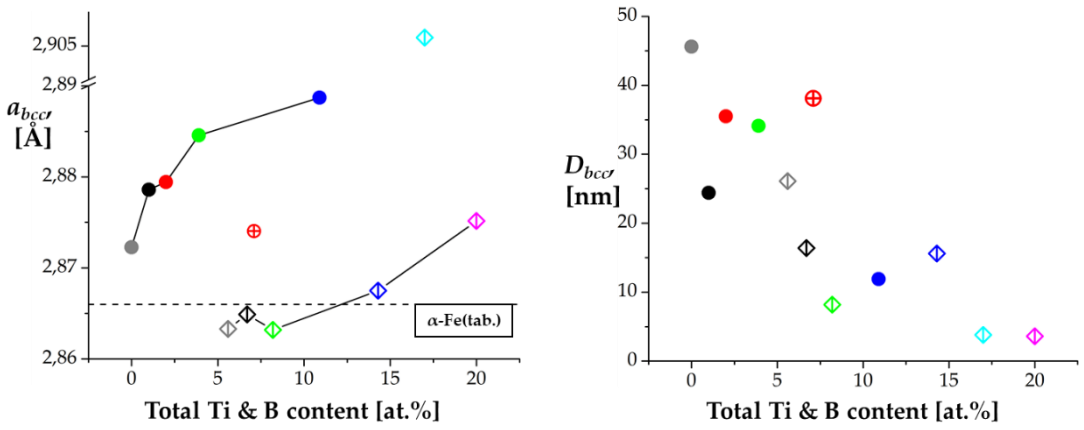


Fig. 1. Chemical compositions of studied as-deposited films.

The formation of a solid solution in nanocrystalline films (a, b, and c) is confirmed by XRD data (the lattice parameter of the bcc phase is higher than that of pure Fe). In single-phase (a) and multiphase (b, c) as-deposited films, with increasing Ti and B content, the lattice parameter of the bcc phase increases (Fig. 2a), and the bcc grain size decreases (Fig. 2b). According to the TEM results, XRD amorphous films (d) have a nanocrystalline structure with a grain size less than 1.6 nm.

The films with a nanocrystalline structure (a, b, c) are strong ferromagnets with a saturation induction in the range of 0.95–2.13 T, depending on the chemical composition. The magnitude of the coercive field of studied films (3÷52 Oe) characterizes them as soft magnetic materials. Films with X-ray amorphous structure are superparamagnetic.



(a) (b)

Fig. 2. Lattice parameter (a) and grain size (b) of the bcc phase as functions of the total Ti and B contents in as-deposited films.

The single-phase as-deposited films (a) have high hardness (12.8÷21.7 GPa) in combination with a low modulus of elasticity (159÷221 GPa) and high elastic recovery (> 55%), which allows predicting high resistance to plastic deformation [2].

The data obtained in this work testifies to the prospects of using SHS boride ceramics as a material for a sputtered target for producing Fe–Ti–B films.

The research was supported by the Russian Foundation for Basic Research, (project no. 18-03-00502).

1. E.N. Sheftel, V.A. Tedzhetov, E.V. Harin, et al., *Phys. Status Solidi C.*, 2016, vol. 13, nos. 10–12, pp. 965–971.
2. A. Leyland, A. Matthews, *Wear*, 2000, vol. 246, pp. 1–11.