Nanocomposites and nanomaterials

Thermal Stability and Magnetic Properties of Some Fe–Cu–Si–B–P Alloys

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Alloys with high saturation induction B_s and low core losses P_{cm} are promising materials for a significant reduction in weight and size of transformer cores and improving the performance of electrical devices. It was established [1] that soft magnetic nanocrystalline alloys Fe–Cu–Si–B and Fe–Cu–Si–B–P have high B_s>1,8 T and coercive force H_c=7.0÷10.0 A/m («SENNTIX 3 » NEC TOKIN Corp.). It is desirable for a commercialization to further increase B_s, reduction of H_c and reduction of core losses at low (industrial) frequencies 0,05÷10 kHz. This problem can be solved by optimizing the chemical composition of the alloy for limiting the growth of α-Fe nanocrystals.

The aim of the study was to determine the effect of alloying on the nanocrystallization process of amorphous Fe–Si–B–P–Cu alloys and their relationship with magnetic properties.

As a result of the studies it was found that ribbons of almost all investigated alloys contain from 1-10 % of the crystalline phase in the initial state. The ribbon of $Fe_{84,3}Si_4B_8P_3Cu_{0,7}$ alloy had a particularly strong texture <100> of α-Fe(Si), which increased after annealing. Heat treatment led to the precipitation of crystals α-Fe(Si) 30÷40 nm in size and a significant decrease of core losses ($P_{10/400}$ decreased from 40 to 7 W/kg) and increase the initial permeability (from 200 to 3500) as compared to the initial state. Crystallization of Fe_3(B, P) after annealing at 710 K $Fe_{82}B_{10}P_7Cu_1$ amorphous alloy was observed, which led to a significant decrease of magnetic properties ($P_{cm(10/400)}$>40 W/kg, H_c>150 A/m).

It was shown that the stability of amorphous ribbons (T_{x1}/T_L) increased with increasing P content in the alloys, which could be explained by the formation of impurity-enriched layers at the interfacial surface between the primary nanocrystals and amorphous matrix. The highest B_s (B_{8000} = 1.66 T) was obtained as a result of heat treatment at T_a = 710 K of core make of $Fe_{84,3}Si_4B_8P_3Cu_{0,7}$ alloy.

1. *A. Makino, H. Men, T. Kubota, K. Yubuta, A. Inoue.* FeSiBPCu Nanocrystalline soft magnetic alloys with high B_s of 1.9 Tesla produced by crystallizing hetero-amorphous phase // Mater. Trans.–2009.-**50**.–P. 204-209.