Nanocomposites and nanomaterials

Thermal stability, nanocrystallization processes and magnetic properties of new nanocrystalline Fe–B–Si–P–Cu–M alloys

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The authors proposed new nanocrystalline soft magnetic Fe-based alloys with lower core loss than Si-steels and higher saturation induction (B_S) than conventional amorphous and/or nanocrystalline alloys [1] with the aim to reduce mass and dimensions of magnetic cores of magnetic transformers. A nano-heteroamorphous initial structure of rapid quenched ribbons is required to reach excellent soft magnetic properties after heat treatment for Fe-Si-B-P-Cu-M base alloys system [1]. Simultaneous additions of both P and Cu in Fe-rich alloys induce heteroamorphous state – α-Fe grains with extreme small size less than 3 nm in supercooled matrix of alloys that exceeds the limit for completely amorphous structure. The only difference between the new Fe-Si-B-P-Cu-M alloys and Fe-Cu-Nb-Si-B alloys is replacement of larger atoms of Nb by smaller P atoms. Crystal growth inhibition which is one of the important factors of nanocrystallization is achieved by Nb addition in FINEMET-alloys [2], however the inhibition mechanism is not obvious for the new investigated alloys. Besides, the replacement of Nb by P makes crystallization strongly dependent on annealing conditions.

The authors studied the thermal stability, nanocrystallization processes and magnetic properties of the Fe-Si-B-P-Cu-M alloys and find out the following benefits of new alloys of certain chemical composition - high saturation magnetic flux density (B_s = 1,85 T), close to B_s of rolled transformer steel (Fe-3 wt.%Si) and approximately three times lower core loss (P_c). This combination of properties is not possessed by any of the known soft magnetic nanocrystalline alloys. Consequently, these alloys are promising materials for production of high-power and highly efficient electrical and electronic devices operating at industrial frequency.

1. *Makino A.* Nanocrystalline soft magnetic Fe-Si-B-P-Cu alloys with high B of 1.8–1.9 T contributable to energy saving // IEEE Trans. Magn. – 2012.–**48**,N 4. - P. 1331–1335.
2. *Nosenko V.K., Semyrga O.M.* Amorphous and nanocrystalline alloys for instrument making and energy efficient technology / monography "Nanoscale systems and nanomaterials: investigations in Ukraine" // Ed. in chief Naumovets O. G.; NAS of Ukraine.- Kiev.: Akademperiodyka, 2014. - P.375-383.