Nanocomposites and nanomaterials

Producing of amorphous-nanocrystalline materials by partial crystallization of amorphous alloys based on Co and Fe

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Two-phase amorphous-nanocrystalline alloys are the new class of materials that in terms of physical properties exceed the properties of nanocrystalline and amorphous materials, creating synergistic effect. Therefore the important direction of modern physical materials science is to develop methods of nanostructurization by controlled partial crystallization of amorphous alloys due to external influences. Based on the analysis of theory high-temperature thermodynamic stability of amorphous alloys the method for producing amorphous-nanocrystalline state from the initial amorphous [1] are proposed. Research carried out on samples of amorphous alloys based on cobalt and iron: $Fe_{80}B_{20,}$ $Co_{84}Fe_{5,3}Si_{8,5}B_{2,2,}$ $Co_{72,5}Ni_{12}Fe_{5,5}Si_{6,4}B_{3,6}$, $Co_{83,85}Fe_{5,7}Si_{7,85}B_{2,6,}$ $Co_{67}Fe_3Cr_3Si_{15}B_{12,}$ $Co_{55}Fe_5Ni_{14}Si_{16}B_{10}$, obtained by the rapid quenched of melt. To create amorphous-nanocrystalline state was determined for each alloy such annealing temperature at which $\Delta\mu_i > 0$ (which is condition for growth frozen crystallization centers), but intensive crystallization process has not begun. When at empirically determined temperature of annealing heat treatment for initial amorphous alloys was carried out and calculated volume part of crystalline phase formed during annealing. The thermal treatment led to the growth of the volume part of crystalline phase X in samples; X is increased to (10-30)% depending on the alloy composition. It was found that the microhardness of the obtained materials is increased as compared to the amorphous state to initial due to an increase in the size of frozen crystallization centers and the formation of amorphous-nanocrystalline state. Electronmicroscopic researces for initial and alloys after annearling showed that the initial amorphous state is characterized by freezed crystallization centers with the average size (2-5) nm. The structure of samples after isothermal annealing characterized by the average size of nanocrystals (10-15) nm, i.e. in this temperature range is the growth of existing crystalline centers. So, the alloys in the amorphous-nanocrystalline state were made, as evidenced by the results of electronmicroscopic studies.

1. V.I. Lysov, T.L. Tsaregradskaya, O.V. Turkov, G.V. Saenko, Features of phase formation and the path of controlled nanostructuring in an amorphous alloy $Fe_{80}B_{20}$ // Journal of Physical Chemistry A, 88 No12, 1981 (2014)