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Structural And Magnetic Studies Of The Nanostructured Fe-(Si,Cr) Alloys

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Abstract:

Nanocrystalline magnetic materials have been the subject of a great number of fundamental and applied investigations due to their potential applications from their remarkable properties such as high saturation magnetization and low coercivity . However, they are greatly affected by various defects and crystalline or atomic disorders [1]. Mössbauer spectra associated with X-rays diffraction and magnetic measurements can get a clear insight of the influences of local disorders .

Nanostructured Fe(Si,Cr) alloys were elaborated by mechanical alloying [2] starting from the pure elements in 3 compositions $Fe_{80}Si_{10}Cr_{10}$, $Fe_{70}Si_{20}Cr_{10}$ and $Fe_{75}Si_{10}Cr_{15}$. The milling process was carried in a planetary ball mill under argon , with a ball to powder weight ratio set to 17/1 , a velocity of 400 rpm and during various times up to 15 hours..

The Fe^{57} Mössbauer spectra of the milled powders , taken at room temperature, show a broad ferromagnetic component and for low silicon content (10%) a central singlet peak. Adequate computer fittings can be achieved by a distribution of hyperfine fields P(H) from which the evaluation of the various Si and Cr environments of the Fe atoms and the mean hyperfine parameters (hyperfine field, isomer shift and relative concentrations) can be deduced. It is then seen that the nanostructured alloys , obtained for 5 hours of milling with a mean grain size of 25 nm, are highly disordered . Increasing the milling time up to 15 hours gives a more homogeneous distribution . For the $Fe_{80}Si_{10}Cr_{10}$ alloy, the P(H) distribution can be separated in two regions (or Gaussians) : one is low fields and probabilities (< 20 T, <H> (probable)= 17 T) and the other with high fields and probabilities (range 20-33 T, < H>(probable)= 27 T) . Each region can be attributed to the different atomic substitutions of the Fe atoms and/or to the contribution of the grain boundary structure due to the heterogeneous nanoscale of the mechanical alloyed materials. Increasing the Cr content such as in the nanostructured $Fe_{75}Si_{10}Cr_{15}$ alloy induces a larger distribution of hyperfine fields with 4 peaks . This can indicate the formation of various Fe environments usually observed in the FeCr alloys. In the contrary, adding Si such as in the nanostructured $Fe_{70}Si_{20}Cr_{10}$ alloy separates the low and high regions of the distribution of hyperfine fields.

Magnetic measurements of the milled $Fe_{80}Si_{10}Cr_{10}$ alloy powder exhibit a soft ferromagnetic character with a decrease of both magnetization and coercive force with milling time .

All the structural and magnetic can be explained by the variations of the atomic disorders related with the silicon and chromium additions and induced defects in the grain boundaries as well as the refinement of the grains due to the mechanical alloying processes.

References:

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