DEVELOPMENT OF NANOSTRUCTURED MATERIALS BY MECHANICAL ALLOYING AND/OR RAPID SOLIDIFICATION

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Soft magnetic based alloys may be produced by both rapid solidification [1] and mechanical alloying [2] processes. This kind of alloys in nanocrystalline form was investigated for applications in magnetic devices as generators, motors, power transformers and sensors [3-4]. However, the magnetic properties of the mechanically attrited materials are inferior to rapidly quenched materials [5-6]. Nevertheless, the use of these materials in power transformers and other energy-conversion devices has been limited by their small thickness [4]. It has also, over the years, proved that MA to be superior to rapid solidification processing as a non-equilibrium processing tool [7]. In the last decades, mechanical alloying of previously melt-spun ribbons is applied as an alternative route to obtain powdered materials [8-9]. The MA of bulk amorphous metallic glasses is a two-step procedure prior to the consolidation or compacting of complicated shape materials in the powder metallurgy industry. Nevertheless, it is known that thermal and structural stability of mechanically alloyed samples is lower than that of the analogous material prepared by rapid solidification [10]. In this work, several Co and Fe rich melt-spun alloys were obtained and mechanically alloyed in low energy milling conditions, and their structure and thermal behavior was analyzed. A detailed knowledge of the temperature dependence of nucleation and crystalline growth is essential for nanomaterials design and to control their microstructure. Furthermore, in technical applications, the thermal stability of nanocrystalline alloys is a problem of fundamental interest to determine the useful working temperature ranges. The kinetics of transformation gives information relative to the stability and applicability of these materials.

An isoconversional method is applied to perform the kinetic analysis. The method was an adaptation to analyze both cold crystallization as well as solidification from the melt. This approach is applied to the study of the crystallization behavior. Once the value of the apparent activation energy is known, the function $f(x)$ can be evaluated from the continuous heating and from isothermal experiments. If the kinetic behavior is the same in both kind of experiments, the experimentally measured $\ln(k_o f(x))$ versus $\ln(1-x)$ has to be independent of heating rate and identical to that obtained in an isothermal regime. That expression can be evaluated from dx/dt by taking

$$\ln(k_o f(x)) = \ln(\frac{dx}{dt}) - \frac{E}{RT} \quad (1)$$

In order to perform the kinetic analysis and to decide which kinetic model agrees better with our experimental crystallization data as the crystallized fraction x. We compare the experimental dependence of $\ln(k_0 f(x))$ against $\ln(1-x)$ and that predicted, assuming different model equations for $f(x)$. Although there is a certain degree of dispersion, the kinetic model that gives the best fit of the experimental data is the Jhonson-Mehl-Avrami-Erofe'ev (JMAE) equation.

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