NANOSTRUCTURED MATERIALS DEVELOPED BY CONTROLLED ANNEALING

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The knowledge of the crystallization kinetics of nanomaterials is important to control their structure and properties. Several authors deal with calculating the amount of transformed material during crystallization. They have led to the determination of temperature-time transformation, T-T-T, curves for the description of the isothermal crystallization reaction since the work of Uhlmann [1]. Other transformation diagram has been introduced [2] to describe non-equilibrium crystallization under continuous heating regime, namely the T-HR-T (temperature-heating rate- transformation) diagram.

Several techniques have been utilized to investigate the kinetics of crystallization processes. In particular, differential scanning calorimetry (DSC) is one of the most often applied to assess crystallization kinetics. From DSC data, several models have been developed to analyze experimental data under isothermal or continuous rate conditions. In this work, we analyze the crystallization process of several Co rich alloys by applying different models, including isoconversional methods. Once a model has been determined, one can construct the transformation diagrams [3]. Transformation diagrams permits us the selection of annealing treatments in order to develop materials with the desired nanostructure. Structural analysis is also performed by X-Ray diffraction (XRD).

Co and Fe rich alloys were investigated for applications in magnetic devices as generators, sensors, actuators and power transformers [4, 5]. The mechanical alloying is a technique that involves the synthesis of materials by high-energy ball milling and has been reported to be capable of producing non-equilibrium structures including amorphous alloys, nanostructured materials and extended solid solutions [6, 7]. The mechanical alloying of rapidly solidified flakes of metallic ribbons is a two-step procedure necessary to obtain powdered samples prior to the consolidation of complicated shape materials. For it, the mechanical alloying of melt – spun flakes of ribbons is applied as an alternative route to develop powdered alloys [8, 9]. In this work, Co rich melt-spun alloys were obtained and mechanically alloyed in low energy milling conditions, and their structure and thermal behaviour was analyzed.

A detailed knowledge of the temperature dependence of nucleation and crystalline growth results essential for nanomaterials design and to control their microstructure. 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.

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Figure: T-HR-T diagram of the crystallization process of a Co based metallic glass. Experimental data (symbols) and isoconversional calculated curves (lines) for transformed fractions (0.1, 0.5 and 0.9).