Influence of cryomilling on structure of CoFeZrB alloy

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Ball milling (BM) is a simple and versatile processing technique to synthesize nonequilibrium materials such as amorphous phases, nanocrystalline phases, and extended solid solutions [1]. This process has been used extensively to study the solid state amorphization of elemental powders and intermetallic compounds (see Chap. 11 of Ref. 1 and references therein). However, only a limited number of experiments were performed to explore the opposite, i.e., the structural transformation of amorphous alloys induced by ball milling. In our work we were interested how the short-time ball milling, and specially the temperature of milling (cryomilling), influences the phase stability of CoFeZrB metallic glass.

High-energy x-ray diffraction (XRD) measurements were performed at the experimental station PETRA 2 using a monochromatic synchrotron radiation of 115 keV (\(\lambda=0.10781\ \text{Å}\)). The samples measured at a room temperature in the transmission mode were illuminated for 180 s by a well collimated incident beam of 1 mm² cross section. XRD patterns were recorded using a two-dimensional detector (mar345 Image plate) in the asymmetric mode to obtain data at a high wave vector transfer (\(Q=4\pi \sin \theta / \lambda\)).

High-energy XRD experiments indicate that the originally amorphous CoFeZrB alloy is progressively crystallizing during the milling process (Fig.1a). After 12 hours milling the Bragg peaks (marked by signs) become more pronounced but they are still rather broad (FWHM > 0.2 Å⁻¹). These observations suggest that a longer milling time increases the amount of crystalline bcc-Fe fraction in the alloy [2]. On the other hand, keeping the vials during milling at a sufficiently low temperature (case of cryomilling) helps to prevent crystallization induced by milling (Fig.1b).

Figure 1: Structure factors, S(Q)-1, of the CoFeZrB alloy in the as-quenched state and for different times when milling a) without and b) with additional cooling (cryomilling).

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References