Fe-based amorphous alloys have an attractive combination of high mechanical strength, high wear resistance and good corrosion properties. Alloys of this family can be produced in the amorphous state by different rapid solidification techniques, and in the present work we studied the crystallization aspects of two types of materials: (a) amorphous Fe₆₀Cr₈Nb₈B₂₄ (at. %) ribbons produced by melt-spinning and (b) partially amorphous coating produced by high velocity oxygen fuel (HVOF). The amorphous Fe₆₀Cr₈Nb₈B₂₄ ribbons were produced by melt spinning with copper wheel rotating at a speed of 50 ms⁻¹ in an argon atmosphere. Annealing treatments were conducted at different temperatures, during short time (60 s) under controlled atmosphere. Coatings were produced by HVOF over a X80 pipe steel substrate using atomized and further milled powders with particle sizes in the range of 20 to 45 µm. TEM observations of the amorphous and crystallized ribbons and of the HVOF coating were carried out in a FEI Tecnai G2 200kV equipment, after the usual thinning by ion milling. XRD patterns indicated the as-spun ribbons to be fully amorphous. No diffraction peak due to crystalline phase was also seen in the ribbons annealed at 450 ºC and 550 ºC, but a clear peak was recognized for the sample annealed at 640 ºC. The coatings obtained by HVOF showed high fraction of amorphous phases and the presence of different crystalline phases. Figure 1 shows STEM bright field micrograph of the amorphous ribbon after annealing at 640 ºC. The sample was fully crystallized although the annealing temperature was slightly lower than the crystallization peak temperature observed by DSC. Figure 2 shows STEM dark field micrograph of the coating layer; as in the ribbons, the crystals are in the nanometric size range and as indicated by XRD and DSC a high fraction of amorphous phase is still present. Figures 3 (a) and (b) show, respectively, the selected area electron diffraction patterns (SAEDP) of the crystallized ribbon and the coating layer. The figure compares both patterns and index the phases as ferrite, FeB and Fe₃B in the ribbon and as ferrite and Fe₂B in the coating layer. In conclusion, TEM observations of crystallized and partially crystallized Fe₆₀Cr₈Nb₈B₂₄ alloys obtained by two rapid solidification processes suggest different sequence of phases formation from the melt and from the amorphous solid.

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Fig. 1: STEM bright field micrograph of the amorphous ribbon after annealing at 640 ºC.

Fig. 2: STEM dark field micrograph of the coating layer with nanometric size range crystals.

Fig. 3: (a) SAEDP of the crystallized Fe₆₀Cr₈Nb₈B₂₄ ribbon; (b) SAEDP of the coating layer produce by HVOF from Fe₆₀Cr₈Nb₈B₂₄ powders. Both patterns indicate the phases associated with the diffraction rings.