

Preparation and Characterization of Master Alloys $\text{Fe}_{48}\text{Cr}_{15}\text{Mo}_{14}\text{C}_{15}\text{B}_6\text{Y}_2$ Metallic Glasses

Badis Bendjemil^{1,2,*}, Nassima Seghairi², Gabriel Lavorato³, Alberto Castellero³, Jamal Bougdira⁵,
Franco Vinai⁴, Marcello Baricco³

¹LASEA, Department of Chemistry, University of Badji-Mokhtar, 23000 Annaba, Algeria

²Department of Mechanical engineering, Faculty of Sciences and Technology, University of 08 mai 1945 Guelma, 24000 Guelma, Algeria

³Dipartimento di Chimica Università di Torino Via P. Giuria 9, I-10125 Torino, Italy

⁴Istituto Nazionale di Ricerca Metrologica Strada delle Cacce 91 I-10135 Torino, Italy

⁵Institut Jean Lamour, Département CP2S, UMR 7198 CNRS–Université de Nancy, Faculté des Sciences et. Techniques, Boulevard des
aiguillettes, B.P. 70239 - 54506 Vandoeuvre-lès-Nancy, France

*Corresponding Author: Badis23@ymail.com

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Abstract The purpose of this work is the characterization of a master alloy of metal glass based on iron $\text{Fe}_{48}\text{Cr}_{15}\text{Mo}_{14}\text{C}_{15}\text{B}_6\text{Y}_2$. Two types of alloys studied B1 which has been prepared by the use of pure element and the other B2 which has been prepared by the use of raw materials. The thermal and structural properties of the samples are measured by a combination of high temperature differential scanning calorimeter (HTDSC), X-ray diffraction and scanning electron microscopy (SEM). Chemical compositions are checked by energy dispersive spectroscopy analysis.

Keywords Master Alloy, High Temperature Differential Scanning Calorimeter, Structural Characterization, X-Ray Diffraction, Scanning Electron Microscopy, Energy Dispersive Spectroscopy Analysis, Fe-Based Metallic Glasses

1. Introduction

The metallic glasses are amorphous alloys obtained by quenching from the liquid phase [1] that have been discovered in 1960 [2]. Most of the alloys can be produced in the form of ribbons of thickness approximately 0.03mm by quenching on a wheel. In the last 20 years have been discovered of alloys that can be produced in massive form, i.e. in the form of bars with a minimum diameter of 1 mm [3-5]. The amorphous alloys can also be obtained by other techniques such as: the grinding [6], the rolling [7], the thin film deposition [8], or the electrochemical deposition [9]. Our study is therefore committed to investigate the thermal properties and the structural characteristics of the two molten alloys for Fe-based metallic glasses whose purpose the possibility to obtain industrial a ribbon and bulk metallic glass form by using the raw materials. The work in this area

and on the composition $\text{Fe}_{48}\text{Cr}_{15}\text{Mo}_{14}\text{C}_{15}\text{B}_6\text{Y}_2$ shows the possibility of obtaining metallic glasses in the form ribbons and bulk with the use of pure elements [10-11].

2. Experimental

All the elements of the sample master alloy of a metallic glass $\text{Fe}_{48}\text{Cr}_{15}\text{Mo}_{14}\text{C}_{15}\text{B}_6\text{Y}_2$ were selected with a high purity, 99.8% (alloy B1). The metals in the form massive are cleaned of any trace of oxide visible to the eye by abrasion of the surface. The compositions are obtained by taking the appropriate quantities in stoichiometric proportions. The metal pieces are then washed in alcohol to 95° in an ultrasonic bath for one to two minutes and then weighed to new. Finally, they are placed in the enclosure of the arc furnace (Bühler) in a controlled atmosphere, free of oxygen. This step of preparation is done as quickly as possible, to avoid to the maximum the re-oxidation of metals. The sample obtained by this process is called sample "molten alloy". In the framework of the possibility of industrial manufacture of metallic glasses from the raw materials, it has prepared a sample molten alloy of a metallic glass (B2) with the same composition. We used a steel AISI430 (55.7 wt %) and the commercial alloy FeB (7.3 wt %) and added the elements pure Mo (25.7 wt %), Cr (5.4 wt %), C(3.4 wt %) and Y(3.4 wt %). The sample "molten alloy" is generally crystal clear sound, it is then necessary to the recast in order to soak the glass to get a metal. The crystalline state has been verified by pairing x-ray diffraction, thermal analysis and scanning electron microscopy. The diffraction was carried out on apparatus of Philips brand type PW1830 (Co-K α , $\lambda=1.7897$ Å). The microstructure has been examined by scanning electron microscopy (SEM) of type Leica stereoscan 4200 and the chemical composition of the alloy has been verified by the dispersion spectroscopy in energy of the x-ray (EDS). The thermal analysis was detected the

thermal effects related to the transformations by high temperatures differential scanning calorimeter (HTDSC) of speed of rise in temperature 0.17K/s. It has used the means of the laboratory of Department of Chemistry at the University of Torino, Italy

3. Results and Discussion

Figure 1 shows XRD patterns of the molten alloy B1. The XRD patterns presents several peaks of diffractions corresponding to the following phases crystalline, indicating that this sample is not amorphous but is fully crystalline: solid solution α - (Fe, Mo, Cr), (Cr, Fe)₂₃C₆, Mo and Fe carbides.

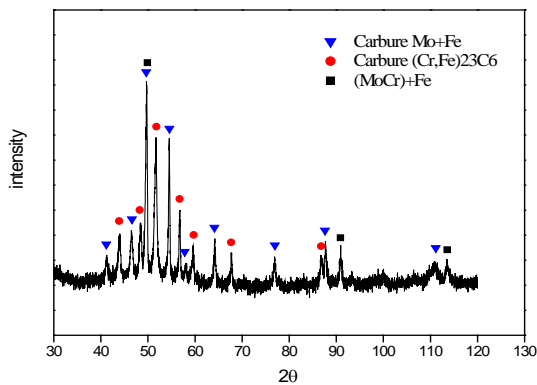


Figure1. XRD of sample B1

The microstructure of the sample of the molten alloy B1 has been observed by SEM (fig. 2). The quantitative determination of the composition of each local crystalline phase is done from a spectrum EDS. Figure 3 shows the EDS spectrum of the crystalline phase of the black point. We found that this phase is an yttrium oxide that is not visible by XRD because the quantity is very small.

The second finding of the analysis of the EDS spectrum (fig. 5) which corresponds to the crystalline phase in dark gray (fig. 4), and shows the phase of the chrome and iron carbide whose chemical composition is the following (Cr, Fe)₂₃C₆.

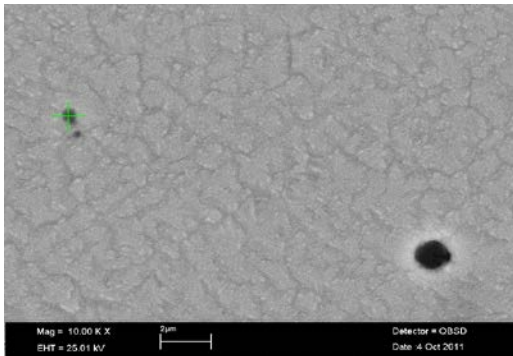


Figure 2. Image of SEM for B1

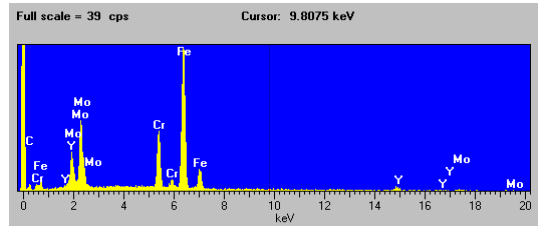


Figure3. EDS spectrum of the black phase

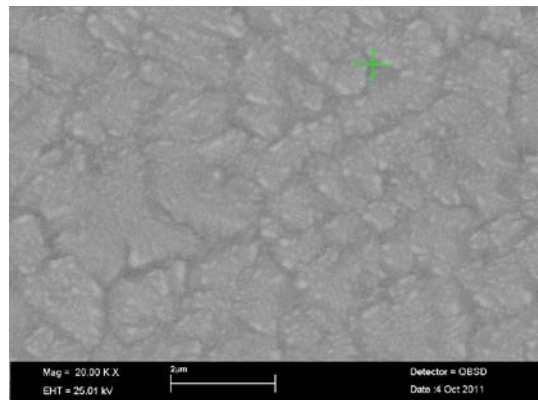


Figure 4. Image of SEM for B1

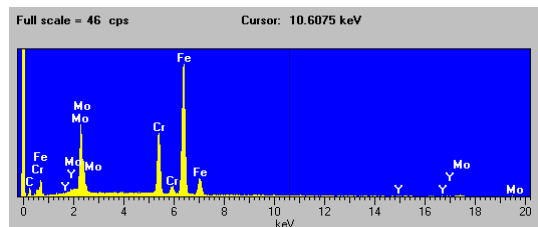


Figure5. EDS Spectrum phase of the dark gray

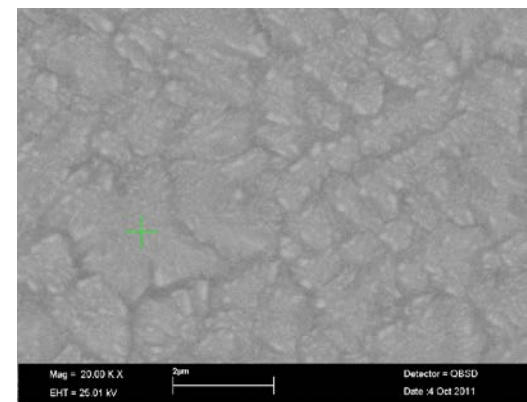


Figure 6. Image of SEM for B1

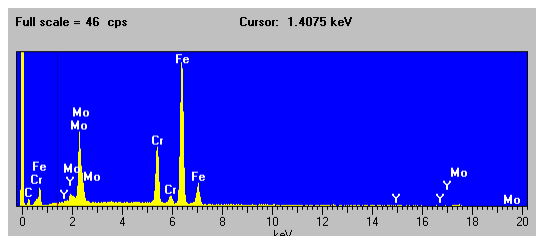


Figure 7. EDS Spectrum phase of the dark gray

We present in figure 6 the image SEM from same sample with their spectral analysis EDS (fig. 7) of the crystalline phase in average gray, the interpretation of this result indicates that this phase is the solid solution α (Fe, Mo, Cr).

The spectrum analysis of the crystalline phase in light gray (fig. 9) that corresponds to the image of SEM (fig. 8), shows that this phase is molybdenum and iron carbide whose chemical composition is $Fe_3 Mo_3 C$.

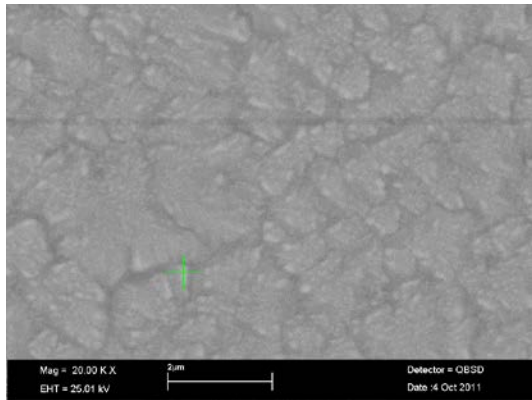


Figure 8. Image of SEM for B1

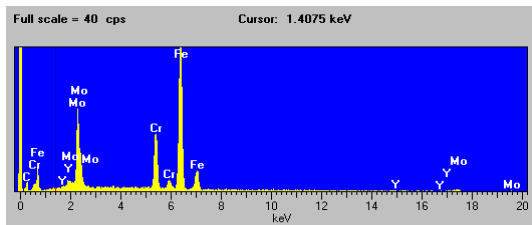


Figure 9. EDS Spectrum phase of the dark gray

Figure 10 shows XRD patterns of the molten alloy B2. The composition presented several peaks of diffractions corresponding to the crystalline phases; therefore this composition is fully crystallized.

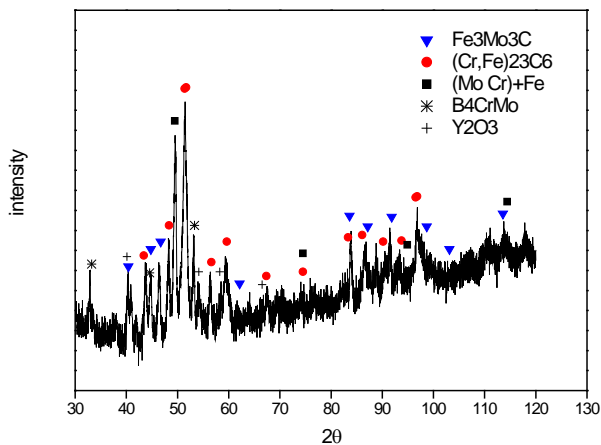


Figure 10. XRD of sample B1

The microstructure of the sample of the molten alloy B2 has been observed by SEM (fig. 11). Figure 12 shows the EDS spectrum of the crystalline phase of the black point. We

found that this phase is an yttrium oxide.

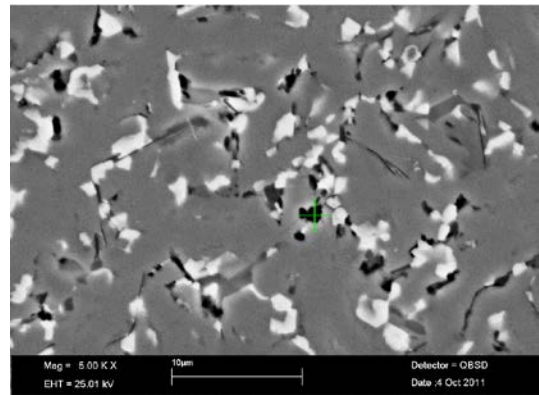


Figure 11. Image of SEM for B2

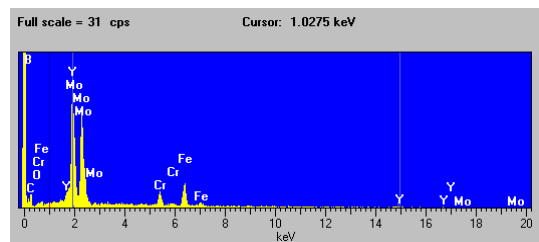


Figure 12. EDS spectrum of the black phase

The second finding of the EDS analysis spectrum of the alloy B2 (fig. 14) corresponds to the crystalline phase in dark gray (fig. 13), and shows the phase of the chrome and iron carbide.

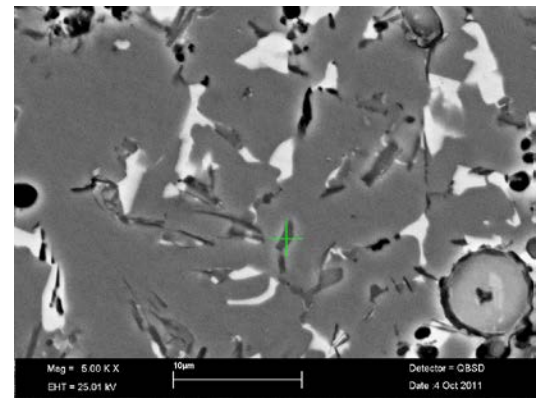


Figure 13. Image of SEM for B2

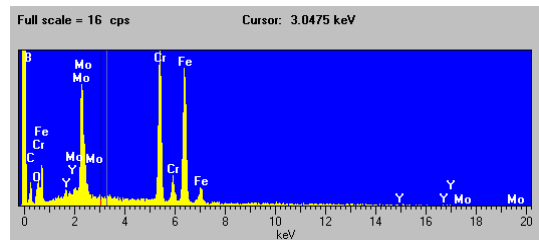


Figure 14. EDS Spectrum phase of the dark gray

The spectrum analysis of the white crystalline phase (fig. 16) that corresponds to the image of SEM (fig. 15) shows

that this is a solid phase α in chemical composition (Mo Cr) +Fe.

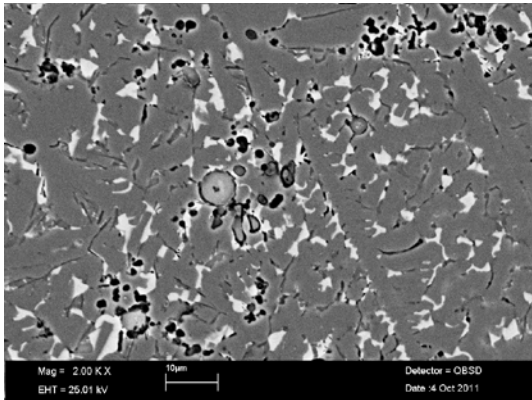


Figure 15. Image of SEM for B2

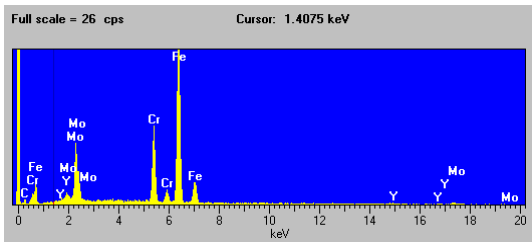


Figure 16. EDS spectrum of the white phase

We present in figure 17 the SEM image of a sample of the alloy B2, with their spectral analysis EDS (fig. 18) of the crystalline phase in average gray; the interpretation of this result indicates that this phase is molybdenum and iron carbide.

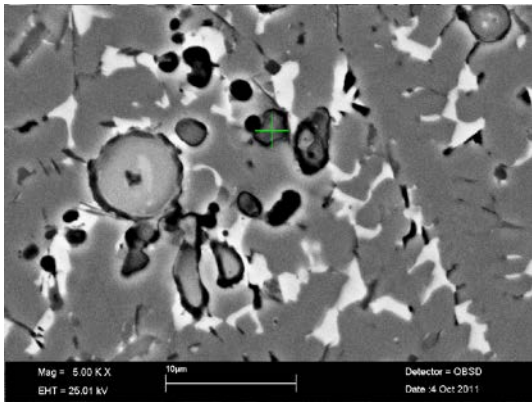


Figure 17. Image of SEM for B2

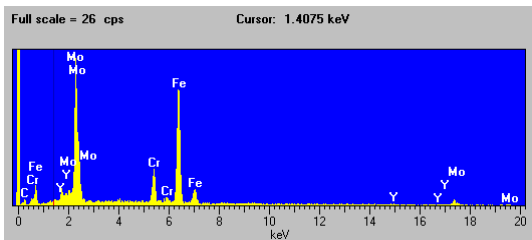


Figure 18. EDS spectrum of the phase average gray

The high temperature differential scanning calorimeter HTDSC relies on the comparison of heat flux as a function of temperature between a reference inert (here a door empty sample) and a sample to characterize which undergoes transformations of phase exothermic or endothermic. In the case of the alloy mother of a metallic glass these measurements used to determine the melting temperatures (endothermic) and solidification (exothermic).

The behavior of the merger of the two molten alloys B1 and B2 is studied by HTDSC (fig. 19). The analysis of this thermo gram shows that for the two alloys B1 and B2, the results are non-eutectic of the merger. For the alloy B1, the first melting temperature (T_m) and the final temperature of fusion (T_f) are 1093 °C and 1214 °C respectively. For the alloy B2, the first melting temperature (T_m) and the final temperature of fusion (T_f) are 1120.4 °C and 1233 °C respectively.

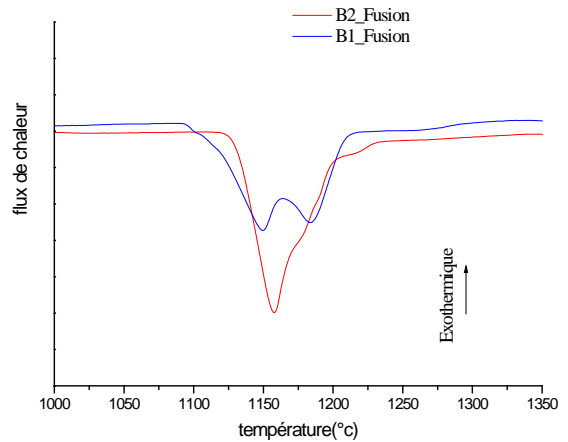


Figure19. HTDSC traces the fusion of the alloy B1 and B2

We present in figure 20, HTDSC who trace the solidification of the two molten alloys B1 and B2. During the cooling, two peaks of exothermic alloy solidification for the B1 are observed whose temperatures are the following: 1122.4 C° and 1128.9 °C. For the alloy B2, there are three peaks of solidification whose temperatures are the following: 1127. 6, 1138 and 1171.2 °C.

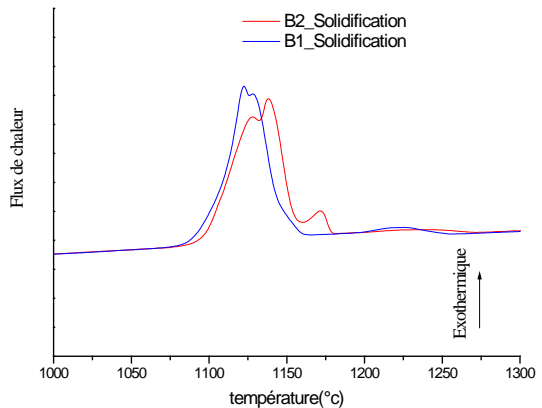


Figure20. HTDSC traces the solidification of the alloy B1 and B2

4. Conclusion

Our study is therefore committed to study the structural and thermal properties of two master alloys for Fe-based metallic glasses and to better understand the existing crystalline phases in these alloys and make a comparison between the latter whose goal is the possibility of industrial manufacture of metallic glasses from the raw materials. We have seen, according to the results of XRD in combination with the SEM and EDS that there are four crystalline phases are the same for the two alloys B1 and B2 which are carbide (molybdenum + iron), carbide (iron + chromium), solid α ((Mo Cr) +Fe) and yttrium oxide, it is for this reason, we can say that there is similarity between the two masters alloys. It must be noted after the results of HTDSC that the temperatures of the fusion and solidification of the alloy B2 are higher in comparison with that of the alloy B1. This is due to the homogeneity of the alloy B1 because these elements are pure.

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