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Influence of yttrium additions on structural behaviour of $Cu_{50}Zr_{50-x}Y_x$ metallic glasses (x = 5, 10, 15, 20, 25)

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The structural behaviour of $Cu_{50}Zr_{50-x}Y_x$ metallic glasses (x = 5, 10, 15, 20, 25) prepared by Melt-Spinning have been studied by means of scanning electron microscopy and transmission electron microscopy techniques. SEM and TEM demonstrated that the microstructural evolution depends on the amount of yttrium. The precipitating phases were identified by SEM and TEM. Finally, the obtained results were summarized. In the future the study will be focus to investigate the thermal and structural behaviour of Cu-Zr-Y alloys by using X-ray diffraction and differential scanning calorimetry techniques to identify the precipitating phases.

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1. Introduction

Bulk metallic glasses (BMGs) have been largely investigated since the early 1990s due to their unique physical, chemical and mechanical properties being of special interest for a wide range of potential applications [1-4]. The first Cu-rich bulk metallic glass-forming alloys were discovered in a Cu–Ti–Zr–Ni system [5], and then Cu–Ti–Zr–Ni–Si and Cu–Ti–Zr–Ni–Sn systems were reported [6, 7]. Very recently, the report of ternary $Cu_{60}Ti_{10}Zr_{30}$ and $Cu_{60}Ti_{15}Hf_{25}$ systems [8, 9], exhibiting excellent mechanical properties, has generated considerable research activity in this area, especially in the microstructure of the ternary systems which is essential to explain the excellent mechanical properties. The effect of yttrium content on the structural behaviour will be described, and finally the role of yttrium will be discussed.

2. Experimental procedures

Alloy ingots with the composition of $Cu_{50}Zr_{50-x}Y_x$ were prepared by Arc-Melting pure metals of 99.99% copper, 99.9% zirconium and 99.9% yttrium in a purified argon atmosphere. For reaching homogeneity, the samples were remelted for several times. From the Cu- Zr pre-alloys amorphous ribbons were prepared by means of rapid quenching from the melt using a single-roller Melt-Spinner under argon atmosphere (Fig. 1). The diameter of the copper roller is 30 cm, with the quenching temperature of 1300 K and the typical rotate speed of 65 Hz.

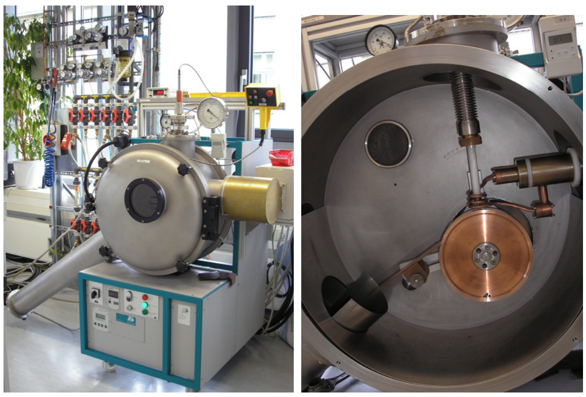

Fig. 1. Melt Spinner

The ribbons were investigated by using scanning electron microscopy (SEM) with a Quanta 200 SEM (Philips FEI Company) (Fig.2)

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Fig. 2. Scanning Electron Microscopy Quanta 200 SEM.

Fig. 3. Transmission Electron Microscopy Tecnai F30 Analytical Microscope

Part of the specimen of $Cu_{50}Zr_{25}Y_{25}$ alloy was supplied for transmission electron microscopy (TEM) observation to check the microstructures for crystallized specimen with a Tecnai F30 Analytical Microscope (Philips FEI Company) (Fig. 3).

The amorphous character and crystalline phases of the specimens have been examine by X-ray diffraction (XRD). The thermal properties of the melt-spin ribbons have been examined by using a Netzsch DSC404 system.

3. Results and discussion

SEM images demonstrated that the microstructural evolution depends on the amount of yttrium, as shown in Fig. 4.

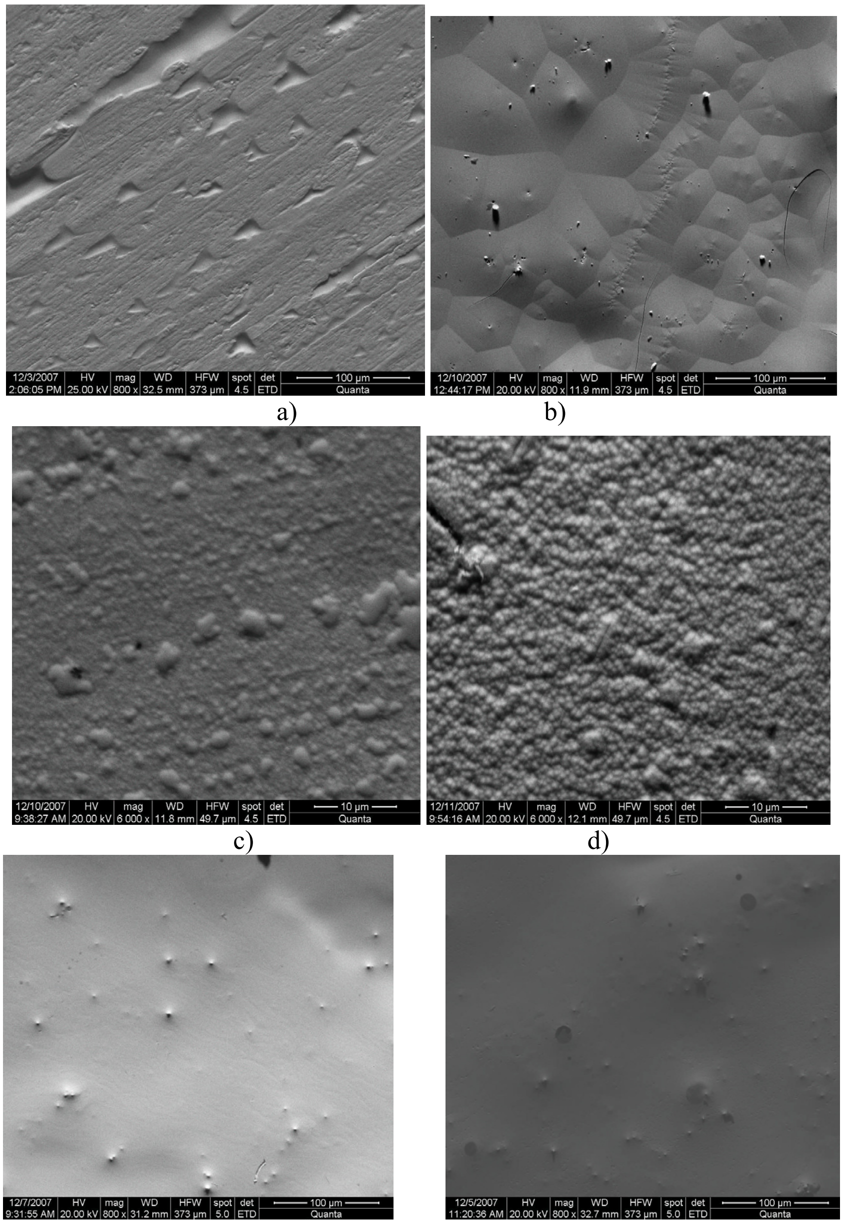

Fig. 4. SEM images of $Cu_{50}Zr_{50-x}Y_x$ alloys a) $Cu_{50}Zr_{50}$ mag. 800 x, b) $Cu_{50}Zr_{45}Y_5$ mag. 800 x, c) $Cu_{50}Zr_{40}Y_{10}$ mag. 6000 x, d) $Cu_{50}Zr_{35}Y_{15}$ mag. 6000 x, e) $Cu_{50}Zr_{30}Y_{20}$ mag. 800 x, f) $Cu_{50}Zr_{25}Y_{25}$ mag. 800 x.

Fig. 4f shows the SEM image of the rapidly quenched $Cu_{50}Zr_{25}Y_{25}$ alloy which is studied too with transmission electron microscopy.

Fig. 5 shows the TEM image of the rapidly quenched $Cu_{50}Zr_{25}Y_{25}$ alloy obtained with a Tecnai F30 Analytical Microscope (Philips FEI Company), that proved an inhomogeneous spherical microsctructure with a sharp interface between precipitates and matrix. Local electron diffraction and high-resolution TEM proved an amorphous structure for both regions. The contrast in the TEM image is related to local differences in chemical compositions. Nanoparticles show irregular shapes (longitudinal and spherical) and have different thickness.

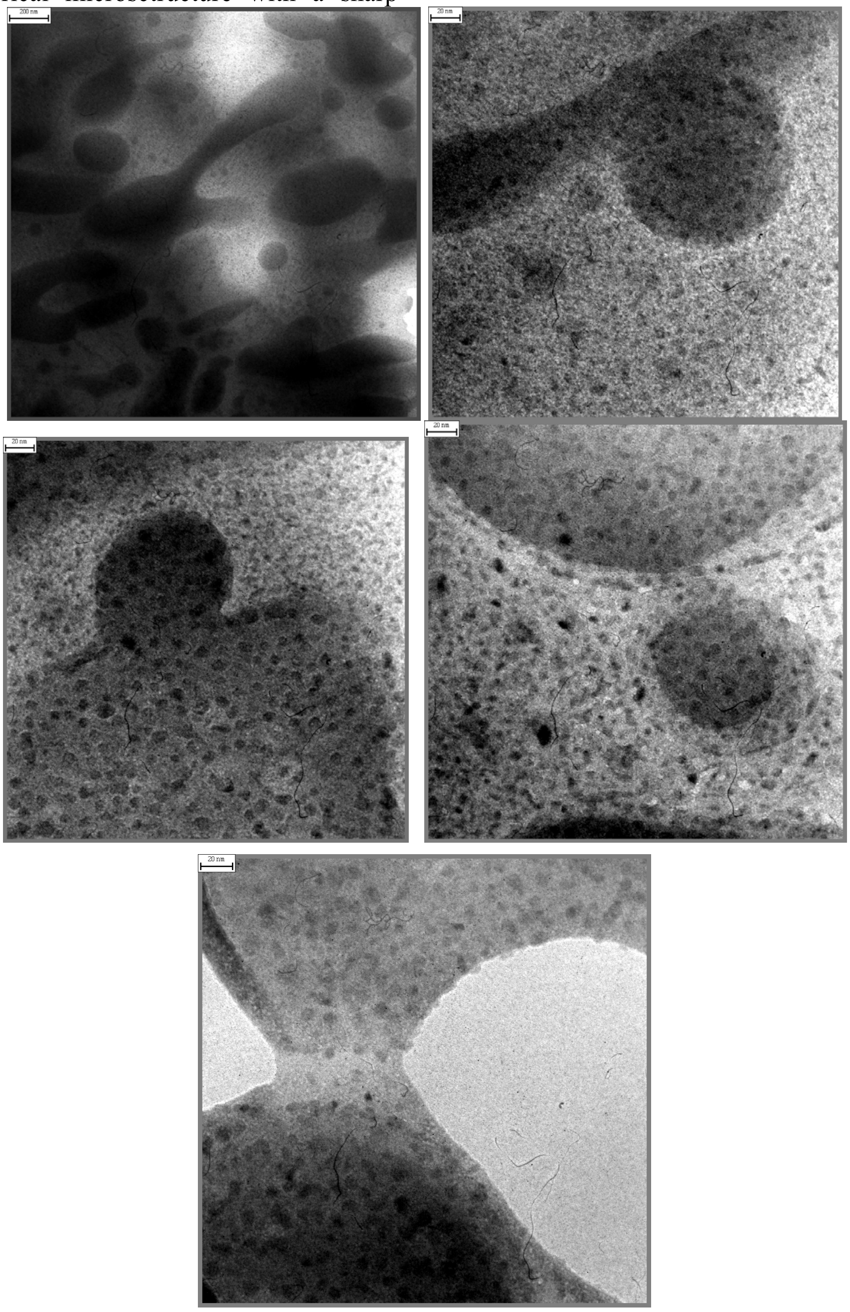

Fig. 5. TEM high resolution image of $Cu_{50}Zr_{25}Y_{25}$

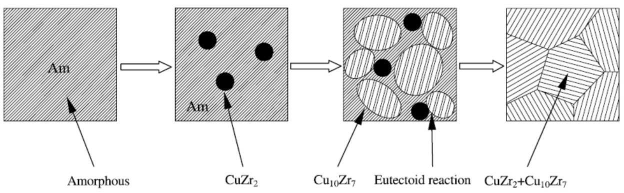

Fig. 6. Schematic diagram of crystallization process for amorphous $Cu_{50}Zr_{50-x}Me_x$ alloys

Fig. 6 shows the schematic diagram of crystallization process for amorphous $Cu_{50}Zr_{50-x}Me_x$ alloys under the condition of continuous heating.

Fig. 7 shows the Cu-Zr binary equilibrium phase diagram which will be explain using X-ray diffraction and differential scanning calorimetry techniques to identify the precipitating phases [10].

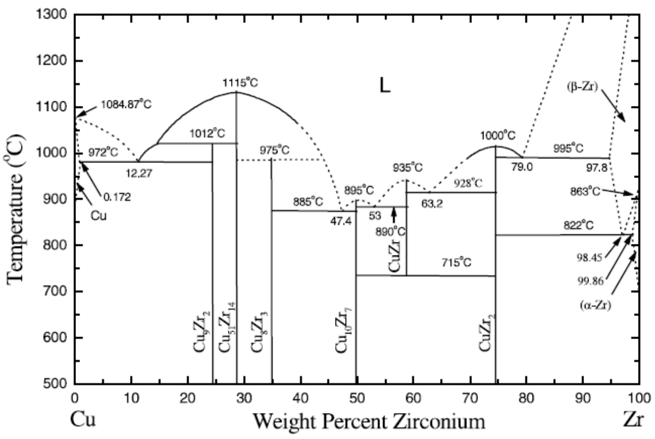

Fig. 8. Cu-Zr binary equilibrium phase diagram

Structural investigation of ribbons before DSC will be done by X-ray diffraction (XRD) with Cu K_{α} radiation using a Siemens D500 diffractometer.

The thermal stability of the alloys will be examined with a differential scanning calorimeter (Netzsch DSC 404) under a flow of purified argon using a constant heating rate of 20 K/min.

4. Conclusions

Depending on the yttrium content, different microstructure behaviour has been observed for $Cu_{50}Zr_{50-x}Y_x$ metallic glasses.

The precipitating phases will be identified by using X-ray diffraction and differential scanning calorimetry techniques.

These types of BMGs are very promising for the further development of Cu-Zr-based alloys as advanced materials.

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