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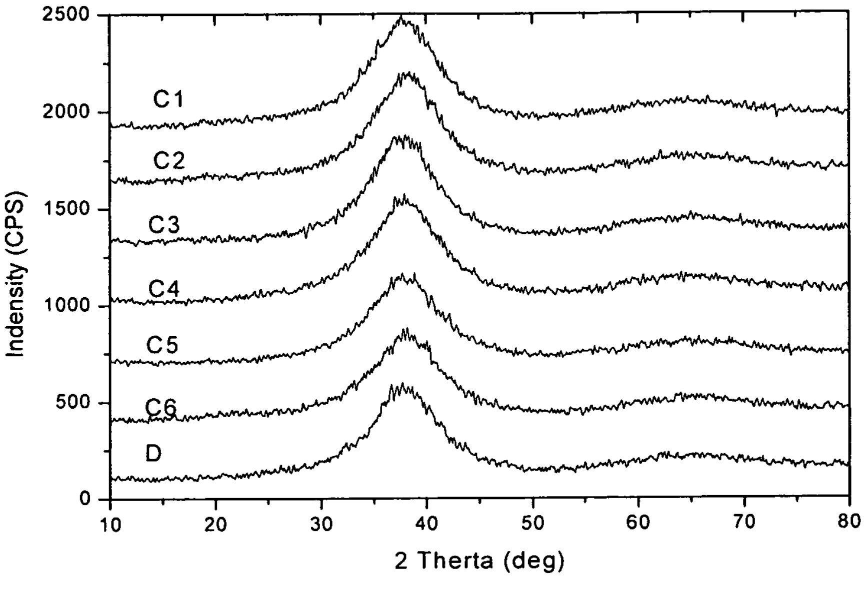
(54) An amorphous alloy and a preparation method thereof

(57) In one aspect, an amorphous alloy comprises Cu, Zr, Be and M. M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu and Zr. In another aspect, an amorphous alloy comprises Cu, Zr, RE and M. RE is at least one element selected from the Rare-Earth Group, M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu, Zr and RE. In yet another aspect, a method for preparing an amorphous alloy comprises melting a raw material comprising Cu, Zr, Be, and M to form an alloy. M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu and Zr.

Fig.1



EP 2 103 699 A1

Description

[0001] The present application claims priority to Chinese Patent Application No. 200810066316.5, filed March 21, 2008, and Chinese Patent Application No. 200910009789.6, filed on January 20, 2009, the entireties of which are hereby incorporated by reference.

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates to an amorphous alloy and a preparing method thereof.

BACKGROUND OF THE DISCLOSURE

[0003] Amorphous alloy systems include different metal based alloys. For example, there are Zr-based, Ti-based, Cu-based, Fe-based, Pd-based, Pt-based, Mg-based, Co-based, Ca-based, Y-based and lanthanide-based alloys, such as La-based, Pr-based, Nd-based alloys and so on. Bulk amorphous alloys are disordered in the long range but ordered in the short range. Due to the particular microstructure, they have desirable mechanical properties, such as high strength, high hardness, relatively wide elastic range, high corrosion resistance, high wearing resistance and so on. The amorphous alloys are widely used in many fields such as aviation, spaceflight, IT electronics, mechanics, chemical industry and so on. However, the preparation conditions of amorphous alloys are strict: high vacuum level and high cooling speed. The size of most prepared amorphous alloys is relatively small and the forms are limited to strip, filament and powder. Therefore the applications of amorphous alloys are limited. In order to obtain bulk amorphous alloy material, the cooling speed should be high enough to prevent the formation of orderly arrayed crystalline. Thus the cost may be high for the manufacture process. The process that costs less and requires less strict conditions is desirable to improve the amorphous alloy forming ability.

[0004] Due to their particular structure, while under stress, the amorphous alloy materials do not have the internal deformation mechanism as crystalline materials do in order to resist deformation. So when the stress reaches a certain degree, the amorphous alloy material may break suddenly, which may lead to accidents. Thus, the applications of the amorphous alloy materials as structural materials are limited. A number of researches have been undertaking to improve the application of bulk amorphous alloys in engineering.

[0005] For conventional amorphous alloys such as (Cu, Zr)-based alloy, strict preparing conditions and high purity of raw materials are required. The disorder degree of the components is not enough to avoid heterogeneity nucleus forming during the preparation process. The forming of amorphous alloy depends on high cooling speed to restrain atoms' spontaneous movement. In terms of toughness characteristics, (Cu, Zr)-based amorphous alloy employs the elements of which the atomic radiuses have no obvious gradients. The atoms may not be piled compactly. Thus the crackle resistance of the materials declines, which results in low toughness in macroscopical structure.

SUMMARY OF THE DISCLOSURE

[0006] In one aspect, an amorphous alloy comprises Cu, Zr, Be and M. M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu and Zr.

[0007] In another aspect, an amorphous alloy comprises Cu, Zr, RE and M. RE is at least one element selected from the Rare-Earth Group , M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu, Zr and RE.

[0008] In yet another aspect, a method for preparing an amorphous alloy comprises melting a raw material comprising Cu, Zr, Be, and M to form an alloy. M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu and Zr.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Fig. 1 is the XRD diagram of the amorphous alloys prepared in the Examples 1-6 and Control 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] According to one embodiment of the present disclosure, a (Cu, Zr)-based amorphous alloy is provided. The (Cu, Zr)-based amorphous alloy comprises Cu, Zr, Be and M. M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu and Zr. The term transition metal refers to elements from group IB, group IIB, group IIIB, group IVB, group VB, group VIB, group VIIB and group VIIIB of the element periodic table. Preferably, the alloy comprises about 15-45 atomic percent of Cu, about 10-50 atomic percent of Zr, less than about 30 atomic percent of Be, and about 5-35 atomic percent of M. More preferably, the alloy comprises about 30-45 atomic percent of Cu, about 30-40 atomic percent of Zr, about 0.01-10 atomic percent of Be, and about 5-25 atomic percent of M.

[0011] In one embodiment, a (Cu, Zr)-based amorphous alloy comprises Cu, Zr, Be and M. M is at least one element selected from a group consisting of Al, Sn, Si, Ti, Ag, Ni, Ta, Hf, Co, Fe, Nb and Y.

[0012] In another embodiment, an amorphous alloy comprises Cu, Zr, RE and M. RE is at least one element selected from the Rare-Earth Group. M is at least one element selected from a group consisting of Al, Sn, Si, group IB, group IIB, group IIIB, group IVB, group VB, group VIB, group VIIB and group VIIIB of the element periodic table, excluding Cu, Zr and RE. Preferably, M comprises Ti and Al. More preferably, the amorphous alloy comprises about 15-45 atomic percent of Cu, about 10-50 atomic percent of Zr, about 1-10 atomic percent of Ti, about 1-20 atomic percent of Al, and about 1-10 atomic percent of RE.

[0013] According to another embodiment of the present disclosure, a method for preparing a (Cu, Zr)-based amorphous alloy is provided. The method comprises melting an raw material and cooling the liquid of metal to form an amorphous alloy.

[0014] The material for preparing the (Cu, Zr)-based amorphous alloy comprises Cu, Zr, Be and M. M is at least one element selected from a group consisting of Al, Sn, Si, and transition metals, excluding Cu and Zr.

[0015] The amount of each element mixed should be adjusted such that the elements in the raw material have the ratio defined above.

[0016] In the method for preparing the (Cu, Zr)-based amorphous alloy, any suitable melting method can be used. For example, the raw materials should be mixed first, and then cooled to form ingots. In this step, the raw materials can be melted in an electric arc melting equipment or an induction melting equipment. The melting temperature and time differ to some extent according to the heating process selected. Usually, the melting temperature can be about 1,000-1,500 °C, preferably about 1,200-1,500 □. The vacuum level should be not higher than about 1000 Pa, preferably about not higher than 10 Pa.

[0017] The ingots should be re-melted and molded. Electric arc melting, induction melting, and resistance melting are commonly used in the re-melting process. The re-melting temperature can be about 700-1,500 °C, preferably about 800-1,200 °C.

[0018] Any suitable molding method can be used to form the amorphous alloy. For example, melt-spinning, copper mold casting, suction casting, die casting, jetting molding, or water quenching can be used. The cooling speed of the cooling ingot process is about $10\text{-}10^4$ K/s, preferably about $10^2\text{-}10^3$ K/s. The cooling speed of the molding process can be about $10\text{-}10^4$ K/s, preferably about $10^2\text{-}10^3$ K/s.

[0019] Since the critical dimensions differ among different components, different molding methods can be selected. The inert gas can be one or more elements selected from the group zero elements of the element periodic table, such as helium, neon, argon, and krypton.

[0020] The present disclosure may improve the crystallization resistance ability effectively and may achieve centimeter level critical dimensions (bulk amorphous alloy has the critical dimension of millimeter). Meanwhile, the strength and the toughness of the amorphous alloys may be enhanced. Due to the better amorphous alloy forming ability, the vacuum degree and cooling speed are not strictly required during melting and molding, and the equipments for melting and molding are not as strict as before. Thus the production of the amorphous alloys can be industrialized much easier. The material of the mould for molding can be low-cost stainless steel, Be-Cu alloy or the materials which have low thermal conductivity. Because of high crystallization resistance ability of the amorphous alloys, the requirements for the purity of the raw material and the vacuum level may be decreased.

[0021] There are two series examples for illustrating the present disclosure.

[0022] Series 1

[0023] Example 1

[0024] Raw materials Cu, Zr, Ti, Al, Y (total amount is about 25 grams) were added to an electric arc melting equipment. The purity of each component in raw materials is about 98 wt%. The ratios of the raw materials were as follows: $Cu_{0.44}Zr_{0.45}Ti_{0.02}Al_{0.07}Y_{0.02}$. The equipment was vacuumized to about 50 Pa. The raw materials were melted at about 1,200-1,500 °C under Ar protection for about 20-50 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about $10^3\text{-}10^4$ K/s. The ingot was re-melted at about 800 -1,200 °C using electric arc melting, and then cooled in a beryllium-copper mold casting process with a cooling speed of about $10^3\text{-}10^4$ K/s to obtain the alloy sample C1 with the size of about 3 × 10 × 100 mm.

[0025] Example 2

[0026] Raw materials Cu, Zr, Al, Ti, Be (total amount is about 200 kilograms) were added to an induction melting equipment. The purity of each component in raw materials is about 98 wt%. The ratios of the raw materials were as follows: $Cu_{0.43}Zr_{0.45}Al_{0.07}Ti_{0.02}Be_{0.02}$. The equipment was vacuumized to about 100 Pa. The raw materials were melted at about 1,200-1,500 °C under Ar protection for about 20 minutes. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about $10\text{-}10^2$ K/s. The ingot was re-melted at about 800-1,200 °C using resistance calefaction melting, and then cooled in a stainless steel mold casting process with a cooling speed of about $10^2\text{-}10^3$ K/s to obtain the alloy sample C2 with the size of about 3 × 10 × 100 mm.

[0027] Example 3

[0028] Raw materials Cu, Zr, Ag, Sn, Be (total amount is about 200 grams) were added to an induction melting equipment. The purity of each component in raw materials is about 98 wt%. The ratios of the raw materials were as follows: $Cu_{0.44}Zr_{0.38}Ag_{0.07}Sn_{0.01}Be_{0.1}$. The equipment was vacuumized to about 500 Pa. The raw materials were melted at about 1,200-1,500 °C using induction melting under Ar protection for about 30-60 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10-10^2 K/s. The ingot was re-melted at about 800-1,200 °C using resistance calefaction melting, and then cooled in a stainless steel mold casting process with a cooling speed of about 10^2-10^3 K/s to obtain the alloy sample C3 with the size of 3 × 10 × 100 mm.

[0029] Example 4

[0030] Raw materials Cu, Zr, Ti, Ni, Si, Be (total amount is about 200 kilograms) were added to an induction melting equipment. The purity of each component in raw materials is about 98 wt%. The ratios of the raw materials were as follows: $Cu_{0.44}Zr_{0.11}Ti_{0.3}Ni_{0.08}Si_{0.01}Be_{0.04}$. The equipment was vacuumized to about 300 Pa. The raw materials were melted at about 1,200-1,500 °C using induction melting under Ar protection for about 20 minutes. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10-10^2 K/s. The ingot was re-melted at about 800-1,200 °C using resistance calefaction melting, and then cooled in a melt-spinning process with a cooling speed of about 10^3-10^4 K/s to obtain the alloy sample C4 with the size of about 3 × 10 × 100 mm.

[0031] Example 5

[0032] Raw materials Cu, Zr, Ti, Be (about 20 grams) were added to a quartz tube. The purity of each component in raw materials is 98 wt%. The ratios of the raw materials were as follows: $Cu_{0.40}Zr_{0.37}Ti_{0.08}Be_{0.15}$. The tube was vacuumized to about 1,000 Pa. The raw materials were melted at about 1,200-1,500 °C using induction melting under Ar protection for about 30-50 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10-10^2 K/s. The ingot was re-melted at about 800-1,200 °C using induction melting, and then cooled in a water quenching process with a cooling speed of about 10^3-10^4 K/s to obtain the alloy sample C5 with the size of about Φ3 × 100 mm.

[0033] Example 6

[0034] Raw materials Cu, Zr, Al, Be (about 20 grams) were added to a quartz tube. The purity of each component in raw materials is about 98 wt%. The ratios of the raw materials were as follows: $Cu_{0.35}Zr_{0.30}Al_{0.05}Be_{0.2}$. The tube was vacuumized to about 500 Pa. The raw materials were melted at about 1,200-1,500 °C using electric arc melting under Ar protection for about 30-50 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10^3-10^4 K/s. The ingot was re-melted at about 800-1,200°C using induction melting, and then cooled in a water quenching process with a cooling speed of about 10^3-10^4 K/s to obtain the alloy sample C6 with the size of Φ3 × 100 mm.

[0035] Control 1

[0036] The control illustrates an amorphous material prepared according to the prior art.

[0037] Raw materials Zr, Ti, Cu (about 25 grams) were added to an electric arc melting equipment. The purity of each component in raw materials is about 99 wt%. The ratios of the raw materials were as follows: $Cu_{0.60}Zr_{0.30}Ti_{0.10}$. The equipment was vacuumized to about 5 Pa. The raw materials were melted at about 1,200-1,500 °C under Ar protection for about 20-50 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10^3-10^4 K/s. The ingot was re-smelted at about 800 -1,200 °C using electric arc melting, and then cooled in a copper mold casting process with a cooling speed of about 10^3-10^4 K/s to obtain the alloy sample D with the size of 3 × 10 × 100 mm.

[0038] Experimental:

[0039] The samples C1-C6 obtained in Example 1-6 and control sample D were tested according to the methods as follow.

[0040] (1) Compression test

[0041] The samples were tested on a XinSansi CMT5000 series testing machine. The test results are shown in Table 1.

[0042] (2) Impact test

[0043] The samples were tested on a XinSansi ZBC1000 series testing machine. The test results are shown in Table 1.

[0044] (3) XRD analysis

[0045] XRD analyzes the physical phase of an alloy material in order to estimate whether the alloy is amorphous. The samples were made into powder for test on a Model D-MAX2200PC X-ray Powder Diffractometer using a Cu Kα radiation. The incidence wave length λ was about 1.54060 Å. The accelerating voltage was about 40 kV. The current was about 20 mA. Step scan was used with a step size of about 0.04 degree. The test results are shown in Fig 1.

[0046] (4) The test of critical dimensions

[0047] A wedged sample formed in the copper mold casting process was cut from the top by a thickness of about 1 mm. The cross section after cutting was analyzed by XRD. The structure type was determined. If the structure type was an amorphous alloy, then the cutting process was continued until the structure was no longer an amorphous alloy. The total cutting thickness was recorded. The critical dimension was the total cutting thickness minus 1 mm. The results are showed in Table 1.

[0048]

Table 1

Samples	Compression Intensity (MPa)	Absorbability Work (J)	Impact Toughness (KJ/m^2)	Critical Dimensions (mm)
C1	2724.35	6.141	205.16	12
C2	2564.24	8.751	295.68	12
C3	2561.51	7.551	252.27	11
C4	2348.31	5.189	173.41	9
C5	2241.24	5.451	182.10	9
C6	2293.34	5.148	167.06	8
D	1834.56	3.521	116.95	7

[0049] As shown in Fig.1, there are no sharp diffraction peaks in the XRD diagrams of the samples C1-C6 and the sample D, which indicates the alloys are all amorphous materials.

[0050] From the results shown in Table 1, the impact toughness of the control sample D is 116.95 KJ/m^2. For the samples C1-C6, the impact toughness is between about 167.06 KJ/m^2 to 295.68 KJ/m^2. The higher the impact toughness, the better the impact resistance capability of the material. The compression strength of the samples C1-C6 is also higher than that of the sample D.

[0051] Many modifications and other embodiments of the present disclosure will come to mind to one skilled in the art to which the present disclosure pertains having the benefit of the teachings presented in the foregoing description. It will be apparent to those skilled in the art that variations and modifications of the present disclosure can be made without departing from the scope or spirit of the present disclosure. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

[0052] Series 2

[0053] Example 1'

[0054] Raw materials Cu, Zr, Ti, Ni, Be (total amount is about 25 grams) were added to an electric arc melting equipment. The purity of each component in raw materials is about 99.9 wt%. The atomic percent of the raw materials follows Cu: Zr: Ti: Ni: Be = 23: 36: 12: 9: 20. The equipment was vacuumized to about 5 Pa. The raw materials were melted at about 1,800 °C under Ar protection for about 30 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10^3K/s. The ingot was re-melted at about 1,800 °C using electric arc melting, and then cooled in a beryllium-copper mold casting process with a cooling speed of about 10^3 K/s to obtain the alloy sample C1' with the size of about 3 × 10 × 100 mm.

[0055] Example 2'

[0056] Raw materials Cu, Zr, Al, Ni, Be (total amount is about 200 kilograms) were added to an induction melting equipment. The purity of each component in raw materials is about 99.9 wt%. The atomic percent of the raw materials follows Cu: Zr: Al: Ni: Be = 25: 35: 9: 6: 25. The equipment was vacuumized to about 100 Pa. The raw materials were melted at about 1,600 °C under Ar protection for about 20 minutes. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10^2 K/s. The ingot was re-melted at about 1,600 °C using resistance calefaction melting, and then cooled in a stainless steel mold casting process with a cooling speed of about 10^2 K/s to obtain the alloy sample C2' with the size of about 3 × 10 × 100 mm.

[0057] Example 3'

[0058] Raw materials Cu, Zr, Ag, Co, Be (about 20 grams) were added to a quartz tube. The purity of each component in raw materials is 99.9 wt%. The atomic percent of the raw materials follows Cu: Zr: Ag: Co: Be = 30: 30: 5: 15: 20. The tube was vacuumized to about 200 Pa. The raw materials were melted at about 1,500 °C using induction melting under Ar protection for about 40 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 50 K/s. The ingot was re-melted at about 1,500 °C using induction melting, and then cooled in a water quenching process with a cooling speed of about 10^3 K/s to obtain the alloy sample C3' with the size of about 3 × 10 × 100 mm.

[0059] Example 4'

[0060] Raw materials Cu, Zr, Hf, Fe, Be (total amount is about 200 kilograms) were added to an induction melting equipment. The purity of each component in raw materials is about 99.9 wt%. The atomic percent of the raw materials follows Cu: Zr: Hf: Fe: Be = 20: 30: 10: 20: 20. The equipment was vacuumized to about 5 Pa. The atomic percent materials were melted at about 1,700 °C using induction melting under Ar protection for about 20 minutes. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10^2 K/s. The ingot was re-melted at about 1,700 °C using resistance calefaction melting, and then cooled in a melt-spinning process with a cooling speed of about 10^3 K/s to obtain the alloy sample C4' with the size of about 3 × 10 × 100 mm.

[0061] Example 5'

[0062] Raw materials Cu, Zr, Ta, Nb, Be (about 20 grams) were added to a quartz tube. The purity of each component in raw materials is about 99.9 wt%. The atomic percent of the raw materials follows Cu: Zr: Ta: Nb: Be = 20:40: 5: 15: 20. The tube was vacuumized to about 0.02 Pa. The raw materials were melted at about 1,800 °C using induction melting under Ar protection for about 50 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 50 K/s. The ingot was re-melted at about 1,800°C using induction melting, and then cooled in a water quenching process with a cooling speed of about 10^3 K/s to obtain the alloy sample C5' with the size of about 3 × 10 × 100 mm.

[0063] Control 1'

[0064] The control illustrates an amorphous material prepared according to the prior art.

[0065] Raw materials Zr, Ti, Cu, Ni, Be (about 25 grams) were added to an electric arc melting equipment. The purity of each component in raw materials is about 99.9 wt%. The atomic percent of the raw materials follows Cu: Zr: Ti: Ni: Be = 12.5: 41: 14: 10: 22.5. The equipment was vacuumized to about 5 Pa. The raw materials were melted at about 1,800 °C under Ar protection for about 50 seconds. The molten master alloy was mixed sufficiently, and then cooled into an ingot with a cooling speed of about 10^3 K/s. The ingot was re-smelted at about 1,800 °C using electric arc melting, and then cooled in a copper mold casting process with a cooling speed of about 10^3 K/s to obtain the alloy sample D' with the size of 3 × 10 × 100 mm.

[0066] Experimental:

[0067] The samples C1'-C5' obtained in Example 1'-5' and control sample D' were tested according to the methods as follow.

[0068] (1) Impact test

[0069] The samples were tested on a XinSansi ZBC 1000 series testing machine. The test results are shown in Table 1'.

[0070] (2) XRD analysis

[0071] XRD analyzes the physical phase of an alloy material in order to estimate whether the alloy is amorphous. The samples were made into powder for test on a Model D-MAX2200PC X-ray Powder Diffractometer using a Cu Kα radiation. The incidence wave length λ was about 1.54060 Å. The accelerating voltage was about 40 kV. The current was about 20 mA. Step scan was used with a step size of about 0.04 degree. The test results are shown in Fig 1'.

[0072]

Table 1'

Samples		Absorbability Work (J)	Impact Toughness (KJ/m^2)
Example 1'	C1'	9.148	304.959
Example 2'	C2'	7.452	521.163
Example 3'	C3'	7.696	256.548
Example 4'	C4'	7.315	243.841
Example 5'	C5'	6.918	230.602
Control 1'	D'	4.621	153.770

[0073] As shown in Fig 1', there are no sharp diffraction peaks in the XRD diagrams of the samples C1'-C5' and the sample D', which indicates the alloys are all amorphous materials.

[0074] From the results shown in Table 1', the impact toughness of the control sample D' is 230.602 KJ/m^2. For the samples C1'-C5', the impact toughness is between about 243.841 KJ/m^2 to 521.163 KJ/m^2. Higher the impact toughness, better the impact resistance capability of the material.

Claims

1. An amorphous alloy, comprising:

Cu, Zr, Be and M;

wherein M is at least one element selected from a group consisting of Al, Sn, Si, group IB, group IIB, group IIIB, group IVB, group VB, group VIB, group VIIB and group VIIIB of the element periodic table, provided that the element is not Cu or Zr.

2. The amorphous alloy of claim 1, wherein the atomic ratio of Cu to Zr is about 0.5 to 1.0.

3. The amorphous alloy of claims 1 or 2, which comprises about 15-45, preferably about 30-45 atomic percent of Cu, about 10-50, preferably about 30-40 atomic percent of Zr, less than about 30, preferably about 0.01-10 atomic percent of Be, and about 5-35, preferably about 5-25 atomic percent of M.

4. The amorphous alloy of claims 1 or 2, which comprises about 15-40, preferably about 20-30 atomic percent of Cu, about 20-40, preferably about 30-40 atomic percent of Zr, about 15-30, preferably about 20-25 atomic percent of Be, and about 10-35, preferably about 15-30 atomic percent of M, wherein, M is at least one element selected from a group consisting of Al, Ta, Hf, Ti, Ni, Co, Fe, Nb, Ag and Y.

5. A method for preparing an amorphous alloy comprising:

melting a raw material comprising Cu, Zr, Be and M to form an alloy;
wherein, M is at least one element selected from a group consisting of Al, Sn, Si, group IB, group IIB, group IIIB, group IVB, group VB, group VIB, group VIIB and group VIIIB of the element periodic table, provided that the element is not Cu or Zr, preferably M is at least one element selected from a group consisting of Al, Sn, Si, Ti, Ag, Ni, Ta, Hf, Co, Fe, Nb and Y.

6. The method of claim 5, wherein the raw material comprises about 15-45 , preferably about 30-45 atomic percent of Cu, about 10-50, preferably about 30-40 atomic percent of Zr, less than about 30, preferably about 0.01-10 atomic percent of Be, and about 5-35, preferably about 5-25 atomic percent of M.

7. The method of claim 5, wherein the raw material comprises about 15-40, preferably about 20-30 atomic percent of Cu, about 20-40, preferably about 30-40 atomic percent of Zr, about 15-30, preferably about 20-25 atomic percent of Be, and about 10-35, preferably about 15-30 atomic percent of M, wherein, M is at least one element selected from a group consisting of Al, Ta, Hf, Ti, Ni, Co, Fe, Nb, Ag and Y.

8. The method according to any one of claims 5 to 7, wherein the melting step comprises:

melting the raw material to form a molten mixture;
cooling the molten mixture to form at least one ingot; and
re-melting the at least one ingot to form the amorphous alloy.

9. The method according to any one of claims 5 to 8, wherein the raw material is melted under a vacuum of about 0.01-1000 Pa, or under a vacuum of less than 200Pa.

10. The method according to any one of claims 5 to 9, wherein the raw material is melted at a temperature of about 1,500 - 2,500 °C, optionally in the presence of an inert gas.

11. The method according to any one of claims 5 to 9, wherein the raw material is melted at a temperature of about 700 - 2,000 °C, optionally in the presence of an inert gas.

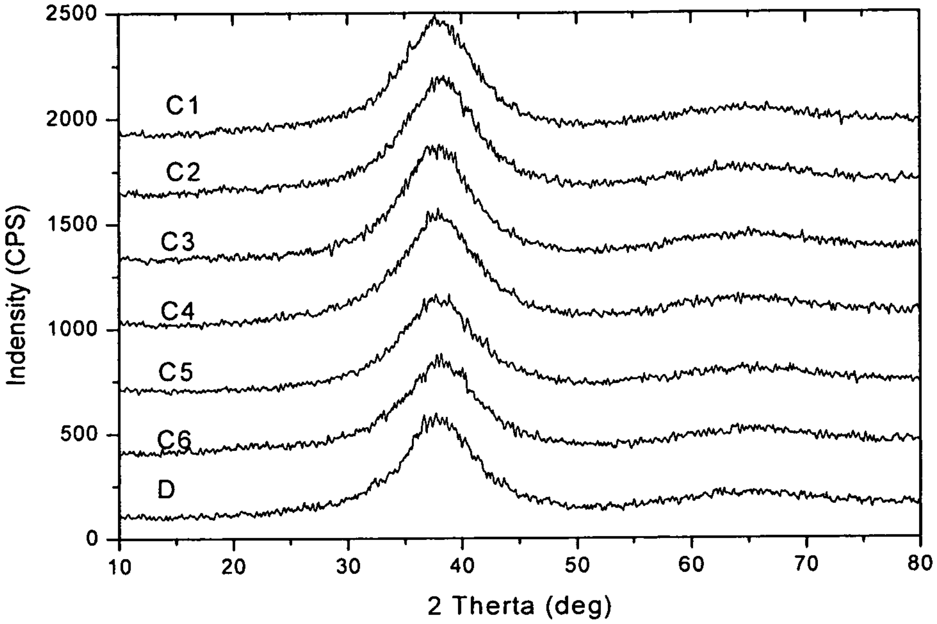
12. The method according to any one of claims 5 to 11, wherein the cooling speed of the cooling molding process is about $10\text{-}10^4$ K/s.

13. The method according to any one of claims 5 to 12, wherein the inert gas is at least one gas selected from the group zero gases.

14. The method according to any one of claims 5 to 13, wherein the purity of Cu, Zr, M and Be is about 99.9%.

15. The method according to any one of claims 5 to 13, wherein the purity of Cu, Zr, M and Be is about 98%.

Fig.1


2500
2000
1500
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Indensity (CPS)
C1
C2
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C5
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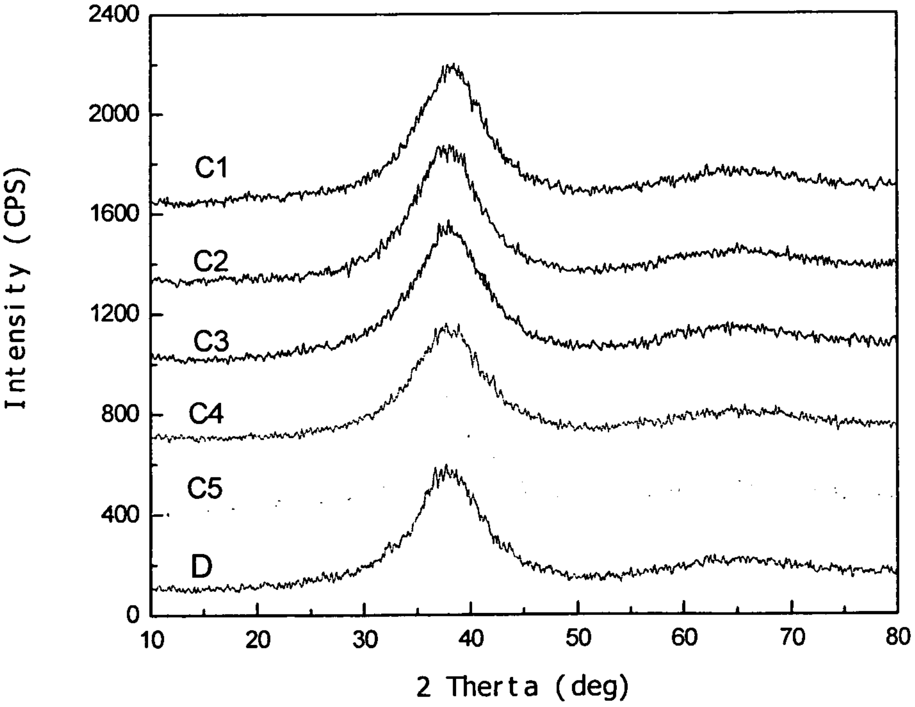
80
2 Therta (deg)

Fig.1'


2400
2000
1600
1200
800
400
0
Intensity (CPS)
C1
C2
C3
C4
C5
D
10
20
30
40
50
60
70
80
2 Therta (deg)

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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 4061

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 288 344 A (PEKER ATAKAN [US] ET AL) 22 February 1994 (1994-02-22) * the whole document * -----	1-15	INV. C22C9/00 C22C16/00 C22C30/02 C22C30/04 C22C1/00 C22C45/00 C22C45/10
A	CONNER R D ET AL: "Composition dependent ductility in the amorphous Zr-Ti-Ni-Cu-Be alloy system" SCRIPTA MATERIALIA, ELSEVIER, AMSTERDAM, NL, vol. 55, no. 7, 1 October 2006 (2006-10-01), pages 645-648, XP025028288 ISSN: 1359-6462 [retrieved on 2006-10-01] * the whole document * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 July 2009	von Zitzewitz, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
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& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 00 4061

15-07-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5288344 A	22-02-1994	NONE	

REFERENCES CITED IN THE DESCRIPTION

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