

**DEVELOPMENT OF NOVEL BINARY AND MULTI-COMPONENT
BULK METALLIC GLASSES**

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Abstract

Bulk Metallic Glasses (BMGs) have been drawing increasing attention in recent years due to their scientific and engineering significance. A great deal of effort in this area has been devoted to developing BMGs in different alloy systems. BMGs based on certain late transition metals (e.g., Fe, Co, Ni, Cu) have many potential advantages over those based on early transition metals. These advantages include even higher strength and elastic modulii, and lower materials cost, to name but a few that are highly preferable for a broad application of BMGs as engineering materials. Nevertheless, these ordinary-late-transition-metal-based BMGs generally have quite limited glass-forming ability (GFA). In particular, for the Ni-based and Cu-based alloys reported prior to this research, the maximum casting thickness allowed to retain their amorphous structures is only \sim 2 mm (or lower) and \sim 5 mm (or lower), respectively.

The first important finding during this research was that certain quinary Ni-based alloys in the Ni-Cu-Ti-Zr-Al system can be cast into 5 mm diameter amorphous rods. This critical casting thickness is the highest for any reported Ni-based BMG's, indicating that these alloys are the easiest metallic glass formers based on Ni discovered to date. Secondly but more interestingly, certain binary alloys in the Cu-Zr and Cu-Hf systems were found to form bulk amorphous samples with casting thicknesses as high as 2 mm. The discovery of these binary BMGs was very surprising since it had been widely considered that only multi-component (having at least three elements) alloys could form bulk metallic glasses. These new binary BMGs have not only challenged the traditional concept about bulk metallic glass formation, but also provided interesting subjects for

future theoretical studies such as molecular dynamics simulations since they possess both the simplicity of binary alloys and the good GFA of multi-component BMGs. As a matter of fact, these binary BMGs have also led to a third and perhaps most significant discovery during this research: the family of Cu-based BMGs in the Cu-Zr-Al-Y system that possesses a critical casting thickness up to 1 cm. These quaternary Cu-based alloys, together with some complicated Fe-based alloys reported by two other groups during the course of this research, are the first centimeter-level BMGs based on the ordinary late transition metals.

This thesis first reviews the fundamentals related to BMG development, then reports in detail the formation and properties of the above-mentioned binary and multi-component BMGs based on Ni and Cu. A generalized geometric model for the critical-value problem of nucleation developed in this research is also presented.

Contents

Acknowledgements.....	ii
Abstract.....	iv
Contents.....	vi
List of Figures.....	ix
List of Tables.....	xii
Chapter 1: Introduction.....	1
1.1 Basic concepts about glasses and metallic glasses.....	1
1.1.1 Glass and glass transition.....	1
1.1.2 Glass formation and glass-forming ability.....	4
1.2 History of metallic glass research and motivation for this thesis.....	7
1.3 Thermodynamics and kinetics related to glass formation and TTT (Time-Transformation-Temperature) diagram.....	10
1.3.1 Thermodynamics of an undercooled liquid.....	10
1.3.2 Kinetics of an undercooled liquid.....	12
1.3.3 Classical theory for crystal nucleation and growth from an undercooled liquid and TTT diagram.....	17
1.4 Frequently used criteria for the development of BMGs.....	26
1.4.1 Reduced glass transition temperature.....	27
1.4.2 Multi-component rule (confusion principle).....	31
1.4.3 Atomic size mismatch.....	32
1.4.4 Chemical interactions among constituent elements.....	34
1.4.5 Considerations based on phase diagrams.....	35

References.....	41
Chapter 2: Formation and properties of Ni-based BMGs in	
Ni-Cu-Ti-Zr-Al system.....	45
2.1 Introduction.....	45
2.2 Experimentals.....	46
2.3 Results and Discussion.....	47
2.3.1 Ternary Ni ₄₅ Ti ₂₀ Zr ₃₅ alloy.....	47
2.3.2 Quaternary Ni ₄₅ Ti ₂₀ Zr _{35-x} Al _x alloys.....	50
2.3.3 Quinary Ni _x Cu _{a-x} Ti _y Zr _{b-y} Al ₁₀ alloys (a~b~45).....	51
2.3.4 Effect of small Si additions.....	54
2.3.5 Mechanical tests.....	55
2.4 Conclusions.....	57
References.....	58
Chapter 3: Formation of bulk metallic glasses in binary Cu-Zr and	
Cu-Hf systems.....	60
3.1 Introduction.....	60
3.2 Experimentals.....	61
3.3 Results and discussions.....	61
3.3.1 Glass-forming abilities.....	61
3.3.2 Thermal analyses with DSC.....	65
3.3.3 Mechanical properties of the three best glass formers.....	69
3.4 Conclusions.....	71
References.....	72

Chapter 4: A generalized model for the critical-value problem of nucleation.....	74
4.1 Introduction.....	74
4.2 Model construction.....	77
4.3 Model solution and interpretation.....	77
4.4 Conclusions.....	85
References.....	87
Chapter 5: Centimeter size BMG formation in Cu-Zr-Al-Y system.....	88
5.1 Introduction.....	88
5.2 Experimentals.....	89
5.3 Results and discussions.....	90
5.4 Conclusions.....	100
References.....	101
Chapter 6: Concluding Remarks.....	102

List of Figures

Chapter 1

1.1 Plots of viscosity data scaled by values of T_g for different glass-forming liquids.....	14
1.2 Plots of the three terms in Eq. (1.13) vs. nucleus radius r	19
1.3 Nucleation rate I_v and crystal growth rate u as a function of temperature for the BMG alloy $\text{Pd}_{40}\text{Cu}_{30}\text{Ni}_{10}\text{P}_{20}$	22
1.4 TTT (Time-Temperature-Transformation) diagram of $\text{Pd}_{40}\text{Cu}_{30}\text{Ni}_{10}\text{P}_{20}$ calculated using a crystallized volume fraction $f = 10^{-6}$	24
1.5 Logarithm of nucleation rate (in $\text{cm}^{-3}\text{s}^{-1}$), $\log I_v$, vs. the reduced temperature, T_r , calculated at different values of the reduced glass transition temperature T_{rg}	30

1.6 Binary phase diagram of Zr-Be system	36
1.7 Binary phase diagram of Ti-Be system.....	36
1.8 Binary phase diagram of Zr-Cu system.....	37
1.9 Binary phase diagram of Zr-Ni system.....	37
1.10 Binary phase diagram of Zr-B system.....	39

Chapter 2

2.1 XRD patterns of selected ternary and quaternary alloys taken with a Co K α source.....	49
2.2 DSC scans of selected ternary and quaternary alloys at a heating rate of 0.33 K/s.....	49
2.3 XRD patterns of selected quaternary and quinary alloys taken with a Co K α source.....	52
2.4 Electron diffraction pattern taken from the transverse cross section of a 5mm	

thick Ni ₄₀ Cu ₅ Ti _{16.5} Zr _{28.5} Al ₁₀ strip.....	52
2.5 DSC scans of selected quaternary and quinary alloys at a heating rate of 0.33 K/s....	53
2.6 Effect of adding a small amount of Si	53
2.7 Compressive stress vs. strain curves of two selected alloys:	

(a) Ni ₄₀ Cu ₅ Ti _{16.5} Zr _{28.5} Al ₁₀ ; and (b) Ni ₄₅ Ti ₂₀ Zr ₂₅ Al ₁₀	56
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Chapter 3

3.1 Binary Cu-Zr phase diagram (reproduced from Ref. [17])	62
3.2 Binary Cu-Hf phase diagram (reproduced from Ref. [17]).....	62
3.3 X-ray (taken with a Cu K α source) and electron diffraction patterns of	
Cu ₄₆ Zr ₅₄ (A1), Cu ₆₄ Zr ₃₆ (A2) and Cu ₆₆ Hf ₃₄ (A3).....	63
3.4 XRD patterns taken from 0.5 mm thick strips of Cu _{100-x} Zr _x (x=34, 36, 38.2, 40	
at.%) using a Cu-K α source.....	66
3.5 XRD patterns taken from the cross sections of the 2mm thick cast strips of	
Cu _{100-x} Zr _x (x=34, 36, 38.2, 40 at.%) using a Cu-K α source.....	66
3.6 DSC scans of the 0.5mm thick strips of Cu ₆₀ Zr ₄₀ , Cu _{61.8} Zr _{38.2} , Cu ₆₆ Zr ₃₄ , and	
the 2mm thick strip of Cu ₆₄ Zr ₃₆ obtained at a heating rate of 0.33K/s.....	68
3.7 Variations of ΔT and T _{rg} with respect to Zr content x in alloy series	
Cu _{100-x} Zr _x (x=34, 36, 38.2, 40 at.%).....	68
3.8 Compressive stress vs. strain curves of the three best glass formers in Cu-Zr	
and Cu-Hf systems obtained at a strain rate of $\sim 4 \times 10^{-4}$ s ⁻¹ at room temperature.....	70

Chapter 4

4.1 The geometric factor as a function of contact angle θ in the large-wall	
heterogeneous solution.....	76

4.2 (a) the geometric construction for the generalized nucleation model; (b) an illustration of the mechanical equilibrium at point S in part (a).....	78
4.3 (a) 3D image of the bivariate function $g(R, \theta)$; (b) 2D plots of $g(R, \theta)$ vs. R/r_c at different values of θ ; (c) 2D plots of $g(R, \theta)$ vs. θ at different values of R/r_c	83

Chapter 5

5.1 (A) Pictures of three cast samples of $\text{Cu}_{46}\text{Zr}_{42}\text{Al}_7\text{Y}_5$, with different diameters: S1, 10mm; S2, 12mm; S3, 14mm; (B) XRD patterns obtained from 10mm (S1); 12mm (S2) and 14mm (S3) diameter rods of $\text{Cu}_{46}\text{Zr}_{42}\text{Al}_7\text{Y}_5$; and from 3mm (M1) and 4mm (M2) diameter rods of the matrix alloy $\text{Cu}_{46}\text{Zr}_{47}\text{Al}_7$	91
5.2 DSC scans of selected alloys at a constant heating rate of 0.33K/s. The upward arrows refer to the glass transition temperatures and the downward arrows refer to the onset of the first crystallization events. The inset at the lower right corner is the isothermal DSC profile of the 10mm diameter rod of $\text{Cu}_{46}\text{Zr}_{42}\text{Al}_7\text{Y}_5$ at a constant temperature of 739K	93
5.3 Melting behaviors of selected alloys measured at a heating rate of 0.33K/s. The arrows refer to the liquidus temperatures.....	95
5.4 TEM image (a), Cu K α 1 X-ray dot map image (b) and Y K α 1 X-ray dot map image (c), of as-cast $\text{Cu}_{46}\text{Zr}_{42}\text{Al}_7\text{Y}_5$. The ripples and scratches in the images were caused by the ultramicrotomy sample preparation method.....	98

List of Tables**Chapter 2**

2.1 Examples of the new Ni-based amorphous alloys developed in this work (T_g and T_{x1} were measured with DSC at a heating rate of 0.33K/s).....	48
---	----

2.2 Some measured mechanical properties of selected alloys	55
--	----

Chapter 3

3.1 Thermal properties of three best glass formers in Cu-Zr and Cu-Hf systems	67
---	----

3.2 Mechanical properties of three best glass formers in Cu-Zr and Cu-Hf systems	69
--	----

Chapter 5

5.1 A list of representative alloys and selected properties.....	92
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