Journal of Alloys and Compounds 475 (2009) 207–219

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: www.elsevier.com/locate/jallcom

A new criterion for predicting the glass-forming ability of bulk metallic glasses

Zhilin Long [a,*], Hongqin Wei [a,c], Yanhuan Ding [a], Ping Zhang [a], Guoqiang Xie [b], Akihisa Inoue [b]

[a] Institute of Fundamental Mechanics and Material Engineering, Xiangtan University, Xiangtan, Hunan 411105, China
[b] Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
[c] Department of Mechanical and Energy Engineering, Shaoyang University, Shaoyang, Hunan 422000, China

ARTICLE INFO

Article history:
Received 30 April 2008
Received in revised form 15 July 2008
Accepted 21 July 2008
Available online 11 September 2008

Keywords:
Amorphous materials
Metals
Casting
Thermal analysis

ABSTRACT

Based on the consideration of both the resistance of amorphous phase against crystallization and the stability of under-cooled liquid against competing crystalline phase formation, a criterion ω, defined as $T_g/T_x - 2T_g/(T_g+T_l)$ (T_g, T_x and T_l denote the glass transition temperature, the onset crystallization temperature and the liquidus temperature, respectively), has been proposed for evaluating the glass-forming ability (GFA) of bulk metallic glasses (BMGs). A survey of the readily available experimental data associated with the thermal analysis of various glass-forming alloys shows that the new criterion ω exhibits the best correlation with the maximum section thickness (D_{max}) as well as the critical cooling rate (R_c) for glass formation among other criteria proposed in recent years, such as $T_{rg}(=T_g/T_l)$, $\Delta T_x(=T_x-T_g)$, $\gamma(=T_x/(T_g+T_l))$, $\gamma_m(=(2T_x-T_g)/T_l)$, $\Delta T_{rg}(=(T_x-T_g)/(T_l-T_g))$, $\delta(=T_x/(T_l-T_g)$, $\varphi(=T_{rg}(\Delta T_x/T_g)^{0.143}$, $\alpha(=T_x/T_l)$, $\beta(=(T_x/T_g+T_g/T_l)$ and $\beta(=T_x\times T_g/(T_l-T_x)^2)$. Therefore, it can be anticipated that this new criterion will be used as a useful and efficient guideline for exploring new BMG formers.

1. Introduction

Over the last two decades, advances in the synthesis of multi-component bulk metallic glasses (BMGs) have resulted in an increasing production size of these materials from 1 mm to several centimeters, and some empirical approaches have been proposed to guide the discovery of new glasses with better glass-forming ability (GFA) [1–3]. Even though these methods offer some useful guideline for searching and screening of BMGs, development of new BMGs has been mainly dependent on series of experiments by changing compositions step by step [4–6]. Hence, it is necessary to establish a simple and easily calculable parameter/criterion to infer the relative GFA of metallic glasses. From the viewpoint of physical metallurgy, a quantitative measure of the GFA is the critical cooling rate, R_c, above which no crystallization occurs during solidification, and lower R_c always corresponds to higher GFA [7,8]. Although this parameter allows a way to directly validate and compare the GFA of different alloys, a number of solidification trials with varying cooling rates of cast materials are required to determine R_c, which is a tedious and costly process [9]. Significant efforts have therefore been devoted to searching for a simple and reliable gauge for quantifying the GFA of metallic glasses. As a result, various criteria have been proposed to gauge relative GFA among BMGs, which can be summarized into three groups: (a) related to characteristic temperatures of alloys, (b) related to fundamental properties of constituent elements and (c) related to physical and thermal properties of alloys and/or their liquids [10]. Most of the GFA criteria in (b) and (c) groups are difficult to be used in real practices because too many unknown physical and thermal properties are involved; whereas the GFA parameters in (a) group can easily be determined from differential thermal analysis and reasonably related to R_c. The most extensively used criteria in category (a) are the reduced glass transition temperature, $T_{rg}(=T_g/T_l)$, the supercooled liquid range, $\Delta T_x(=T_x-T_g)$, and the parameter $\gamma(=T_x/(T_g+T_l))$ (where T_g, T_x, and T_l denote the glass transition temperature, the onset of crystallization temperature and the liquidus temperature, respectively) [11–13]. Indeed, a large number of good glass-forming systems obey these criteria. But many exceptions also occur, especially in some of the BMG systems synthesized recently [13,14]. It is suggested that further investigations have to be performed to obtain a better and more precise criterion to reflect the GFA of BMGs. In this paper, a new criterion to predict the GFA for various BMGs will be proposed based on the analysis of the crystallization processes during cooling and reheating of the supercooled liquid. The validity and liability of this criterion will be verified using available experimental data for various metallic glasses.

2. Criterion development

Indeed, glass formation is a competition process between the supercooled liquid and the resulting crystalline phases [10,13]. As Lu and Liu [15] pointed out, the liquid phase stability for

* Corresponding author. Tel.: +86 732 8298287; fax: +86 732 8293240.
E-mail address: longzl@xtu.edu.cn (Z. Long).

0925-8388/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.jallcom.2008.07.087

glass-forming liquids should include two components: (1) the stability of the liquid at the equilibrium state (i.e., stable state), and (2) the stability of the liquid during under-cooling (i.e., metastable state). When two glass-forming liquids have different T_g and T_l, their relative liquid phase stability can be measured by the parameter of T_n (=$1/2(T_g+T_l)$), which is the average of the stability of the liquids at equilibrium and metastable states and actually reflects the relative stability of the glass-forming liquids. In general, without considering the effect of the competing crystalline phases, a glass-forming liquid having a lower value of T_n should have a relatively higher liquid phase stability and thus a larger GFA. In realistic cases, glass-forming liquids have different liquids phase stabilities. Therefore, to manifest the relative GFA among those liquids, T_n should be normalized with respect to T_g, resulting in T_n/T_g(=$1/2+1/(2T_{rg})$), implying that T_{rg} is inversely proportional to T_n/T_g. For any given glass-forming liquid, a lower T_n/T_g value always correlates with a larger T_{rg} value and hence a higher GFA, which is in consistent with Turbull's criterion T_{rg} [11]. Base on the above analysis, the relation between GFA and T_n/T_g can be described as:

$$\mathrm{GFA} \propto \frac{1}{T_n/T_g} \tag{1}$$

Considering that GFA is inversely proportional to R_c. This leads to the following correlation between R_c and T_n/T_g, i.e.,

$$\mathrm{GFA} \propto \frac{1}{R_c} \propto -\log_{10}^{R_c} \propto \left(\frac{T_n}{T_g}\right) = \frac{2T_g}{T_g+T_l} \tag{2}$$

or

$$\log_{10}^{R_c} \propto \frac{-2T_g}{T_g+T_l} \tag{3}$$

On the other hand, it is well known that the supercooled liquid region ΔT_x(=T_x-T_g) is an indication of the tendency of a glass upon heating above T_g [12]. A large ΔT_x value may indicate that the supercooled liquid can remain stable in a wide temperature range without crystallization and has a high resistance to the nucleation and growth of crystalline phases. Since crystallization is actually a competitive process with respect to glass formation, a large ΔT_x would lead to a high GFA. This speculation has been well confirmed in several glass-forming alloy systems in which the supercooled liquid region correlate reasonably well with the GFA of alloys [16–19]. In order to make possible comparison between various glasses showing different T_g, this temperature interval should be weighted by $1/T_g$, leading to the factor $(T_x-T_g)/T_g$(=$(T_x/T_g)-1$), which is dimensionless. As such, GFA is proportional to the factor T_x/T_g based on the glass stability upon the reheating process of a glass. Taking into account the relationship between GFA and R_c, R_c can also be expressed as:

$$\log_{10}^{R_c} \propto \frac{T_g}{T_x} \tag{4}$$

By combining Eqs. (3) and (4), a new dimensionless criterion, which links the R_c of an alloy with its characteristic thermal temperatures T_g, T_x, and T_l, can be defined by:

$$\omega = \frac{T_g}{T_x} - \frac{2T_g}{T_g+T_l} \tag{5}$$

As clearly shown in Eqs. (3)–(5), R_c increases with an increase in ω. Since the GFA increases with a decrease in R_c or ω, it is reasonably to assume that the maximum section thickness, D_{max}, which is another indictor of GFA and scales inversely with R_c value, is in proportion to the reciprocal value of the ω parameter, $1/\omega$, i.e.,

$$D_{max} \propto \frac{1}{\omega} \tag{6}$$

3. Criterion validation and application

To order to compare the efficiency of the currently proposed ω criterion with other GFA criteria reported so far, including T_{rg}(=T_g/T_l), ΔT_x(=T_x-T_g), γ(=$T_x/(T_g+T_l)$), γ_m(=$(2T_x-T_g)/T_l$), ΔT_{rg}(=$(T_x-T_g)/(T_l-T_g)$), δ(=$T_x/(T_l-T_g)$, φ(=$T_{rg}(\Delta T_x/T_g)^{0.143}$), α(=T_x/T_l), β(=$T_x/T_g+T_g/T_l$), and β(=$T_x\times T_g/(T_l-T_x)^2$) [11–13,20–25], They have been plotted against the R_c and D_{max} for a number of metallic glasses. The number of data points used for R_c and D_{max} are 53 and 411, respectively. For convenient discussion, β(=$T_x\times T_g/(T_l-T_x)^2$) criterion is labeled as β_I in the following text. In this study, the majority of the characteristic temperatures (i.e., T_g, T_x and T_l) were measured by DSC and/or DTA at a heating rate of 20 K/min and most of the D_{max} values were obtained by copper mould casting method. Table 1 presents the T_g, T_x, T_l and R_c, as well as the calculated T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_I and ω values for a variety of metallic glasses in the literature [10]. Fig. 1 shows the plots of R_c against T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_I and ω, respectively, for 53 metallic glasses listed in Table 1. As shown in Fig. 1, a linear relationship between the R_c and each of the eleven GFA criteria can be obtained using the linear regression method, as demonstrated by the solid lines. The dashed lines in these plots show the 95% prediction limits for these corrections. Apparently, all GFA criteria exhibit a direct proportional or inverse relationship with respect to the R_c value, indicting that all these criteria can, to a certain extent, reflect the GFA of the alloys. From the regression analysis of the plots between the various GFA criteria and R_c, the statistical correlation factors, R^2, have been evaluated using a readily available regression program. The R^2 values can give an idea of the effectiveness and consistency of different GFA criteria. The higher the R^2 value, the better the correlation between the proposed GFA criterion and R_c will be. The values of the correlation coefficient, R^2, were computed to 0.7322 for the R_c–T_{rg} plot, 0.5986 for the R_c–ΔT_x plot, 0.9137 for the R_c–γ plot, 0.9144 for the R_c–γ_m plot, 0.6953 for the R_c–ΔT_{rg} plot, 0.7212 for the R_c–δ plot, 0.8054 for the R_c–φ plot, 0.8841 for the R_c–α plot, 0.9235 for the R_c–β plot, 0.4796 for the R_c–β_I plot and 0.9264 for the R_c–ω plot (Fig. 1). By referring to the values of R^2, one can see that the newly proposed ω criterion has the best relation with R_c, since the value of R^2 corresponding to the R_c–ω plot is the highest among all the GFA criteria, though β, γ_m and γ are close to ω with a R^2 value of 0.9235, 0.9144 and 0.9137, respectively, with R_c. A linear regression analysis showed that the relation between ω, β, γ_m and γ with R_c can be expressed as:

$$R_c = 1.183\times10^{-3}\ \exp(54.639\omega) \tag{7}$$

$$R_c = 5.319\times10^{36}(-48.526\beta) \tag{8}$$

$$R_c = 3.947\times10^{14}\ \exp(-43.802\gamma_m) \tag{9}$$

$$R_c = 1.333\times10^{21}\ \exp(-113.138\gamma) \tag{10}$$

where R_c is in K/s. Table 2 tabulates T_g, T_x, T_l and D_{max}, along with calculated T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_I and $1/\omega$ values for the already reported BMGs based on Cu [24,26–29], Ca [24], Mg [24], La [24,30,31], Pd [24], Ti [24,32], Pr [24], Y [24], Co [24,33], Au [34], Hf [35], Gd [36], Zr [24,28,37], Fe [6,24,38–44] and Ni [24,45,46]. Table 3 compares the R^2 values for D_{max} with various GFA criteria. It is evident from Table 3 that the reciprocal value of the newly proposed ω, $1/\omega$, gives an R^2 value of 0.4141 with D_{max}, which is also the highest among all the GFA criteria. Moreover, as shown in Fig. 1 and Table 3, it is interesting to note that the R^2 values for the plots of different GFA criteria with D_{max} are not as high as those with R_c for any of the criteria. This may be due to the fact that R_c does not depend on the conductivity of material and hence has a better correlation to the GFA criteria than the D_{max} [21]. From the

Table 1
The T_g, T_x, T_l, R_c and the calculated T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_1, and ω for the already reported metallic glasses (ref. [10])

Alloys	T_g (K)	T_x (K)	T_l (K)	R_c (K/s)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_1	ω
$Zr_{66}Al_8Ni_{26}$	672	707.6	1251	66.6	0.53717	35.6	0.36797	0.59408	0.06149	1.2221	0.3529	0.56563	1.5901	1.6103	0.25078
$Zr_{66}Al_8Cu_7Ni_{19}$	662.3	720.7	1200.8	22.7	0.55155	58.4	0.38683	0.64882	0.10845	1.3383	0.38974	0.60018	1.6397	2.0708	0.208
$Zr_{66}Al_8Cu_{12}Ni_{14}$	655.1	732.5	1172.1	9.8	0.55891	77.4	0.40089	0.69098	0.14971	1.4168	0.41181	0.62495	1.6771	2.4831	0.17728
$Zr_{66}Al_9Cu_{16}Ni_9$	657.2	736.7	1170.6	4.1	0.56142	79.5	0.40305	0.69725	0.15485	1.4349	0.41506	0.62934	1.6824	2.5716	0.17297
$Zr_{65}Al_{7.5}Cu_{17.5}Ni_{10}$	656.5	735.6	1167.6	1.5	0.56226	79.1	0.40327	0.69776	0.15476	1.4392	0.41545	0.63001	1.6828	2.5877	0.17266
$Zr_{57}Ti_5Al_{10}Cu_{20}Ni_8$	676.7	720	1145.2	10	0.5909	43.3	0.39519	0.66652	0.09242	1.5368	0.39883	0.62871	1.6549	2.6949	0.19701
$Zr_{38.5}Ti_{16.5}Ni_{9.75}Cu_{15.25}Be_{20}$	630	678	1003	1.4	0.62812	48	0.41519	0.72383	0.12869	1.8177	0.43466	0.67597	1.7043	4.0439	0.15762
$Zr_{39.88}Ti_{15.12}Ni_{9.98}Cu_{13.77}Be_{21.25}$	629	686	1006	1.4	0.62525	57	0.41957	0.73857	0.15119	1.8196	0.44354	0.68191	1.7159	4.2138	0.14749
$Zr_{41.2}Ti_{13.8}Cu_{12.5}Ni_{10}Be_{22.5}$	623	672	996	1.4	0.6255	49	0.41507	0.7239	0.13137	1.8016	0.43483	0.6747	1.7042	3.9881	0.15747
$Zr_{42.63}Ti_{12.37}Cu_{11.25}Ni_{10}Be_{23.75}$	623	712	1057	5	0.5894	89	0.42381	0.75781	0.20507	1.6406	0.44624	0.6736	1.7323	3.7267	0.13333
$Zr_{44}Ti_{11}Cu_{10}Ni_{10}Be_{25}$	625	739	1206	12.5	0.51824	114	0.4036	0.7073	0.19621	1.2719	0.40631	0.61277	1.7006	2.1178	0.16305
$Zr_{45.38}Ti_{9.62}Cu_{8.75}Ni_{10}Be_{26.25}$	623	740	1239	17.5	0.50282	117	0.39742	0.69169	0.18994	1.2013	0.39587	0.59726	1.6906	1.8515	0.17272
$Zr_{46.75}Ti_{8.25}Cu_{7.5}Ni_{10}Be_{27.5}$	622	727	1185	28	0.52489	105	0.40232	0.70211	0.1865	1.2913	0.407	0.6135	1.6937	2.1557	0.16714
$La_{55}Al_{25}Ni_{15}Cu_5$	473.6	541.2	899.6	34.5	0.52646	67.6	0.39412	0.67675	0.15869	1.2704	0.39853	0.6016	1.6692	1.9954	0.18532
$La_{55}Al_{25}Ni_{10}Cu_{10}$	467.4	547.2	835	22.5	0.55976	79.8	0.42015	0.7509	0.21708	1.4886	0.43473	0.65533	1.7305	3.0878	0.13641
$La_{55}Al_{25}Ni_5Cu_{15}$	459.1	520	878.1	35.9	0.52283	60.9	0.38887	0.66154	0.14535	1.2411	0.39166	0.59219	1.6555	1.8617	0.19623
$La_{55}Al_{25}Ni_5Cu_{10}Co_5$	465.2	541.8	822.5	18.8	0.56559	76.6	0.42075	0.75185	0.21439	1.5164	0.43699	0.65872	1.7303	3.1989	0.13609
$Pd_{40}Cu_{30}Ni_{10}P_{20}$	586	660	856	0.1	0.68458	74	0.4577	0.85748	0.27407	2.4444	0.50923	0.77103	1.8109	10.068	0.07512
$Ti_{34}Zr_{11}Cu_{47}Ni_8$	698.4	727.2	1169.2	100	0.59733	28.8	0.38938	0.6466	0.06117	1.5446	0.37862	0.62196	1.6386	2.5996	0.21248
Ni	425	425	1725	3.00E+10	0.24638	0	0.19767	0.24638	0	0.3269	0	0.24638	1.2464	0.1069	0.60465
$Fe_{91}B_9$	600	600	1628	2.60E+07	0.36855	0	0.2693	0.36855	0	0.5837	0	0.36855	1.3686	0.3407	0.4614
$Pd_{95}Si_5$	647	647	1688	5.00E+07	0.38329	0	0.27709	0.38329	0	0.6215	0	0.38329	1.3833	0.3863	0.44582
$Pd_{75}Si_{25}$	656	656	1343	1.00E+06	0.48846	0	0.32816	0.48846	0	0.9549	0	0.48846	1.4885	0.9118	0.34367
$Zr_{65}Be_{35}$	623	623	1238	1.00E+07	0.50323	0	0.33477	0.50323	0	1.013	0	0.50323	1.5032	1.0262	0.33047
$Ti_{63}Be_{37}$	673	673	1353	6.30E+06	0.49741	0	0.33218	0.49741	0	0.9897	0	0.49741	1.4974	0.9795	0.33564
$Pd_{82}Si_{18}$	648	648	1071	1800	0.60504	0	0.37696	0.60504	0	1.5319	0	0.60504	1.605	2.3468	0.24607
$Au_{77.8}Si_{8.4}Ge_{13.8}$	293	293	629	3.00E+06	0.46582	0	0.31779	0.46582	0	0.872	0	0.46582	1.4658	0.7604	0.36443
$Mg_{65}Cu_{7.5}Ni_{7.5}Zn_5Ag_5Y_{10}$	426	464	717	50	0.59414	38	0.40595	0.70014	0.13058	1.5945	0.42053	0.64714	1.6833	3.0881	0.1727
$Ni_{59}Zr_{16}Ti_{13}Si_3Sn_2Nb_7$	845	885	1301	40	0.6495	40	0.4124	0.71099	0.08772	1.9408	0.41989	0.68025	1.6968	4.3213	0.16729
$Pd_{42.5}Cu_{30}Ni_{7.5}P_{20}$	574	660	834	0.067	0.68825	86	0.46875	0.89448	0.33077	2.5385	0.52463	0.79137	1.8381	12.513	0.05436
$Pd_{42.5}Cu_{27.5}Ni_{10}P_{20}$	584	665	871	0.083	0.67049	81	0.45704	0.85649	0.28223	2.3171	0.50549	0.76349	1.8092	9.1517	0.07545
$Pd_{40}Cu_{32.5}Ni_{7.5}P_{20}$	568	654	932	0.133	0.60944	86	0.436	0.79399	0.23626	1.7967	0.46526	0.70172	1.7609	4.8066	0.11117
$Pd_{40}Cu_{25}Ni_{15}P_{20}$	596	668	910	0.15	0.65495	72	0.44356	0.81319	0.2293	2.1274	0.48411	0.73407	1.7758	6.7982	0.10071
$Pd_{45}Cu_{25}Ni_{10}P_{20}$	595	675	884	0.1	0.67308	80	0.45639	0.85407	0.27682	2.3356	0.50519	0.76357	1.8075	9.1945	0.07688
$Pd_{45}Cu_{30}Ni_5P_{20}$	577	659	861	0.083	0.67015	82	0.45828	0.86063	0.28873	2.3204	0.50699	0.76539	1.8123	9.3188	0.07307
$Pd_{37.5}Cu_{30}Ni_{12.5}P_{20}$	572	647	929	0.133	0.61572	75	0.43105	0.77718	0.21008	1.8123	0.46048	0.69645	1.7468	4.6537	0.12192
$Mg_{70}Ni_{15}Nd_{15}$	467	489	844	178.2	0.55332	22	0.373	0.60545	0.05836	1.2971	0.35746	0.57938	1.6004	1.812	0.24258
$Mg_{65}Ni_{20}Nd_{15}$	459	501	805	30	0.57019	42	0.39636	0.67453	0.12139	1.448	0.40504	0.62236	1.6617	2.4883	0.1899
$Mg_{75}Ni_{15}Nd_{10}$	450	470	790	46.1	0.56962	20	0.37903	0.62025	0.05882	1.3824	0.36494	0.59494	1.6141	2.0654	0.23164
$Mg_{77}Ni_{18}Nd_5$	429	437	887	49,000	0.48365	8	0.33207	0.50169	0.01747	0.9542	0.27367	0.49267	1.5023	0.9258	0.32972
$Mg_{90}Ni_5Nd_5$	426	449	919	53,000	0.46355	23	0.33383	0.5136	0.04665	0.9108	0.30536	0.48857	1.5175	0.8659	0.31532
$Mg_{80}Ni_{10}Nd_{10}$	454	471	878	1251.4	0.51708	17	0.3536	0.55581	0.04009	1.1108	0.32326	0.53645	1.5545	1.2909	0.28222
$Mg_{65}Cu_{25}Y_{10}$	413	473	760	50	0.54342	60	0.40324	0.70132	0.17291	1.3631	0.41241	0.62237	1.6887	2.3716	0.16897
$Mg_{65}Cu_{25}Gd_{10}$	423	484	740	1	0.57162	61	0.41617	0.73649	0.19243	1.5268	0.43336	0.65405	1.7158	3.124	0.14654
$La_{55}Al_{25}Ni_{20}$	491	555	941	67.5	0.52179	64	0.38757	0.65781	0.14222	1.2333	0.3899	0.5898	1.6521	1.8289	0.19893
$La_{55}Al_{25}Cu_{20}$	456	495	896	72.3	0.50893	39	0.36612	0.59598	0.08864	1.125	0.35805	0.55246	1.5945	1.4037	0.24666
$La_{66}Al_{14}Cu_{20}$	395	449	731	37.5	0.54036	54	0.39876	0.6881	0.16071	1.3363	0.40654	0.61423	1.6771	2.2302	0.17813
$Pd_{40}Ni_{40}P_{20}$	575	640	905	0.167	0.63536	65	0.43243	0.77901	0.19697	1.9394	0.46519	0.70718	1.7484	5.2403	0.12141
$Pd_{77}Cu_6Si_{17}$	642	686	1128	125	0.56915	44	0.38757	0.64716	0.09053	1.4115	0.38794	0.60816	1.6377	2.2543	0.21044
$Pd_{79.5}Cu_4Si_{16.5}$	635	678	1086	500	0.58471	43	0.39396	0.6639	0.09534	1.5033	0.39786	0.62431	1.6524	2.5863	0.19864
$Pd_{77.5}Cu_6Si_{16.5}$	637	686	1058	100	0.60208	49	0.40472	0.69471	0.11639	1.6295	0.41721	0.64839	1.679	3.1577	0.17695
$Ni_{60}Nb_{40}$	933	933	1484	1400	0.62871	0	0.38602	0.62871	0	1.6933	0	0.62871	1.6287	2.8672	0.22797
$Ca_{65}Mg_{15}Zn_{20}$	375	410	630	20	0.59524	35	0.40796	0.70635	0.13725	1.6078	0.42404	0.65079	1.6886	3.1767	0.16837

Table 2
The T_g, T_x, T_l, D_{max} and the calculated T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_1, and $1/\omega$ for the reported BMGs based on Cu, Ca, Mg, La, Pd, Ti, Pr, Y, Co, Au, Hf, Gd, Zr, Fe and Ni

Based metal	Alloy composition (at.%) [ref.]	T_g (K)	T_x (K)	T_l (K)	D_{max} (mm)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_1	$1/\omega$
Cu-	$Cu_{55}Zr_{42.5}Ga_{2.5}$ [24]	709	762	1199	1	0.59133	53	0.39937	0.67973	0.10816	1.5551	0.40809	0.63553	1.6661	2.829	5.3402
	$Cu_{57.5}Zr_{37.5}Ga_5$ [24]	745	785	1241	1	0.60032	40	0.39527	0.66479	0.08065	1.5827	0.39515	0.63255	1.654	2.8125	5.0304
	$Cu_{52.5}Zr_{40}Ga_{7.5}$ [24]	744	777	1218	1.5	0.61084	33	0.39602	0.66502	0.06962	1.6392	0.39124	0.63793	1.6552	2.9725	5.0221
	$Cu_{55}Zr_{40}Ga_5$ [24]	736	779	1193	2	0.61693	43	0.40384	0.68902	0.09409	1.7046	0.41102	0.65298	1.6754	3.3451	5.5032
	$Cu_{52.5}Zr_{42.5}Ga_5$ [24]	733	777	1187	2	0.61752	44	0.40469	0.69166	0.09692	1.7115	0.41301	0.65459	1.6776	3.3881	5.5608
	$Cu_{46}Zr_{54}$ [24]	696	746	1201	2	0.57952	50	0.39325	0.66278	0.09901	1.4772	0.39767	0.62115	1.6514	2.508	5.0204
	$Cu_{46}Zr_{47}Al_7$ [24]	705	781	1163	3	0.60619	76	0.41809	0.73689	0.16594	1.7052	0.44083	0.67154	1.714	3.7732	6.7627
	$Cu_{46}Zr_{37}Al_7Y_{10}$ [24]	665	743	1118	4	0.59481	78	0.41671	0.73435	0.17219	1.6402	0.43781	0.66458	1.7121	3.5136	6.7075
	$Cu_{46}Zr_{45}Al_7Y_2$ [24]	693	770	1143	8	0.6063	77	0.41939	0.74103	0.17111	1.7111	0.44282	0.67367	1.7174	3.8354	6.8919
	$Cu_{46}Zr_{42}Al_7Y_5$ [24]	672	772	1113	10	0.60377	100	0.43249	0.78347	0.22676	1.7506	0.45979	0.69362	1.7526	4.4615	8.5088
	$Cu_{60}Hf_{25}Ti_{15}$ [24]	730	790	1177	4	0.62022	60	0.41426	0.72218	0.13423	1.7673	0.43388	0.6712	1.7024	3.8506	6.3111
	$Cu_{52.5}Hf_{40}Al_{7.5}$ [24]	779	833	1250	3	0.6232	54	0.41055	0.7096	0.11465	1.7686	0.42547	0.6664	1.6925	3.7317	5.977
	$Cu_{60}Zr_{30}Ti_{10}$ [24]	720	757	1160	4	0.62069	37	0.40266	0.68448	0.08409	1.7205	0.406	0.65259	1.6721	3.356	5.4006
	$Cu_{47}Ti_{33}Zr_{11}Si_1Ni_6Sn_2$ [24]	720	765	1140	6	0.63158	45	0.41129	0.71053	0.10714	1.8214	0.42485	0.67105	1.6941	3.9168	5.9886
	$Cu_{50}Zr_{43}Al_7$ [24]	721	792	1176	4	0.6131	71	0.4175	0.73384	0.15604	1.7407	0.44012	0.67347	1.7116	3.8726	6.6575
	$Cu_{47}Zr_{43}Al_7Ag_3$ [24]	716	795	1156	5	0.61938	79	0.42468	0.75606	0.17955	1.8068	0.45192	0.68772	1.7297	4.3678	7.3707
	$Cu_{47}Zr_{43}Al_7Be_3$ [24]	715	798	1139	6	0.62774	83	0.43042	0.77349	0.19575	1.8821	0.46137	0.70061	1.7438	4.9068	8.0202
	$Cu_{43}Zr_{43}Al_7Ag_7$ [24]	710	797	1125	8	0.63111	87	0.43433	0.78578	0.20964	1.9205	0.46744	0.70844	1.7536	5.2598	8.5471
	$Cu_{43}Zr_{43}Al_7Be_7$ [24]	710	813	1126	12	0.63055	103	0.44281	0.8135	0.2476	1.9543	0.47844	0.72202	1.7756	5.892	10.011
	$Cu_{49}Hf_{42}Al_9$ [24]	778	863	1249	10	0.6229	85	0.42575	0.75901	0.18047	1.8323	0.45385	0.69095	1.7322	4.5063	7.47
	$Cu_{45}Zr_{48}Al_7$ [24]	708	766	1186	5	0.59696	58	0.40444	0.69477	0.12134	1.6025	0.41741	0.64587	1.6789	3.0744	5.6607
	$Cu_{47}Ti_{33}Zr_{11}Ni_8Si_1$ [24]	720	757	1157	4	0.6223	37	0.4033	0.68626	0.08467	1.7323	0.40706	0.65428	1.6737	3.4065	5.4365
	$Cu_{47}Ti_{33}Zr_9Nb_2Ni_8Si_1$ [24]	728	762	1159	5	0.62813	34	0.40382	0.6868	0.07889	1.768	0.40529	0.65746	1.6748	3.5197	5.4411
	$Cu_{47}Ti_{33}Zr_7Nb_4Ni_8Si_1$ [24]	713	736	1172	5	0.60836	23	0.39045	0.64761	0.05011	1.6035	0.3723	0.62799	1.6406	2.7605	4.7114
	$Cu_{47}Ti_{33}Zr_5Nb_6Ni_8Si_1$ [24]	712	739	1187	2	0.59983	27	0.38915	0.64532	0.05684	1.5558	0.37567	0.62258	1.6378	2.6216	4.6817
	$Cu_{47}Ti_{33}Zr_3Nb_8Ni_8Si_1$ [24]	708	731	1228	1	0.57655	23	0.37758	0.61401	0.04423	1.4058	0.35319	0.59528	1.609	2.0953	4.2171
	$Cu_{47}Ti_{33}Nb_{11}Ni_8Si_1$ [24]	710	732	1265	0.5	0.56126	22	0.37063	0.59605	0.03964	1.3189	0.34151	0.57866	1.5923	1.8294	3.9847
	$Cu_{47}Zr_{11}Ni_8Ti_{34}$ [24]	671	717	1160	3	0.57845	46	0.39159	0.65776	0.09407	1.4663	0.39429	0.6181	1.647	2.4515	4.9283
	$Cu_{60}Zr_{30}Ti_{10}$ [24]	713	750	1151	4	0.61946	37	0.40236	0.68375	0.08447	1.7123	0.40577	0.65161	1.6714	3.3255	5.3866
	$(Cu_{60}Zr_{30}Ti_{10})_{98}Y_2$ [24]	707	757	1122	5	0.63012	50	0.41389	0.71925	0.12048	1.8241	0.43143	0.67469	1.7008	4.0173	6.217
	$(Cu_{60}Zr_{30}Ti_{10})_{90}Be_{10}$ [24]	720	762	1130	5	0.63717	42	0.41189	0.7115	0.10244	1.8585	0.4244	0.67434	1.6955	4.0513	6.0059
	$(Cu_{60}Zr_{30}Ti_{10})_{99}Sn_1$ [24]	730	776	1155	5	0.63203	46	0.41167	0.71169	0.10824	1.8259	0.42566	0.67186	1.695	3.9437	6.0174
	$Cu_{60}Hf_{25}Ti_{15}$ [24]	745	805	1182	4	0.63029	60	0.41775	0.73181	0.1373	1.8421	0.43964	0.68105	1.7108	4.2196	6.5684
	$(Cu_{0.6}Hf_{0.25}Ti_{0.15})_{98}Nb_2$ [24]	746	792	1184	4	0.63007	46	0.41036	0.70777	0.10502	1.8082	0.42302	0.66892	1.6917	3.845	5.922
	$(Cu_{0.6}Hf_{0.25}Ti_{0.15})_{96}Nb_4$ [24]	747	789	1188	4	0.62879	42	0.40775	0.69949	0.09524	1.7891	0.41662	0.66414	1.685	3.7021	5.7249
	$(Cu_{0.6}Hf_{0.25}Ti_{0.15})_{94}Nb_6$ [24]	745	785	1190	4	0.62605	40	0.40568	0.69328	0.08989	1.764	0.41208	0.65966	1.6797	3.5655	5.586
	$(Cu_{0.6}Hf_{0.25}Ti_{0.15})_{92}Nb_8$ [24]	745	783	1198	2.5	0.62187	38	0.40299	0.68531	0.08389	1.7285	0.40634	0.65359	1.6729	3.3871	5.4167
	$Cu_{60}Zr_{33}Ti_7$ [24]	740	768	1191	3	0.62133	28	0.39772	0.66835	0.06208	1.7029	0.38901	0.64484	1.6592	3.1762	5.0736
	$Cu_{54}Ag_6Zr_{33}Ti_7$ [24]	709	738	1135	6	0.62467	29	0.40022	0.67577	0.06808	1.7324	0.39549	0.65022	1.6656	3.3199	5.2158
	$Cu_{46.4}Ag_{11.6}Zr_{35}Ti_7$ [24]	689	732	1119	6	0.61573	43	0.40487	0.69258	0.1	1.7023	0.4141	0.65416	1.6781	3.3675	5.5838
	$Cu_{60}Zr_{30}Ti_{10}$ [24]	724	746	1175	2	0.61617	22	0.39284	0.65362	0.04878	1.6541	0.37387	0.63489	1.6466	2.9347	4.8076
	$Cu_{55}Ni_5Zr_{30}Ti_{10}$ [24]	717	750	1204	2	0.59551	33	0.39042	0.65033	0.06776	1.54	0.38344	0.62292	1.6415	2.609	4.773
	$Cu_{47}Ni_{13}Zr_{30}Ti_{10}$ [24]	727	754	1251	1	0.58114	27	0.38119	0.6243	0.05153	1.4389	0.36288	0.60272	1.6183	2.2192	4.3648
	$Cu_{55}Ag_5Zr_{30}Ti_{10}$ [24]	704	733	1149	3	0.61271	29	0.39557	0.66319	0.06517	1.6472	0.3883	0.63795	1.6539	2.9819	4.9854
	$Cu_{50}Ag_{10}Zr_{30}Ti_{10}$ [24]	694	726	1130	4	0.61416	32	0.39803	0.6708	0.07339	1.6651	0.39555	0.64248	1.6603	3.087	5.1293
	$Cu_{45}Ag_{15}Zr_{30}Ti_{10}$ [24]	687	717	1121	5	0.61285	30	0.39657	0.66637	0.06912	1.6521	0.39165	0.63961	1.6565	3.018	5.0453
	$Cu_{40}Ag_{20}Zr_{30}Ti_{10}$ [24]	677	708	1125	3	0.60178	31	0.3929	0.65689	0.0692	1.5804	0.38719	0.62933	1.6476	2.7564	4.8822
	$Cu_{35}Ag_{25}Zr_{30}Ti_{10}$ [24]	677	706	1138	2	0.5949	29	0.38898	0.64587	0.06291	1.5315	0.37914	0.62039	1.6377	2.5611	4.6966
	$Cu_{45}Ni_5Ag_{10}Zr_{30}Ti_{10}$ [24]	710	738	1160	5	0.61207	28	0.39465	0.66034	0.06222	1.64	0.38549	0.63621	1.6515	2.9423	4.9334
	$Cu_{60}Hf_{20}Ti_{20}$ [24]	740	767	1211	4	0.61107	27	0.39313	0.65566	0.05732	1.6285	0.3806	0.63336	1.6476	2.8791	4.8494
	$Cu_{60}Hf_{17.5}Ti_{22.5}$ [24]	732	755	1229	3	0.59561	23	0.38501	0.63303	0.04628	1.5191	0.36313	0.61432	1.627	2.4598	4.4847

	$Cu_{45}Zr_{45}Ag_{10}$ [26]	683	756	1159	6	0.5893	73	0.4104	0.7153	0.1534	1.5882	0.428	0.6523	1.6962	3.1793	6.1784
	$Cu_{45}Zr_{45}Ag_7Al_3$ [26]	688	768	1151	7	0.5977	80	0.4176	0.7368	0.1728	1.6587	0.4394	0.6673	1.714	3.6021	6.775
	$Cu_{45}Zr_{45}Ag_5Al_5$ [26]	697	783	1147	9	0.6077	86	0.4246	0.7576	0.1911	1.74	0.4505	0.6827	1.7311	4.119	7.4515
	$Cu_{45}Zr_{45}Ag_3Al_7$ [26]	708	786	1177	8	0.6015	78	0.417	0.7341	0.1663	1.6759	0.4388	0.6678	1.7117	3.64	6.6858
	$Cu_{44}Zr_{44}Ag_6Al_6$ [26]	698	790	1144	10	0.6101	92	0.4289	0.771	0.2063	1.7713	0.4567	0.6906	1.7419	4.4002	7.9572
	$Cu_{42}Zr_{42}Ag_8Al_8$ [26]	705	780	1213	12	0.5812	75	0.4067	0.7049	0.1476	1.5354	0.4219	0.643	1.6876	2.933	5.9275
	$Cu_{40}Zr_{40}Ag_{10}Al_{10}$ [26]	710	765	1273	3	0.5577	55	0.3858	0.6442	0.0977	1.3588	0.3869	0.6009	1.6352	2.1047	4.7166
	$Cu_{40}Zr_{44}Ag_8Al_8$ [26]	693	791	1176	15	0.5893	98	0.4232	0.756	0.2029	1.6377	0.4455	0.6726	1.7307	3.6982	7.4331
	$Cu_{38}Zr_{46}Ag_8Al_8$ [26]	692	795	1145	20	0.6044	103	0.4328	0.7843	0.2274	1.755	0.4603	0.6943	1.7532	4.4909	8.5442
	$Cu_{36}Zr_{48}Ag_8Al_8$ [26]	683	791	1142	25	0.5981	108	0.4334	0.7872	0.2353	1.7233	0.4594	0.6926	1.7562	4.3851	8.6979
	$Cu_{34}Zr_{50}Ag_8Al_8$ [26]	680	780	1148	15	0.5923	100	0.4267	0.7666	0.2137	1.6667	0.4503	0.6794	1.7394	3.9166	7.824
	$Cu_{50}Zr_{50}$ [27]	686	744	1237	2	0.5546	58	0.3869	0.6483	0.1053	1.3503	0.3895	0.6015	1.6391	2.0999	4.7945
	$Cu_{48}Zr_{48}Ag_4$ [27]	681	743	1199	3	0.568	62	0.3952	0.6714	0.1197	1.4344	0.4032	0.6197	1.659	2.4334	5.206
	$Cu_{46}Zr_{46}Ag_8$ [27]	677	745	1167	4	0.5801	68	0.404	0.6967	0.1388	1.5204	0.4176	0.6384	1.6806	2.8322	5.7323
	$Cu_{44}Zr_{44}Ag_{12}$ [27]	684	764	1156	4	0.5917	80	0.4152	0.7301	0.1695	1.6186	0.4353	0.6609	1.7087	3.4008	6.5872
	$Cu_{42}Zr_{42}Ag_{16}$ [27]	685	757	1232	2	0.556	72	0.3949	0.6729	0.1316	1.3839	0.4029	0.6145	1.6611	2.2983	5.2568
	$Cu_{45}Zr_{35}Ag_{10}Hf_{10}$ [27]	690	769	1171	4	0.5892	79	0.4132	0.7242	0.1642	1.5988	0.4322	0.6567	1.7037	3.2834	6.4213
	$Cu_{45}Zr_{25}Ag_{10}Hf_{20}$ [27]	698	783	1218	3	0.5731	85	0.4087	0.7126	0.1635	1.5058	0.4241	0.6429	1.6948	2.8883	6.1409
	$Cu_{45}Zr_{15}Ag_{10}Hf_{30}$ [27]	712	799	1275	2	0.5584	87	0.4021	0.6949	0.1545	1.4192	0.4134	0.6267	1.6806	2.5108	5.7321
	$Cu_{50}Zr_{50}$ [28]	670	717	1208	2	0.5546	47	0.3818	0.6325	0.0874	1.3327	0.3793	0.5935	1.6248	1.9926	4.5264
	$Cu_{43}Zr_{43}Ag_7Ti_7$ [28]	670	714	1118	5	0.5993	44	0.3993	0.678	0.0982	1.5938	0.406	0.6386	1.665	2.931	5.2928
	$Cu_{43}Zr_{43}Ag_7In_7$ [28]	704	748	1135	5	0.6203	44	0.4067	0.6978	0.1021	1.7355	0.4172	0.659	1.6828	3.516	5.6966
	$Cu_{43}Zr_{40}Ag_7Ti_{10}$ [28]	656	707	1095	7	0.5991	51	0.4038	0.6922	0.1162	1.6105	0.4158	0.6457	1.6768	3.0808	5.5998
	$Cu_{64}Zr_{36}$ [28]	787	833	1230	2	0.6398	46	0.413	0.7146	0.1038	1.8804	0.4263	0.6772	1.6983	4.1595	6.0823
	$Cu_{57}Zr_{36}Ag_7$ [28]	712	755	1156	4	0.6159	43	0.4042	0.6903	0.0969	1.7005	0.4123	0.6531	1.6763	3.343	5.533
	$Cu_{54}Zr_{36}Ag_{10}$ [28]	719	759	1146	6	0.6274	40	0.407	0.6972	0.0937	1.7775	0.4151	0.6623	1.683	3.6438	5.6736
	$Cu_{49}Zr_{36}Ag_{10}Ti_5$ [28]	691	737	1130	8	0.6115	46	0.4047	0.6929	0.1048	1.6788	0.4151	0.6522	1.6781	3.2973	5.5972
	$Cu_{50}Zr_{42.5}Ti_{7.5}$ [29]	677	717	1152	5	0.5877	40	0.392	0.6571	0.0842	1.5095	0.3922	0.6224	1.6468	2.5652	4.904
	$(Cu_{0.5}Zr_{0.425}Ti_{0.075})_{99}Sn_1$ [29]	683	730	1140	6	0.5991	47	0.4004	0.6816	0.1028	1.5974	0.4086	0.6404	1.6679	2.966	5.3676
	$(Cu_{0.5}Zr_{0.425}Ti_{0.075})_{99}Si_1$ [29]	683	731	1141	6	0.5986	48	0.4008	0.6827	0.1048	1.5961	0.4095	0.6407	1.6689	2.9701	5.3928
	$(Cu_{0.5}Zr_{0.425}Ti_{0.075})_{98.8}Sn_{0.6}Si_{0.6}$ [29]	682	734	1141	7	0.5977	52	0.4026	0.6889	0.1133	1.5991	0.4137	0.6433	1.674	3.022	5.5268
Ca-	$Ca_{66.4}Al_{33.6}$ [24]	528	540	873	1	0.60481	12	0.38544	0.6323	0.03478	1.5652	0.35205	0.61856	1.6275	2.5712	4.4637
	$Ca_{60}Al_{30}Ag_{10}$ [24]	483	531	868	2	0.55645	48	0.39304	0.66705	0.12468	1.3792	0.39998	0.61175	1.6558	2.2583	5.1393
	$Ca_{63}Al_{32}Cu_5$ [24]	512	523	831	2	0.61613	11	0.38943	0.6426	0.03448	1.6395	0.35576	0.62936	1.6376	2.8227	4.619
	$Ca_{55}Mg_{25}Zn_{20}$ [24]	375	418	751	1	0.49933	43	0.37123	0.61385	0.11436	1.1117	0.36635	0.55659	1.614	1.4136	4.328
	$Ca_{55}Mg_{20}Zn_{25}$ [24]	383	428	702	2	0.54558	45	0.39447	0.67379	0.14107	1.3417	0.40167	0.60969	1.6631	2.1834	5.2947
	$Ca_{55}Mg_{18}Zn_{27}$ [24]	389	419	671	0.5	0.57973	30	0.39528	0.66915	0.10638	1.4858	0.40188	0.62444	1.6569	2.5666	5.143
	$Ca_{55}Mg_{15}Zn_{30}$ [24]	387	419	696	0.5	0.55603	32	0.38689	0.64799	0.10356	1.356	0.38931	0.60201	1.6387	2.1133	4.7859
	$Ca_{60}Mg_{25}Zn_{15}$ [24]	377	409	744	1	0.50672	32	0.36485	0.59274	0.08719	1.1144	0.35611	0.54973	1.5916	1.374	4.0137
	$Ca_{60}Mg_{20}Zn_{20}$ [24]	378	415	660	4	0.57273	37	0.39981	0.68485	0.13121	1.4716	0.41079	0.62879	1.6706	2.6134	5.4789
	$Ca_{60}Mg_{17.5}Zn_{22.5}$ [24]	383	421	650	10	0.58923	38	0.40755	0.70615	0.14232	1.5768	0.42345	0.64769	1.6884	3.0748	5.945
	$Ca_{60}Mg_{15}Zn_{25}$ [24]	379	427	650	6	0.58308	48	0.41497	0.73077	0.17712	1.5756	0.43391	0.65692	1.7097	3.2543	6.6247
	$Ca_{60}Mg_{10}Zn_{30}$ [24]	380	400	666	0.5	0.57057	20	0.38241	0.63063	0.06993	1.3986	0.3745	0.6006	1.6232	2.1482	4.4758
	$Ca_{62.5}Mg_{17.5}Zn_{20}$ [24]	375	412	640	10	0.58594	37	0.40591	0.70156	0.13962	1.5547	0.42074	0.64375	1.6846	2.9721	5.8385
	$Ca_{65}Mg_{25}Zn_{10}$ [24]	387	405	759	0.5	0.50988	18	0.3534	0.55731	0.04839	1.0887	0.3288	0.5336	1.5564	1.2507	3.5694
	$Ca_{65}Mg_{20}Zn_{15}$ [24]	380	405	668	5	0.56886	25	0.38645	0.64371	0.08681	1.4063	0.38548	0.60629	1.6347	2.225	4.6931
	$Ca_{65}Mg_{15}Zn_{20}$ [24]	377	410	630	6	0.59841	33	0.40715	0.70317	0.13043	1.6206	0.42241	0.65079	1.6859	3.1936	5.8564
	$Ca_{65}Mg_{10}Zn_{25}$ [24]	377	412	659	2	0.57208	35	0.39768	0.6783	0.12411	1.461	0.40723	0.62519	1.6649	2.5459	5.3405
	$Ca_{70}Mg_{15}Zn_{15}$ [24]	371	397	688	0.5	0.53924	26	0.37488	0.61483	0.08202	1.2524	0.36873	0.57703	1.6093	1.7393	4.2763
	$Ca_{70}Mg_{10}Zn_{20}$ [24]	367	399	657	0.5	0.5586	32	0.38965	0.65601	0.11034	1.3759	0.39408	0.60731	1.6458	2.1999	4.926
	$Ca_{40}Mg_{30}Cu_{30}$ [24]	395	430	694	0.5	0.56916	35	0.39486	0.67003	0.11706	1.4381	0.40246	0.6196	1.6578	2.437	5.1768

Table 2 (*Continued*)

Based metal	Alloy composition (at.%) [ref.]	T_g (K)	T_x (K)	T_l (K)	D_{max} (mm)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_1	$1/\omega$
	$Ca_{40}Mg_{25}Cu_{35}$ [24]	399	436	680	4	0.58676	37	0.40408	0.69559	0.13167	1.5516	0.41762	0.64118	1.6795	2.922	5.6959
	$Ca_{45}Mg_{30}Cu_{25}$ [24]	401	436	717	1	0.55927	35	0.38998	0.6569	0.11076	1.3797	0.39462	0.60809	1.6466	2.2142	4.9414
	$Ca_{45}Mg_{25}Cu_{30}$ [24]	400	438	678	6	0.58997	38	0.40631	0.70206	0.13669	1.5755	0.42135	0.64602	1.685	3.0417	5.8436
	$Ca_{45}Mg_{19}Cu_{36}$ [24]	399	428	714	0.5	0.55882	29	0.38455	0.64006	0.09206	1.3587	0.38411	0.59944	1.6315	2.0878	4.6455
	$Ca_{47.5}Mg_{22.5}Cu_{30}$ [24]	399	440	673	6	0.59287	41	0.41045	0.71471	0.14964	1.6058	0.4282	0.65379	1.6956	3.2338	6.1571
	$Ca_{50}Mg_{30}Cu_{20}$ [24]	402	439	731	2	0.54993	37	0.38747	0.65116	0.11246	1.3343	0.39098	0.60055	1.642	2.0698	4.8521
	$Ca_{50}Mg_{25}Cu_{25}$ [24]	400	439	655	9	0.61069	39	0.41611	0.72977	0.15294	1.7216	0.43777	0.67023	1.7082	3.7637	6.5416
	$Ca_{50}Mg_{22.5}Cu_{27.5}$ [24]	400	442	663	10	0.60332	42	0.4158	0.73002	0.1597	1.6806	0.4371	0.66667	1.7083	3.6199	6.5621
	$Ca_{50}Mg_{20}Cu_{30}$ [24]	401	442	690	8	0.58116	41	0.40513	0.7	0.14187	1.5294	0.41944	0.64058	1.6834	2.8818	5.8094
	$Ca_{53}Mg_{23}Cu_{24}$ [24]	406	439	655	7	0.61985	33	0.41376	0.72061	0.13253	1.7631	0.43293	0.67023	1.7011	3.8202	6.2691
	$Ca_{55}Mg_{25}Cu_{20}$ [24]	398	428	668	8	0.59581	30	0.4015	0.68563	0.11111	1.5852	0.41167	0.64072	1.6712	2.9574	5.4588
	$Ca_{55}Mg_{20}Cu_{25}$ [24]	399	426	720	2	0.55417	27	0.3807	0.62917	0.08411	1.3271	0.37704	0.59167	1.6218	1.9665	4.4746
	$Ca_{55}Mg_{15}Cu_{30}$ [24]	397	437	706	3	0.56232	40	0.39619	0.67564	0.12945	1.4142	0.405	0.61898	1.6631	2.3975	5.3019
	$Ca_{55}Mg_{10}Cu_{35}$ [24]	397	422	770	0.5	0.51558	25	0.36161	0.58052	0.06702	1.1314	0.3472	0.54805	1.5786	1.3834	3.8405
	$Ca_{58}Mg_{18}Cu_{24}$ [24]	388	426	667	6	0.58171	38	0.40379	0.69565	0.1362	1.5269	0.41727	0.63868	1.6796	2.8458	5.706
	$Ca_{60}Mg_{25}Cu_{15}$ [24]	390	416	676	2	0.57692	26	0.39024	0.65385	0.09091	1.4545	0.39168	0.61538	1.6436	2.4	4.8593
	$Ca_{60}Mg_{20}Cu_{20}$ [24]	387	412	678	4	0.5708	25	0.38685	0.64454	0.08591	1.4158	0.38578	0.60767	1.6354	2.2534	4.7046
	$Ca_{60}Mg_{15}Cu_{25}$ [24]	396	428	687	1	0.57642	32	0.3952	0.66958	0.10997	1.4708	0.40226	0.623	1.6572	2.5266	5.1565
	$Ca_{60}Mg_{13}Cu_{27}$ [24]	394	426	701	1	0.56205	32	0.38904	0.65335	0.10423	1.3876	0.39252	0.6077	1.6433	2.2194	4.8722
	$Ca_{65}Mg_{25}Cu_{10}$ [24]	405	429	691	0.5	0.58611	24	0.39142	0.65557	0.08392	1.5	0.39127	0.62084	1.6454	2.5311	4.8779
	$Ca_{65}Mg_{20}Cu_{15}$ [24]	386	405	679	2	0.56848	19	0.38028	0.62445	0.06485	1.3823	0.36957	0.59647	1.6177	2.0823	4.382
	$Ca_{65}Mg_{15}Cu_{20}$ [24]	383	409	682	4	0.56158	26	0.38404	0.63783	0.08696	1.3679	0.38226	0.59971	1.6295	2.1018	4.6044
	$Ca_{65}Mg_{10}Cu_{25}$ [24]	388	420	711	2	0.54571	32	0.38217	0.63572	0.09907	1.3003	0.38194	0.59072	1.6282	1.9244	4.5932
	$Ca_{65}Mg_{5}Cu_{30}$ [24]	403	424	757	0.5	0.53236	21	0.36552	0.58785	0.05932	1.1977	0.34892	0.56011	1.5845	1.5409	3.9117
	$Ca_{70}Mg_{20}Cu_{10}$ [24]	356	385	702	0.5	0.50712	29	0.36389	0.58974	0.08382	1.1127	0.35431	0.54843	1.5886	1.3639	3.9729
	$Ca_{70}Mg_{10}Cu_{20}$ [24]	385	407	713	1	0.53997	22	0.37067	0.60168	0.06707	1.2409	0.35861	0.57083	1.5971	1.6734	4.0871
	$Ca_{55}Mg_{11}Zn_{11}Cu_{23}$ [24]	379	430	717	1	0.52859	51	0.39234	0.67085	0.15089	1.2722	0.39679	0.59972	1.6632	1.9785	5.269
	$Ca_{50}Mg_{20}Zn_{5}Cu_{25}$ [24]	399	441	654	10	0.61009	42	0.4188	0.73853	0.16471	1.7294	0.44216	0.67431	1.7154	3.8784	6.8061
	$Ca_{50}Mg_{15}Zn_{10}Cu_{25}$ [24]	395	434	678	10	0.5826	39	0.40447	0.69764	0.13781	1.5336	0.41839	0.64012	1.6813	2.8794	5.7509
	$Ca_{50}Mg_{10}Zn_{15}Cu_{25}$ [24]	395	427	702	2	0.56268	32	0.38924	0.65385	0.10423	1.3909	0.39281	0.60826	1.6437	2.2303	4.8801
	$Ca_{50}Mg_{25}Zn_{15}Cu_{10}$ [24]	383	430	723	8	0.52974	47	0.38879	0.65975	0.13824	1.2647	0.39244	0.59474	1.6525	1.9184	5.0477
	$Ca_{47}Mg_{19}Zn_{7}Cu_{27}$ [24]	393	440	676	6	0.58136	47	0.4116	0.72041	0.16608	1.5548	0.4291	0.65089	1.701	3.1047	6.3325
Mg-	$Mg_{80}Ni_{10}Nd_{10}$ [24]	454	471	878	0.6	0.51708	17	0.3536	0.55581	0.04009	1.1108	0.32326	0.53645	1.5545	1.2909	3.5433
	$Mg_{70}Ni_{15}Nd_{15}$ [24]	467	489	844	1.5	0.55332	22	0.373	0.60545	0.05836	1.2971	0.35746	0.57938	1.6004	1.812	4.1224
	$Mg_{75}Ni_{15}Nd_{10}$ [24]	450	470	790	2.8	0.56962	20	0.37903	0.62025	0.05882	1.3824	0.36494	0.59494	1.6141	2.0654	4.317
	$Mg_{65}Cu_{25}Er_{10}$ [24]	422	480	766	3	0.55091	58	0.40404	0.70235	0.1686	1.3953	0.4148	0.62663	1.6884	2.4764	5.9267
	$Mg_{65}Ni_{20}Nd_{15}$ [24]	459	501	805	3.5	0.57019	42	0.39636	0.67453	0.12139	1.448	0.40504	0.62236	1.6617	2.4883	5.2659
	$Mg_{65}Cu_{15}Ag_{10}Er_{10}$ [24]	427	465	733	6	0.58254	38	0.40086	0.68622	0.12418	1.5196	0.41218	0.63438	1.6715	2.7645	5.4923
	$Mg_{65}Cu_{7.5}Ni_{7.5}Zn_{5}Ag_{5}Y_{10}$ [24]	426	464	717	9	0.59414	38	0.40595	0.70014	0.13058	1.5945	0.42053	0.64714	1.6833	3.0881	5.7905
	$Mg_{65}Cu_{25}Y_{10}$ [24]	413	473	760	4	0.54342	60	0.40324	0.70132	0.17291	1.3631	0.41241	0.62237	1.6887	2.3716	5.9181
	$Mg_{65}Cu_{25}Gd_{10}$ [24]	423	484	740	8	0.57162	61	0.41617	0.73649	0.19243	1.5268	0.43336	0.65405	1.7158	3.124	6.8242
	$Mg_{65}Cu_{25}Dy_{10}$ [24]	422	492	750	3	0.56267	70	0.4198	0.74933	0.21341	1.5	0.43519	0.656	1.7285	3.1192	7.2681
	$Mg_{65}Cu_{25}Pr_{10}$ [24]	413	446	784	1	0.52679	33	0.3726	0.61097	0.08895	1.2022	0.36703	0.56888	1.6067	1.6123	4.2382
	$Mg_{65}Cu_{25}Nd_{10}$ [24]	423	456	744	1	0.56855	33	0.39075	0.65726	0.1028	1.4206	0.39477	0.6129	1.6466	2.3255	4.9335
	$Mg_{65}Cu_{25}Ho_{10}$ [24]	417	473	751	1	0.55526	56	0.40497	0.70439	0.16766	1.4162	0.41668	0.62983	1.6896	2.5522	5.9678
	$Mg_{65}Cu_{15}Ag_{5}Pd_{5}Gd_{10}$ [24]	430	472	748	10	0.57487	42	0.40068	0.68717	0.13208	1.4843	0.4122	0.63102	1.6725	2.6644	5.5259
	$Mg_{65}Cu_{25}Gd_{5}Y_{5}$ [24]	413	486	755	5	0.54702	73	0.4161	0.7404	0.21345	1.4211	0.42695	0.64371	1.7238	2.7738	7.0125
	$Mg_{65}Cu_{20}Ni_{5}Gd_{10}$ [24]	420	481	786	5	0.53435	61	0.39884	0.68957	0.16667	1.3142	0.40551	0.61196	1.6796	2.1717	5.6605
	$Mg_{65}Cu_{15}Ag_{10}Y_{4}Gd_{6}$ [24]	424	467	682	8	0.6217	43	0.42224	0.7478	0.16667	1.8101	0.44818	0.68475	1.7231	4.2836	7.0824
	$Mg_{65}Cu_{15}Ag_{10}Y_{2}Gd_{8}$ [24]	420	464	683	9	0.61493	44	0.42067	0.74378	0.1673	1.7643	0.44537	0.67936	1.7197	4.0633	6.9632
	$Mg_{65}Cu_{15}Ag_{10}Gd_{10}$ [24]	416	459	686	7.5	0.60641	43	0.41652	0.73178	0.15926	1.7	0.43835	0.6691	1.7098	3.7056	6.6082

	$Mg_{65}Cu_{7.5}Ni_{7.5}Ag_5Zn_5Gd_{10}$ [24]	440	477	726	11	0.60606	37	0.40909	0.70799	0.12937	1.6678	0.42536	0.65702	1.6902	3.3851	5.9625
	$Mg_{65}Cu_{7.5}Ni_{7.5}Ag_5Zn_5Gd_{7.5}Y_{2.5}$ [24]	438	474	719	13	0.60918	36	0.40968	0.70932	0.12811	1.6868	0.42615	0.65925	1.6914	3.4588	5.9909
	$Mg_{65}Cu_{7.5}Ni_{7.5}Ag_5Zn_5Gd_5Y_5$ [24]	434	472	718	14	0.60446	38	0.40972	0.71031	0.1338	1.662	0.42669	0.65738	1.692	3.385	6.0234
	$Mg_{65}Cu_{7.5}Ni_{7.5}Ag_5Zn_5Gd_{2.5}Y_{7.5}$ [24]	433	473	735	9.5	0.58912	40	0.40497	0.69796	0.13245	1.5662	0.41906	0.64354	1.6815	2.9836	5.7473
	$Mg_{65}Cu_{7.5}Ni_{7.5}Ag_5Zn_5Y_{10}$ [24]	430	459	728	9	0.59066	29	0.39637	0.67033	0.09732	1.5403	0.40167	0.63049	1.6581	2.7276	5.1504
	$Mg_{58.5}Cu_{30.5}Y_{11}$ [24]	422	496	762	9	0.55381	74	0.41892	0.74803	0.21765	1.4588	0.43176	0.65092	1.7292	2.9582	7.248
	$Mg_{57}Cu_{31.5}Y_{9.2}Nd_{2.3}$ [24]	428	502	777	10	0.55084	74	0.4166	0.74131	0.21203	1.4384	0.42857	0.64607	1.7237	2.8411	7.0315
	$Mg_{57}Cu_{31.5}Y_8Nd_{3.5}$ [24]	426	501	778	12	0.54756	75	0.41611	0.74036	0.21307	1.4233	0.42713	0.64396	1.7236	2.7816	7.0098
	$Mg_{57}Cu_{31}Y_{6.6}Nd_{5.4}$ [24]	427	491	778	14	0.54884	64	0.40747	0.71337	0.18234	1.3989	0.41839	0.63111	1.6987	2.5453	6.2135
	$Mg_{65.5}Cu_{25.4}Gd_9$ [24]	411	457	741	6	0.55466	46	0.3967	0.67881	0.13939	1.3848	0.40553	0.61673	1.6666	2.3287	5.3821
	$Mg_{63.5}Cu_{27.5}Gd_9$ [24]	425	469	773	4	0.54981	44	0.39149	0.66365	0.12644	1.3477	0.39752	0.60673	1.6533	2.1568	5.0847
	$Mg_{61.5}Cu_{29.5}Gd_9$ [24]	433	472	785	4	0.55159	39	0.38752	0.65096	0.1108	1.3409	0.39095	0.60127	1.6417	2.0861	4.8456
	$Mg_{65}Cu_{25}Gd_{10}$ [24]	413	473	739	7	0.55886	60	0.41059	0.72124	0.18405	1.4509	0.42413	0.64005	1.7041	2.7609	6.4047
	$Mg_{63}Cu_{27}Gd_{10}$ [24]	418	481	755	4	0.55364	63	0.41006	0.72053	0.18694	1.4273	0.42238	0.63709	1.7044	2.6781	6.3971
	$Mg_{61}Cu_{29}Gd_{10}$ [24]	420	480	762	4	0.55118	60	0.40609	0.70866	0.17544	1.4035	0.4173	0.62992	1.694	2.5351	6.0849
	$Mg_{59}Cu_{31}Gd_{10}$ [24]	424	482	769	4	0.55137	58	0.40402	0.70221	0.16812	1.3971	0.41486	0.62679	1.6882	2.4811	5.9222
	$Mg_{64.5}Cu_{24.5}Gd_{11}$ [24]	413	472	739	6	0.55886	59	0.40972	0.71854	0.18098	1.4479	0.42311	0.6387	1.7017	2.7344	6.3297
	$Mg_{62.5}Cu_{26.5}Gd_{11}$ [24]	427	483	748	9	0.57086	56	0.41106	0.72059	0.17445	1.5047	0.42694	0.64572	1.702	2.9369	6.3593
	$Mg_{60.5}Cu_{28.5}Gd_{11}$ [24]	425	485	755	8	0.56291	60	0.41102	0.72185	0.18182	1.4697	0.42546	0.64238	1.7041	2.8275	6.4123
	$Mg_{58.5}Cu_{30.5}Gd_{11}$ [24]	427	490	753	8	0.56707	63	0.41525	0.7344	0.19325	1.5031	0.43131	0.65073	1.7146	3.0249	6.7705
	$Mg_{61}Cu_{28}Gd_{11}$ [24]	422	483	737	12	0.57259	61	0.41674	0.73813	0.19365	1.5333	0.43424	0.65536	1.7171	3.1593	6.8732
La-	$La_{66}Al_{14}Cu_{20}$ [24]	395	449	731	2	0.54036	54	0.39876	0.6881	0.16071	1.3363	0.40654	0.61423	1.6771	2.2302	5.6137
	$La_{55}Al_{25}Ni_{20}$ [24]	491	555	941	3	0.52179	64	0.38757	0.65781	0.14222	1.2333	0.3899	0.5898	1.6521	1.8289	5.0269
	$La_{70}Al_{14}(Cu,Ni)_{16}$ [24]	404	429	763	0.5	0.52949	25	0.36761	0.59502	0.06964	1.195	0.35567	0.56225	1.5914	1.5536	4.0104
	$La_{68}Al_{14}(Cu,Ni)_{18}$ [24]	405	431	724	1	0.55939	26	0.38175	0.63122	0.0815	1.3511	0.37774	0.5953	1.6236	2.0333	4.4999
	$La_{66}Al_{14}(Cu,Ni)_{20}$ [24]	405	431	674	1.5	0.60089	26	0.39944	0.67804	0.09665	1.6022	0.40576	0.63947	1.6651	2.9561	5.2916
	$La_{62}Al_{14}(Cu,Ni)_{24}$ [24]	417	446	738	10	0.56504	29	0.38615	0.64363	0.09034	1.3894	0.38594	0.60434	1.6346	2.1812	4.697
	$La_{55}Al_{25}Ni_{10}Cu_{10}$ [24]	467.4	547.2	835	5	0.55976	79.8	0.42015	0.7509	0.21708	1.4886	0.43473	0.65533	1.7305	3.0878	7.3306
	$La_{55}Al_{25}Cu_{20}$ [24]	455.9	494.8	896.1	3	0.50876	38.9	0.36598	0.59558	0.08837	1.124	0.35781	0.55217	1.5941	1.4008	4.049
	$La_{55}Al_{25}Ni_5Cu_{10}Co_5$ [24]	465.2	541.8	822.5	9	0.56559	76.6	0.42075	0.75185	0.21439	1.5164	0.43699	0.65872	1.7303	3.1989	7.348
	$La_{62}Cu_{12}Ni_{12}Al_{14}$ [24]	423	452	744	12	0.56855	29	0.38732	0.64651	0.09034	1.4081	0.38755	0.60753	1.6371	2.2424	4.7415
	$La_{62}Al_{14}Cu_{24}$ [24]	401	449	734	5	0.54632	48	0.39559	0.67711	0.14414	1.3483	0.40329	0.61172	1.666	2.2167	5.3623
	$La_{62}Al_{14}Cu_{22}Ag_2$ [24]	401	455	722	5	0.5554	54	0.40516	0.70499	0.16822	1.4174	0.41696	0.63019	1.6901	2.5594	5.9823
	$La_{62}Al_{14}Cu_{20}Ag_4$ [24]	404	456	729	8	0.55418	52	0.40247	0.69684	0.16	1.4031	0.41336	0.62551	1.6829	2.4718	5.7866
	$La_{62}Al_{14}Cu_{19}Ag_5$ [24]	405	456	730	5	0.55479	51	0.40176	0.69452	0.15692	1.4031	0.41252	0.62466	1.6807	2.4599	5.7306
	$La_{62}Al_{14}Cu_{18}Ag_6$ [24]	406	457	736	5	0.55163	51	0.40018	0.69022	0.15455	1.3848	0.41003	0.62092	1.6772	2.3836	5.638
	$La_{62}Al_{14}Cu_{17}Ag_7$ [24]	406	458	739	5	0.54939	52	0.4	0.69012	0.15616	1.3754	0.4095	0.61976	1.6775	2.3549	5.6404
	$La_{62}Al_{14}Cu_{16}Ag_8$ [24]	407	458	744	5	0.54704	51	0.39791	0.68414	0.15134	1.3591	0.40647	0.61559	1.6724	2.2789	5.5116
	$La_{62}Al_{14}(Cu_{5/6}Ag_{1/6})_{20}(Ni_{1/2}Co_{1/2})_4$ [24]	412	472	713	16	0.57784	60	0.41956	0.74614	0.19934	1.5681	0.43869	0.66199	1.7235	3.3482	7.1206
	$La_{62}Al_{14}(Cu_{5/6}Ag_{1/6})_{16}(Ni_{1/2}Co_{1/2})_8$ [24]	415	477	708	16	0.58616	62	0.42476	0.7613	0.2116	1.628	0.44663	0.67373	1.7356	3.7097	7.6377
	$La_{62}Al_{14}(Cu_{5/6}Ag_{1/6})_{14}(Ni_{1/2}Co_{1/2})_{10}$ [24]	418	491	703	20	0.59459	73	0.438	0.80228	0.25614	1.7228	0.46328	0.69844	1.7692	4.5665	9.4732
	$La_{62}Al_{14}(Cu_{5/6}Ag_{1/6})_{12}(Ni_{1/2}Co_{1/2})_{12}$ [24]	429	471	698	16	0.61461	42	0.41792	0.73496	0.15613	1.7509	0.44084	0.67479	1.7125	3.9213	6.6883
	$La_{32}Ce_{32}Al_{16}Ni_5Cu_{15}$ [24]	403	451	712	10	0.56601	48	0.40448	0.70084	0.15534	1.4595	0.41753	0.63343	1.6851	2.6681	5.8582
	$La_{32}Ce_{32}Al_{16}Ni_5Cu_{12}Co_3$ [24]	406	455	709	10	0.57264	49	0.40807	0.71086	0.16172	1.5017	0.42321	0.64175	1.6933	2.8633	6.0955
	$La_{32}Ce_{32}Al_{16}Ni_5Cu_{10}Co_5$ [24]	413	467	718	12	0.57521	54	0.41291	0.72563	0.17705	1.5311	0.43001	0.65042	1.706	3.0614	6.4918
	$La_{32}Ce_{32}Al_{16}Ni_5Cu_7Co_8$ [24]	416	471	739	10	0.56292	55	0.40779	0.71177	0.17028	1.4582	0.42149	0.63735	1.6951	2.728	6.1395
	$La_{32}Ce_{32}Al_{16}Ni_5Cu_5Co_{10}$ [24]	424	472	767	10	0.5528	48	0.39631	0.67797	0.13994	1.3761	0.40483	0.61538	1.666	2.2997	5.3677
	$La_{62}Al_{14}(Cu_{0.5}Ni_{0.5})_{24}$ [24]	423	452	744	12	0.56855	29	0.38732	0.64651	0.09034	1.4081	0.38755	0.60753	1.6371	2.2424	4.7415
	$La_{55}Al_{25}Cu_{20}$ [30]	443	498	879	2	0.504	55	0.3767	0.6291	0.1262	1.1422	0.374	0.5666	1.6281	1.5198	4.5587
	$La_{55}Al_{20}Ag_5Cu_{20}$ [30]	429	503	823	4	0.5213	74	0.4018	0.7011	0.1878	1.2766	0.4054	0.6112	1.6938	2.1073	5.9673
	$La_{55}Al_{17.5}Ag_{7.5}Cu_{20}$ [30]	425	498	852	3	0.4988	73	0.39	0.6702	0.171	1.1663	0.3877	0.5845	1.6706	1.6889	5.3251

Table 2 (*Continued*)

Based metal	Alloy composition (at.%) [ref.]	T_g (K)	T_x (K)	T_l (K)	D_{max} (mm)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_l	$1/\omega$
	$La_{55}Al_{15}Ag_{10}Cu_{20}$ [30]	416	483	787	2	0.5286	67	0.4015	0.6989	0.1806	1.3019	0.4071	0.6137	1.6896	2.1742	5.8935
	$La_{55}Al_{25}Ag_{5}Cu_{15}$ [30]	452	503	860	3	0.5256	51	0.3834	0.6442	0.125	1.2328	0.3847	0.5849	1.6384	1.7839	4.7714
	$La_{60}Al_{15}Ag_{5}Cu_{20}$ [30]	401	481	759	5	0.5283	80	0.4147	0.7391	0.2235	1.3436	0.4196	0.6337	1.7278	2.4957	7.0274
	$La_{62.5}Al_{12.5}Ag_{5}Cu_{20}$ [30]	389	472	721	6	0.5395	83	0.4252	0.7698	0.25	1.4217	0.4326	0.6547	1.7529	2.9614	8.1135
	$La_{65}Al_{10}Ag_{5}Cu_{20}$ [30]	380	458	716	5	0.5307	78	0.4179	0.7486	0.2321	1.3631	0.4232	0.6397	1.736	2.6146	7.3387
	$La_{62.5}Al_{12.5}Ag_{5}Cu_{17.5}Fe_{2.5}$ [30]	391	464	711	7	0.5499	73	0.4211	0.7553	0.2281	1.45	0.4326	0.6526	1.7366	2.9737	7.5158
	$La_{62.5}Al_{12.5}Ag_{5}Cu_{15}Fe_{5}$ [30]	390	445	713	6	0.547	55	0.4035	0.7013	0.1703	1.3777	0.4134	0.6241	1.688	2.4163	5.9087
	$La_{62.5}Al_{12.5}Ag_{5}Cu_{17.5}Co_{2.5}$ [30]	393	473	712	8	0.552	80	0.4281	0.7767	0.2508	1.4828	0.4396	0.6643	1.7555	3.2543	8.3644
	$La_{62.5}Al_{12.5}Ag_{5}Cu_{15}Co_{5}$ [30]	397	474	700	9	0.5671	77	0.4321	0.7871	0.2541	1.5644	0.4486	0.6771	1.7611	3.6843	8.7904
	$La_{70.0}Al_{12.4}(Cu,Ni)_{17.6}$ [31]	397	418	759	0.5	0.5231	21	0.3616	0.5784	0.058	1.1547	0.3436	0.5507	1.576	1.4271	3.8036
	$La_{68.0}Al_{13.2}(Cu,Ni)_{18.8}$ [31]	400	426	743	1	0.5384	26	0.3727	0.6083	0.0758	1.242	0.3642	0.5734	1.6034	1.6957	4.1831
	$La_{66.0}Al_{14.0}(Cu,Ni)_{20.0}$ [31]	404	435	703	1.5	0.5747	31	0.393	0.6629	0.1037	1.4548	0.3981	0.6188	1.6514	2.4468	5.0293
	$La_{64.6}Al_{14.6}(Cu,Ni)_{20.8}$ [31]	406	442	706	5	0.5751	36	0.3975	0.6771	0.12	1.4733	0.4067	0.6261	1.6637	2.5748	5.3097
	$La_{63.1}Al_{15.2}(Cu,Ni)_{21.7}$ [31]	408	448	709	10	0.5755	40	0.4011	0.6883	0.1329	1.4884	0.4128	0.6319	1.6735	2.6832	5.5498
	$La_{62.0}Al_{15.6}(Cu,Ni)_{22.4}$ [31]	410	453	712	11	0.5758	43	0.4037	0.6966	0.1424	1.5	0.4171	0.6362	1.6807	2.7687	5.7392
	$La_{61.4}Al_{15.9}(Cu,Ni)_{22.7}$ [31]	413	459	729	10.5	0.5665	46	0.4019	0.6927	0.1456	1.4525	0.4139	0.6296	1.6779	2.6004	5.6661
	$La_{60.5}Al_{16.3}(Cu,Ni)_{23.2}$ [31]	414	465	734	8	0.564	51	0.4051	0.703	0.1594	1.4531	0.4181	0.6335	1.6872	2.6604	5.9148
	$La_{59.6}Al_{16.6}(Cu,Ni)_{23.8}$ [31]	416	475	750	8	0.5547	59	0.4074	0.712	0.1767	1.4222	0.4195	0.6333	1.6965	2.6129	6.1638
	$La_{58.6}Al_{17.0}(Cu,Ni)_{24.4}$ [31]	421	489	774	5	0.5439	68	0.4092	0.7196	0.1926	1.3853	0.4191	0.6318	1.7054	2.5346	6.3964
	$La_{57.6}Al_{17.5}(Cu,Ni)_{24.9}$ [31]	425	499	790	8	0.538	74	0.4107	0.7253	0.2027	1.3671	0.419	0.6317	1.7121	2.5044	6.574
	$La_{56.5}Al_{17.9}(Cu,Ni)_{25.6}$ [31]	433	492	823	2	0.5261	59	0.3917	0.6695	0.1513	1.2615	0.3956	0.5978	1.6624	1.9445	5.2468
	$La_{55.4}Al_{18.4}(Cu,Ni)_{26.2}$ [31]	426	491	881	2	0.4835	65	0.3757	0.6311	0.1429	1.0791	0.3696	0.5573	1.6361	1.3752	4.6352
Pd-	$Pd_{79.5}Cu_{4}Si_{16.5}$ [24]	635	675	1086	0.75	0.58471	40	0.39221	0.65838	0.08869	1.4967	0.39377	0.62155	1.6477	2.5374	4.931
	$Pd_{77.5}Cu_{6}Si_{16.5}$ [24]	637	678	1058	1.5	0.60208	41	0.4	0.67958	0.09739	1.6105	0.40671	0.64083	1.6664	2.9909	5.3218
	$Pd_{81.5}Cu_{2}Si_{16.5}$ [24]	633	670	1097	2	0.57703	37	0.38728	0.64448	0.07974	1.444	0.38446	0.61076	1.6355	2.3261	4.6952
	$Pd_{77}Cu_{6}Si_{17}$ [24]	642	686	1128	2	0.56915	44	0.38757	0.64716	0.09053	1.4115	0.38794	0.60816	1.6377	2.2543	4.752
	$Pd_{73.5}Cu_{10}Si_{16.5}$ [24]	645	685	1136	2	0.56778	40	0.38462	0.6382	0.08147	1.3951	0.38151	0.60299	1.6298	2.1722	4.6021
	$Pd_{71.5}Cu_{12}Si_{16.5}$ [24]	652	680	1154	2	0.56499	28	0.37652	0.61352	0.05578	1.3546	0.3602	0.58925	1.6079	1.9733	4.2232
	$Pd_{40}Ni_{40}P_{20}$ [24]	590	671	991	25	0.59536	81	0.42441	0.75883	0.202	1.6733	0.44819	0.67709	1.7326	3.8661	7.5232
	$Pd_{40}Cu_{30}Ni_{10}P_{20}$ [24]	576.9	655.8	836	72	0.69007	78.9	0.46415	0.87883	0.30452	2.5311	0.51921	0.78445	1.8268	11.651	15.855
	$Pd_{77}Cu_{6}Si_{17}$ [24]	642.4	686.4	1128	2	0.5695	44	0.38771	0.64752	0.09061	1.4135	0.38814	0.60851	1.638	2.2611	4.7577
	$Pd_{79}Cu_{6}Si_{10}P_{5}$ [24]	609	682	995	5	0.61206	73	0.42519	0.75879	0.18912	1.7668	0.45191	0.68543	1.7319	4.2395	7.4845
	$Pd_{79}Cu_{5}Ag_{1}Si_{10}P_{5}$ [24]	614	684	1001	4	0.61339	70	0.42353	0.75325	0.18088	1.7674	0.44965	0.68332	1.7274	4.1793	7.2839
	$Pd_{79}Cu_{4}Ag_{2}Si_{10}P_{5}$ [24]	613	684	1005	5	0.60995	71	0.42274	0.75124	0.18112	1.7449	0.44814	0.6806	1.7258	4.0692	7.2216
	$Pd_{79}Cu_{3}Ag_{3}Si_{10}P_{5}$ [24]	610	683	1005	5	0.60697	73	0.42291	0.75224	0.18481	1.7291	0.44804	0.6796	1.7266	4.0183	7.2621
	$Pd_{79}Cu_{2}Ag_{4}Si_{10}P_{5}$ [24]	611	676	1006	7	0.60736	65	0.41806	0.73658	0.16456	1.7114	0.44085	0.67197	1.7137	3.7928	6.751
Ti-	$Ti_{50}Ni_{30}Cu_{32}Sn_{3}$ [24]	686	759	1283	1	0.53468	73	0.38547	0.64848	0.12228	1.2714	0.38811	0.59158	1.6411	1.8963	4.8304
	$Ti_{50}Ni_{15}Cu_{25}Sn_{3}Be_{7}$ [24]	688	733	1207	2	0.57001	45	0.38681	0.64457	0.08671	1.4123	0.38594	0.60729	1.6354	2.2446	4.7062
	$Ti_{45}Ni_{15}Cu_{25}Sn_{3}Be_{7}Zr_{5}$ [24]	680	741	1142	5	0.59545	61	0.4067	0.70228	0.13203	1.6039	0.42179	0.64886	1.6852	3.1336	5.8395
	$Ti_{40}Zr_{25}Ni_{8}Cu_{9}Be_{18}$ [24]	621	668	1009	8	0.61546	47	0.40982	0.70862	0.12113	1.7216	0.4255	0.66204	1.6911	3.5675	5.9638
	$Ti_{50}Cu_{42.5}Ni_{7.5}$ [24]	670	708	1226	0.2	0.54649	38	0.37342	0.60848	0.06835	1.2734	0.36255	0.57749	1.6032	1.7679	4.174
	$Ti_{47.5}Zr_{2.5}Cu_{42.5}Ni_{7.5}$ [24]	673	720	1225	1.5	0.54939	47	0.37935	0.62612	0.08514	1.3043	0.37548	0.58776	1.6192	1.9	4.4335
	$Ti_{42.5}Zr_{2.5}Hf_{5}Cu_{42.5}Ni_{7.5}$ [24]	677	726	1203	2.5	0.56276	49	0.38617	0.64422	0.09316	1.3802	0.38659	0.60349	1.6351	2.1602	4.7104
	$Ti_{41.5}Zr_{2.5}Hf_{5}Cu_{42.5}Ni_{7.5}Si_{1}$ [24]	680	730	1199	5	0.56714	50	0.3885	0.65054	0.09634	1.4066	0.39048	0.60884	1.6407	2.2568	4.8142
	$Ti_{55}Zr_{10}Cu_{9}Ni_{8}Be_{18}$ [24]	629	667	1013	6	0.62093	38	0.40621	0.69595	0.09896	1.737	0.41566	0.65844	1.6813	3.5045	5.6532
	$Ti_{50}Zr_{15}Cu_{9}Ni_{8}Be_{18}$ [24]	622	662	1009	6	0.61645	40	0.40589	0.69574	0.10336	1.7106	0.41637	0.6561	1.6808	3.4197	5.6544
	$Ti_{50}Ni_{24}Cu_{20}B_{1}Si_{2}Sn_{3}$ [24]	726	800	1310	1	0.5542	74	0.39293	0.66718	0.12671	1.3699	0.39981	0.61069	1.6561	2.233	5.1457
	$Ti_{34}Zr_{11}Cu_{47}Ni_{8}$ [24]	698.4	727.2	1169	4.5	0.59743	28.8	0.38942	0.64671	0.0612	1.5453	0.37868	0.62207	1.6387	2.602	4.708
	$Ti_{41.5}Zr_{2.5}Hf_{5}Cu_{42.5}Ni_{7.5}Si_{1}$ [24]	684.6	719.9	1206	2	0.56766	35.3	0.38078	0.6262	0.0677	1.3807	0.3715	0.59693	1.6192	2.0857	4.4101
	$Ti_{41.5}Zr_{2.5}Hf_{5}Cu_{37.5}Ni_{7.5}Si_{1}Sn_{5}$ [24]	693.3	757.5	1176	6	0.58954	64.2	0.40523	0.69872	0.133	1.5693	0.41951	0.64413	1.6821	2.9986	5.7646
	$Ti_{40}Zr_{10}Cu_{40}Pd_{10}$ [24]	660	709	1184	4	0.55743	49	0.38449	0.6402	0.09351	1.3531	0.38432	0.59882	1.6317	2.074	4.65

	$Ti_{40}Zr_{10}Cu_{34}Pd_{16}$ [24]	672	723	1231	4	0.5459	51	0.37993	0.62876	0.09123	1.2934	0.37755	0.58733	1.6218	1.8827	4.4801
	$Ti_{40}Zr_{10}Cu_{32}Pd_{18}$ [24]	683	740	1272	3	0.53695	57	0.37852	0.62657	0.09677	1.2564	0.37645	0.58176	1.6204	1.7858	4.4593
	$Ti_{40}Zr_{10}Cu_{30}Pd_{20}$ [24]	687	747	1279	3	0.53714	60	0.37996	0.63096	0.10135	1.2618	0.37903	0.58405	1.6245	1.8132	4.529
	$Ti_{53}Cu_{15}Ni_{18.5}Al_7Si_3Sc_3B_{0.5}$ [24]	709	767	1240	2	0.57177	58	0.39354	0.66532	0.10923	1.4444	0.39972	0.61855	1.6536	2.4306	5.0806
	$Ti_{53}Cu_{15}Ni_{18.5}Al_7Si_3Hf_3B_{0.5}$ [24]	695	749	1230	2	0.56504	54	0.38909	0.65285	0.10093	1.4	0.39211	0.60894	1.6427	2.25	4.8585
	$Ti_{40}Zr_{10}Cu_{38}Pd_{12}$ [32]	666	715	1189	6	0.5601	49	0.3854	0.6426	0.0937	1.3671	0.3857	0.6014	1.6337	2.1195	4.6858
	$Ti_{40}Zr_{10}Cu_{36}Pd_{14}$ [32]	669	718	1191	6	0.5617	49	0.386	0.644	0.0939	1.3755	0.3865	0.6029	1.635	2.147	4.7081
Pr-	$Pr_{68}Cu_{25}Al_7$ [24]	382	402	705	1.5	0.54184	20	0.36983	0.59858	0.06192	1.2446	0.35537	0.57021	1.5942	1.6726	4.0421
	$Pr_{68}(Cu,Ni)_{25}Al_7$ [24]	399	416	703	1.5	0.56757	17	0.3775	0.61593	0.05592	1.3684	0.36144	0.59175	1.6102	2.0151	4.2554
	$Pr_{72}(Cu,Ni)_{25}Al_3$ [24]	367	402	743	1.5	0.49394	35	0.36216	0.58816	0.09309	1.0691	0.35297	0.54105	1.5893	1.2688	3.9734
	$Pr_{72}(Cu,Ni)_{21}Al_7$ [24]	395	410	760	1.5	0.51974	15	0.35498	0.55921	0.0411	1.1233	0.32558	0.53947	1.5577	1.322	3.5787
Y-	$Y_{56}Al_{24}Co_{20}$ [24]	636	690	1078	1.5	0.58998	54	0.40257	0.69017	0.12217	1.5611	0.41464	0.64007	1.6749	2.915	5.5675
	$Y_{36}Sc_{20}Al_{24}Co_{20}$ [24]	645	760	1034	25	0.62379	115	0.45265	0.84623	0.29563	1.9537	0.48747	0.73501	1.8021	6.5294	12.442
	$Y_{36}Sc_{20}Al_{24}Co_{10}Ni_{10}$ [24]	645	731	1010	25	0.63861	86	0.44169	0.80891	0.23562	2.0027	0.47875	0.72376	1.7719	6.0572	9.7185
Co-	$Co_{50}Cr_{15}Mo_{14}C_{15}B_6$ [24]	819	895	1417	2	0.57798	76	0.40027	0.68525	0.12709	1.4967	0.41141	0.63162	1.6708	2.6901	5.4787
	$Co_{48}Cr_{15}Mo_{14}C_{15}B_6Er_2$ [24]	848	933	1394	10	0.60832	85	0.41615	0.73027	0.15568	1.7088	0.4378	0.6693	1.7086	3.7229	6.5604
	$Co_{43}Fe_{20}Ta_{5.5}B_{31.5}$ [24]	910	982	1526	2	0.59633	72	0.40312	0.69069	0.11688	1.5942	0.4149	0.64351	1.6755	3.0196	5.5694
	$[(Co_{0.9}Fe_{0.1})_{0.7}5B_{0.2}Si_{0.0}5]_{96}Nb_4$ [33]	803	843	1457	2	0.551	40	0.37301	0.60604	0.06116	1.2890	0.35890	0.57859	1.6009	1.7956	4.1334
	$[(Co_{0.8}Fe_{0.2})_{0.7}5B_{0.2}Si_{0.0}5]_{96}Nb_4$ [33]	813	853	1445	2.5	0.563	40	0.37777	0.61799	0.06329	1.3497	0.36574	0.59031	1.6118	1.9788	4.2918
	$[(Co_{0.7}Fe_{0.3})_{0.7}5B_{0.2}Si_{0.0}5]_{96}Nb_4$ [33]	820	860	1430	3.5	0.573	40	0.38222	0.62937	0.06557	1.4098	0.37230	0.60140	1.6222	2.1705	4.4524
	$[(Co_{0.6}Fe_{0.4})_{0.7}5B_{0.2}Si_{0.0}5]_{96}Nb_4$ [33]	823	865	1418	4	0.58	42	0.38599	0.63963	0.07059	1.4538	0.37927	0.61001	1.6314	2.3279	4.6093
Au-	$Au_{55}Cu_{25}Si_{20}$ [34]	348	383	654	0.5	0.5321	35	0.3822	0.6391	0.1144	1.2516	0.3831	0.5856	1.6327	1.8148	4.6728
	$Au_{46}Ag_5Cu_{29}Si_{20}$ [34]	395	420	664	1	0.5949	25	0.3966	0.6702	0.0929	1.5613	0.4009	0.6325	1.6582	2.7865	5.1417
	$Au_{52}Pd_{2.3}Cu_{29.2}Si_{16.5}$ [34]	393	427	651	2	0.6037	34	0.409	0.7081	0.1318	1.655	0.4254	0.6559	1.6902	3.3444	5.9701
	$Au_{49}Ag_{5.5}Pd_{2.3}Cu_{26.9}Si_{16.3}$ [34]	401	459	644	5	0.6227	58	0.4392	0.8028	0.2387	1.8889	0.4723	0.7127	1.7673	5.3779	9.4185
Hf-	$Hf_{47}Cu_{29.25}Ni_{9.75}Al_{14}$ [35]	790	875	1278	10	0.6182	85	0.4231	0.7512	0.1742	1.793	0.4494	0.6847	1.7257	4.2562	7.2029
	$Hf_{48}Cu_{29.25}Ni_{9.75}Al_{13}$ [35]	785	874	1280	10	0.6133	89	0.4232	0.7523	0.1798	1.7657	0.4492	0.6828	1.7267	4.1623	7.2527
	$Hf_{51}Cu_{27.75}Ni_{9.25}Al_{12}$ [35]	777	872	1344	8	0.5781	95	0.4111	0.7195	0.1676	1.5379	0.4281	0.6488	1.7004	3.0413	6.3139
Gd-	$Gd_{60}Co_{25}Al_{15}$ [36]	572	617	952	5	0.6008	45	0.4049	0.6954	0.1184	1.6237	0.4177	0.6481	1.6795	3.1448	5.6686
	$Gd_{60}Ni_{15}Al_{25}$ [36]	603	648	1006	4	0.5994	45	0.4027	0.6889	0.1117	1.6079	0.4136	0.6441	1.674	3.0488	5.5242
Zr-	$Zr_{65}Al_{7.5}Cu_{17.5}Ni_{10}$ [24]	656.5	735.6	1167	16	0.56255	79.1	0.4034	0.69811	0.15495	1.4409	0.41566	0.63033	1.683	2.5949	5.7996
	$Zr_{57}Ti_5Al_{10}Cu_{20}Ni_8$ [24]	676.7	720	1145	10	0.591	43.3	0.39524	0.66664	0.09246	1.5375	0.3989	0.62882	1.655	2.6974	5.078
	$Zr_{65.5}Al_{5.6}Ni_{6.5}Cu_{22.4}$ [24]	630	733	1211	3	0.52023	103	0.39815	0.69034	0.17728	1.2616	0.40154	0.60528	1.6837	2.0211	5.712
	$Zr_{41.2}Ti_{13.8}Cu_{12.5}Ni_{10}Be_{22.5}$ [24]	623	672	996	50	0.6255	49	0.41507	0.7239	0.13137	1.8016	0.43483	0.6747	1.7042	3.9881	6.3503
	$Zr_{54}Cu_{46}$ [24]	696	746	1201	2	0.57952	50	0.39325	0.66278	0.09901	1.4772	0.39767	0.62115	1.6514	2.508	5.0204
	$Zr_{47}Cu_{46}Al_7$ [24]	705	781	1163	3	0.60619	76	0.41809	0.73689	0.16594	1.7052	0.44083	0.67154	1.714	3.7732	6.7627
	$Zr_{41}Ti_{14}Cu_{12.5}Ni_8Be_{22.5}C_2$ [24]	628	683	997	5	0.62989	55	0.42031	0.74022	0.14905	1.8509	0.44466	0.68506	1.7175	4.3503	6.8236
	$Zr_{41}Ti_{14}Cu_{12.5}Ni_2Be_{22.5}C_8$ [24]	629	727	992	3	0.63407	98	0.44849	0.83165	0.26997	2.0028	0.48605	0.73286	1.7899	6.5117	11.219
	$Zr_{26}Ti_{10}Cu_8Ni_8Be_{20}Y_4Mg_{24}$ [24]	650	700	951	5	0.68349	50	0.43723	0.78864	0.16611	2.3256	0.47363	0.73607	1.7604	7.2221	8.5779
	$Zr_{40}Ti_{15}Cu_{11}Ni_{11}Be_{21.5}Y_1Mg_{0.5}$ [24]	630	674	975	5	0.64615	44	0.41994	0.73641	0.12754	1.9536	0.44162	0.69128	1.716	4.6867	6.6813
	$Zr_{48}Nb_8Cu_{14}Ni_{12}Be_{18}$ [24]	656	724	1072	8	0.61194	68	0.41898	0.73881	0.16346	1.7404	0.44253	0.67537	1.7156	3.9218	6.8111
	$Zr_{48}Nb_8Cu_{12}Fe_8Be_{24}$ [24]	658	751	1071	8	0.61438	93	0.43436	0.78805	0.22518	1.8184	0.46443	0.70121	1.7557	4.8258	8.6933
	$Zr_{36}Nb_{12}Cu_{10}Ni_8Be_{20}Y_2Mg_{12}$ [24]	653	733	1029	5	0.6346	80	0.43579	0.79009	0.21277	1.9495	0.47001	0.71234	1.7571	5.463	8.741
	$Zr_{36}Nb_{12}Cu_{10}Ni_6Fe_2Be_{20}Y_2Mg_{12}$ [24]	670	712	1029	5	0.65112	42	0.41907	0.73275	0.11699	1.9833	0.43818	0.69193	1.7138	4.7472	6.5655
	$Zr_{54}Al_{15}Ni_{10}Cu_{19}Y_2$ [24]	714	787	1112	5	0.64209	73	0.431	0.77338	0.18342	1.9774	0.46341	0.70773	1.7443	5.3199	7.9869
	$Zr_{53}Al_{14}Ni_{10}Cu_{19}Y_4$ [24]	668	766	1069	5	0.62488	98	0.44099	0.80823	0.24439	1.9102	0.4749	0.71656	1.7716	5.5734	9.7162
	$Zr_{51}Cu_{20.7}Ni_{12}Al_{16.3}$ [24]	722	800	1132	3	0.63781	78	0.4315	0.77562	0.19024	1.9512	0.46397	0.70671	1.7458	5.2402	8.0878
	$Zr_{55}Al_{20}Co_{25}$ [24]	761	840	1245	2.5	0.61124	79	0.41874	0.73815	0.16322	1.7355	0.44212	0.6747	1.7151	3.8972	6.7922
	$Zr_{48}Cu_{45}Al_7$ [24]	698	758	1208	5	0.57781	60	0.39769	0.67715	0.11765	1.4863	0.40681	0.62748	1.6638	2.6128	5.3073
	$Zr_{48}Cu_{43}Al_7Ag_2$ [24]	700	761	1152	12	0.60764	61	0.41091	0.71354	0.13496	1.6836	0.42865	0.66059	1.6948	3.4844	6.1012
	$Zr_{48}Cu_{42}Al_7Ag_3$ [24]	700	763	1135	10	0.61674	63	0.4158	0.72775	0.14483	1.754	0.43708	0.67225	1.7067	3.8596	6.473

Table 2 (*Continued*)

Based metal	Alloy composition (at.%) [ref.]	T_g (K)	T_x (K)	T_l (K)	D_{max} (mm)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_l	$1/\omega$
	$Zr_{48}Cu_{40}Al_7Ag_5$ [24]	699	769	1121	10	0.62355	70	0.42253	0.74844	0.16588	1.8223	0.4487	0.68599	1.7237	4.3383	7.1002
	$Zr_{48}Cu_{37}Al_7Ag_8$ [24]	698	765	1125	10	0.62044	67	0.41964	0.73956	0.15691	1.7916	0.44377	0.68	1.7164	4.1201	6.8191
	$Zr_{48}Cu_{36}Ag_8Al_8$ [37]	690	791	1143	25	0.604	101	0.43153	0.78040	0.22300	1.7461	0.45863	0.69204	1.7501	4.4049	8.3717
	$Zr_{48}Cu_{34}Pd_2Ag_8Al_8$ [37]	699	794	1140	30	0.613	95	0.43176	0.77982	0.21540	1.8005	0.46092	0.69649	1.7491	4.6360	8.3225
	$Zr_{50}Cu_{48}Ag_2$ [28]	668	719	1192	2	0.5604	51	0.3866	0.646	0.0973	1.3721	0.3879	0.6032	1.6367	2.1468	4.7441
	$Zr_{50}Cu_{45}Ag_5$ [28]	669	728	1188	4	0.5631	59	0.392	0.6625	0.1137	1.4027	0.3979	0.6128	1.6513	2.3017	5.0393
	$Zr_{50}Cu_{43}Ag_7$ [28]	669	727	1171	4	0.5713	58	0.3951	0.6704	0.1155	1.4482	0.4027	0.6208	1.658	2.4671	5.1801
	$Zr_{50}Cu_{40}Ag_{10}$ [28]	667	733	1177	5	0.5667	66	0.3975	0.6788	0.1294	1.4373	0.4071	0.6228	1.6656	2.4801	5.361
	$Zr_{50}Cu_{38}Ag_{12}$ [28]	663	734	1187	4	0.5586	71	0.3968	0.6782	0.1355	1.4008	0.4058	0.6184	1.6656	2.3714	5.3616
Fe-	$(Fe_{0.75}B_{0.2}Si_{0.05})_{96}Nb_4$ [24]	835	880	1475	1.5	0.5661	45	0.38095	0.62712	0.07031	1.375	0.37282	0.59661	1.62	2.0756	4.4263
	$[(Fe_{0.9}Co_{0.1})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [24]	832	877	1460	2	0.56986	45	0.38264	0.63151	0.07166	1.3965	0.37549	0.60068	1.6239	2.1468	4.4906
	$[(Fe_{0.8}Co_{0.2})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [24]	830	880	1431	2.5	0.58001	50	0.38921	0.6499	0.08319	1.4642	0.38812	0.61495	1.6403	2.4058	4.7848
	$[(Fe_{0.7}Co_{0.3})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [24]	828	878	1413	3.5	0.58599	50	0.39179	0.65676	0.08547	1.5009	0.39225	0.62137	1.6464	2.5399	4.8996
	$[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [24]	825	875	1407	4	0.58635	50	0.39203	0.65743	0.08591	1.5034	0.3927	0.62189	1.647	2.5506	4.9114
	$[(Fe_{0.5}Co_{0.5})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [24]	820	870	1397	5	0.58697	50	0.39242	0.65855	0.08666	1.5078	0.39345	0.62276	1.6479	2.5687	4.9312
	$Fe_{48}Cr_{15}Mo_{14}C_{15}B_6Y_2$ [24]	839	886	1464	7	0.57309	47	0.38472	0.6373	0.0752	1.4176	0.37952	0.60519	1.6291	2.2251	4.5801
	$Fe_{45}Co_3Cr_{15}Mo_{14}C_{15}B_6Y_2$ [24]	834	880	1446	8	0.57676	46	0.38596	0.64039	0.07516	1.4379	0.38111	0.60858	1.6319	2.291	4.6265
	$Fe_{43}Co_5Cr_{15}Mo_{14}C_{15}B_6Y_2$ [24]	835	872	1442	9	0.57906	37	0.38296	0.63037	0.06096	1.4366	0.37083	0.60472	1.6234	2.2411	4.4613
	$Fe_{39}Co_9Cr_{15}Mo_{14}C_{15}B_6Y_2$ [24]	838	888	1466	10	0.57162	50	0.38542	0.63984	0.07962	1.414	0.38198	0.60573	1.6313	2.2274	4.624
	$Fe_{41}Co_7Cr_{15}Mo_{14}C_{15}B_6Y_2$ [24]	838	875	1436	16	0.58357	37	0.38478	0.6351	0.06187	1.4632	0.37352	0.60933	1.6277	2.3298	4.5313
	$Fe_{61}B_{15}Mo_7Zr_8Co_7Y_2$ [24]	904.6	916.4	1490	5	0.60711	11.8	0.38269	0.62295	0.02016	1.5654	0.32642	0.61503	1.6202	2.5196	4.318
	$Fe_{61}B_{15}Mo_7Zr_8Co_6Y_2Al_1$ [24]	899.5	955.6	1495	5	0.60167	56.1	0.39908	0.67672	0.09421	1.6047	0.40461	0.6392	1.664	2.9543	5.2635
	$Fe_{61}B_{15}Mo_7Zr_8Co_5Y_2Cr_2$ [24]	901.1	958.9	1490	5	0.60477	57.8	0.40103	0.68235	0.09815	1.6283	0.40833	0.64356	1.6689	3.0633	5.376
	$Fe_{56}Mn_5Cr_7Mo_{12}Er_2C_{12}B_6$ [24]	793	832	1401	8	0.56602	39	0.37922	0.6217	0.06414	1.3684	0.36793	0.59386	1.6152	2.0378	4.3432
	$Fe_{63}C_{15}Mo_{14}Er_2B_6$ [24]	771	830	1389	3	0.55508	59	0.38426	0.64003	0.09547	1.343	0.38436	0.59755	1.6316	2.0479	4.6506
	$Fe_{58}Cr_5Mo_{14}Er_2C_{15}B_6$ [24]	793	829	1416	6	0.56003	36	0.37528	0.61088	0.05778	1.3307	0.35989	0.58545	1.6054	1.9079	4.1911
	$Fe_{48}Cr_{15}Mo_{14}Er_2C_{15}B_6$ [24]	844	880	1446	8	0.58368	36	0.38428	0.63347	0.0598	1.4618	0.37176	0.60858	1.6263	2.3184	4.5051
	$Fe_{68.3}C_{6.9}Si_{2.5}B_{6.7}P_{8.8}Cr_{2.2}Mo_{2.5}Al_{2.1}$ [24]	795	835	1316	4	0.6041	40	0.39555	0.66489	0.07678	1.6027	0.39396	0.6345	1.6544	2.8692	5.0277
	$Fe_{72}Nb_4B_{20}Si_4$ [24]	842	880	1420	2	0.59296	38	0.38904	0.64648	0.06574	1.5225	0.38073	0.61972	1.6381	2.541	4.7093
	$(Fe_{72}Nb_4B_{20}Si_4)_{99}Y_1$ [24]	855	881	1419	2	0.60254	26	0.38742	0.63918	0.0461	1.5621	0.36564	0.62086	1.6329	2.6024	4.5765
	$(Fe_{72}Nb_4B_{20}Si_4)_{98}Y_2$ [24]	855	903	1416	2	0.60381	48	0.39762	0.67161	0.08556	1.6096	0.39999	0.63771	1.66	2.9337	5.1581
	$(Fe_{72}Nb_4B_{20}Si_4)_{97}Y_3$ [24]	859	915	1416	4	0.60664	56	0.4022	0.68573	0.10054	1.6427	0.41054	0.64619	1.6718	3.1314	5.4456
	$(Fe_{72}Nb_4B_{20}Si_4)_{96}Y_4$ [24]	905	933	1424	3	0.63553	28	0.4006	0.67486	0.05395	1.7977	0.38662	0.6552	1.6665	3.5024	5.1859
	$Fe_{74}Nb_6Y_3B_{17}$ [24]	831	879	1391	2	0.59741	48	0.39559	0.66643	0.08571	1.5696	0.39736	0.63192	1.6552	2.7864	5.0654
	$\{[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{0.96}Nb_{0.04}\}_{100}$ [6]	826	870	1452	4	0.5689	44	0.3819	0.6295	0.0703	1.3898	0.374	0.5992	1.6221	2.1216	4.4598
	$\{[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{0.96}Nb_{0.04}\}_{99}Cr_1$ [6]	827	871	1462	4	0.5657	44	0.3805	0.6259	0.0693	1.3717	0.3719	0.5958	1.6189	2.0623	4.4073
	$\{[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{0.96}Nb_{0.04}\}_{98}Cr_2$ [6]	830	873	1469	4	0.565	43	0.3797	0.6236	0.0673	1.3662	0.37	0.5943	1.6168	2.0399	4.3727
	$\{[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{0.96}Nb_{0.04}\}_{97}Cr_3$ [6]	831	874	1474	3.5	0.5638	43	0.3792	0.6221	0.0669	1.3593	0.3691	0.5929	1.6155	2.0175	4.3524
	$\{[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{0.96}Nb_{0.04}\}_{96}Cr_4$ [6]	833	874	1481	3	0.5625	41	0.3777	0.6178	0.0633	1.3488	0.3657	0.5901	1.6117	1.976	4.2896
	$Fe_{76}Si_9B_{10}P_5$ [38]	780	832	1258	2.5	0.62	52	0.4082	0.7027	0.1088	1.7402	0.4209	0.6613	1.6866	3.5743	5.8112
	$Fe_{27}Co_{40}Zr_3Ti_3Mo_{1.5}Si_{1.5}B_{24}$ [39]	811	856	1379	1.5	0.5881	45	0.3909	0.6534	0.0792	1.507	0.3889	0.6207	1.6436	2.538	4.8358
	$(Fe_{81.5}Si_{3.8}C_{14}Tm_{0.7})_{92.37}P_{7.63}$ [39]	687	752	1284	1	0.5351	65	0.3815	0.6363	0.1089	1.2596	0.3819	0.5857	1.6297	1.8254	4.6199
	$(Fe_{81.5}Si_{3.8}C_{14}Tm_{0.7})_{90.9}P_{9.1}$ [39]	717	767	1318	1	0.544	50	0.3769	0.6199	0.0832	1.2762	0.3717	0.5819	1.6137	1.8114	4.3451
	$Fe_{65.5}Cr_4Mo_4Ga_4P_{12}C_5B_{5.5}$ [39]	745	806	1322	3	0.5635	61	0.3899	0.6558	0.1057	1.3969	0.394	0.6097	1.6454	2.2552	4.9148
	$Fe_{76}Mo_4(P_{0.45},C_{0.2},B_{0.2},Si_{0.15})_{20}$ [23]	744	788	1245	4	0.5976	44	0.3962	0.6683	0.0878	1.5729	0.3988	0.6329	1.6567	2.8072	5.1008
	$Fe_{66}Co_{10}Mo_4(P_{0.45},C_{0.2},B_{0.2},Si_{0.15})_{20}$ [40]	744	788	1221	6	0.6093	44	0.401	0.6814	0.0922	1.652	0.4067	0.6454	1.6685	3.127	5.3502
	$Fe_{56}Co_{20}Mo_4(P_{0.45},C_{0.2},B_{0.2},Si_{0.15})_{20}$ [40]	736	778	1220	5	0.6033	42	0.3978	0.6721	0.0868	1.6074	0.4006	0.6377	1.6603	2.931	5.169
	$Fe_{46}Co_{30}Mo_4(P_{0.45},C_{0.2},B_{0.2},Si_{0.15})_{20}$ [40]	734	775	1233	3	0.5953	41	0.394	0.6618	0.0822	1.5531	0.3941	0.6286	1.6512	2.7119	4.9805
	$Fe_{72}Y_6B_{22}$ [41]	898	944	1419	2	0.6328	46	0.4074	0.6977	0.0883	1.8119	0.4138	0.6653	1.6841	3.7572	5.6776
	$Fe_{71}Ni_1Y_6B_{22}$ [41]	883	926	1507	2	0.5859	43	0.3875	0.643	0.0689	1.484	0.3803	0.6145	1.6346	2.4223	4.6587
	$Fe_{70}Ni_2Y_6B_{22}$ [41]	880	925	1509	2	0.5832	45	0.3872	0.6428	0.0715	1.4706	0.3812	0.613	1.6343	2.3867	4.6589

	$Fe_{69}Ni_3Y_6B_{22}$ [41]	874	910	1503	1.5	0.5815	36	0.3828	0.6294	0.0572	1.4467	0.3685	0.6055	1.6227	2.2617	4.4433
	$Fe_{68}Ni_4Y_6B_{22}$ [41]	872	907	1470	1.5	0.5932	35	0.3873	0.6408	0.0585	1.5167	0.3746	0.617	1.6333	2.4952	4.6136
	$Fe_{67}Ni_5Y_6B_{22}$ [41]	866	891	1469	1	0.5895	25	0.3816	0.6236	0.0415	1.4776	0.3551	0.6065	1.6184	2.3096	4.3443
	$Fe_{70}Co_2Y_6B_{22}$ [41]	898	944	1420	2	0.6324	46	0.4073	0.6972	0.0881	1.8084	0.4135	0.6648	1.6836	3.7414	5.6668
	$Fe_{68}Co_4Y_6B_{22}$ [41]	896	941	1414	2	0.6337	45	0.4074	0.6973	0.0869	1.8166	0.4131	0.6655	1.6839	3.7686	5.6683
	$Fe_{66}Co_6Y_6B_{22}$ [41]	887	925	1509	2	0.5878	38	0.3861	0.6382	0.0611	1.4871	0.3746	0.613	1.6306	2.4057	4.5763
	$Fe_{64}Co_8Y_6B_{22}$ [41]	884	927	1505	2.5	0.5874	43	0.388	0.6445	0.0692	1.4928	0.3812	0.616	1.636	2.4529	4.6826
	$Fe_{62}Co_{10}Y_6B_{22}$ [41]	885	932	1503	2.5	0.5888	47	0.3903	0.6514	0.0761	1.5081	0.387	0.6201	1.6419	2.5298	4.7993
	$Fe_{60}Co_{12}Y_6B_{22}$ [41]	881	924	1498	2.5	0.5881	43	0.3884	0.6455	0.0697	1.4976	0.3819	0.6168	1.6369	2.4707	4.6989
	$Fe_{58}Co_{14}Y_6B_{22}$ [41]	880	925	1485	2.5	0.5926	45	0.3911	0.6532	0.0744	1.5289	0.3874	0.6229	1.6437	2.5957	4.8271
	$Fe_{56}Co_{16}Y_6B_{22}$ [41]	882	927	1494	2.5	0.5904	45	0.3902	0.6506	0.0735	1.5147	0.3858	0.6205	1.6414	2.5432	4.784
	$Fe_{71}Mo_1Y_6B_{22}$ [41]	902	960	1517	2.5	0.5946	58	0.3969	0.6711	0.0943	1.561	0.4016	0.6328	1.6589	2.791	5.1594
	$Fe_{70}Mo_2Y_6B_{22}$ [41]	907	969	1508	3.5	0.6015	62	0.4012	0.6837	0.1032	1.6123	0.4098	0.6426	1.6698	3.0252	5.409
	$Fe_{69}Mo_3Y_6B_{22}$ [41]	908	958	1488	6	0.6102	50	0.3998	0.6774	0.0862	1.6517	0.4031	0.6438	1.6653	3.0967	5.2665
	$Fe_{68}Mo_4Y_6B_{22}$ [41]	915	944	1488	6.5	0.6149	29	0.3928	0.6539	0.0506	1.6475	0.3754	0.6344	1.6466	2.9187	4.8139
	$Fe_{67}Mo_5Y_6B_{22}$ [41]	920	941	1483	3.5	0.6204	21	0.3916	0.6487	0.0373	1.6714	0.3613	0.6345	1.6432	2.947	4.7176
	$Fe_{76}Mo_2Ga_2P_{10}C_4B_4Si_2$ [42]	736	788	1247	2	0.59	52	0.39729	0.67337	0.10167	1.5407	0.40390	0.63168	1.6607	2.7473	5.2118
	$Fe_{74}Mo_4Ga_2P_{10}C_4B_4Si_2$ [42]	740	790	1276	1.5	0.58	50	0.39189	0.65838	0.09331	1.4743	0.39453	0.61919	1.6476	2.4765	4.9375
	$Fe_{75}Mo_2Ga_3P_{10}C_4B_4Si_2$ [42]	738	798	1230	2.5	0.6	60	0.40549	0.69756	0.12195	1.6220	0.41908	0.64878	1.6813	3.1557	5.7204
	$Fe_{73}Mo_4Ga_3P_{10}C_4B_4Si_2$ [42]	744	801	1283	2	0.58	57	0.39521	0.66887	0.10580	1.4868	0.40168	0.62444	1.6566	2.5677	5.1371
	$Fe_{79}P_{10}C_4B_4Si_3$ [43]	740	774	1263	1	0.586	34	0.38646	0.63985	0.06503	1.4805	0.37722	0.61292	1.6319	2.3972	4.6060
	$Fe_{78}Mo_1P_{10}C_4B_4Si_3$ [43]	742	780	1268	1.5	0.585	38	0.38799	0.64492	0.07219	1.4818	0.38247	0.61496	1.6362	2.4266	4.6924
	$Fe_{77}Mo_2P_{10}C_4B_4Si_3$ [43]	742	783	1264	2.5	0.587	41	0.39032	0.65187	0.07854	1.4998	0.38797	0.61944	1.6423	2.5106	4.8105
	$Fe_{76}Mo_3P_{10}C_4B_4Si_3$ [43]	750	793	1250	3.5	0.6	43	0.39650	0.66880	0.08600	1.5860	0.39866	0.63440	1.6573	2.8478	5.1079
	$Fe_{75}Mo_4P_{10}C_4B_4Si_3$ [43]	752	799	1227	4	0.613	47	0.40379	0.68963	0.09900	1.6830	0.41236	0.65131	1.6755	3.2838	5.5217
	$Fe_{74}Mo_5P_{10}C_4B_4Si_3$ [43]	758	799	1263	3	0.6	41	0.39528	0.66491	0.08113	1.5811	0.39535	0.63245	1.6541	2.8090	5.0331
	$(Fe_{0.75}B_{0.15}Si_{0.10})_{99}Zr_1$ [44]	867	919	1469	0.75	0.59	52	0.39332	0.66077	0.08631	1.5253	0.39455	0.62539	1.6500	2.6293	4.9682
	$(Fe_{0.75}B_{0.15}Si_{0.10})_{99}Nb_1$ [44]	815	858	1455	0.5	0.56	43	0.37791	0.61909	0.06715	1.3399	0.36769	0.58955	1.6128	1.9596	4.3116
	$(Fe_{0.75}B_{0.15}Si_{0.10})_{98}Nb_2$ [44]	812	870	1425	1	0.57	58	0.38899	0.65143	0.09468	1.4203	0.39082	0.61071	1.6414	2.2971	4.8258
	$(Fe_{0.75}B_{0.15}Si_{0.10})_{96}Nb_4$ [44]	835	885	1369	1.5	0.61	50	0.40157	0.68305	0.09366	1.6578	0.40783	0.64653	1.6699	3.1565	5.3839
Ni-	$Ni_{60}Nb_{30}Ta_{10}$ [24]	934	961	1559	2	0.5991	27	0.38548	0.63374	0.0432	1.5376	0.36093	0.61642	1.628	2.51	4.4922
	$Ni_{61}Zr_{28}Nb_7Al_4$ [24]	848	898	1348	1	0.62908	50	0.40893	0.70326	0.1	1.796	0.41966	0.66617	1.688	3.7605	5.8137
	$Ni_{61}Zr_{22}Nb_7Al_4Ta_6$ [24]	867	927	1379	2	0.62872	60	0.41273	0.71574	0.11719	1.8105	0.42913	0.67223	1.6979	3.9339	6.1261
	$Ni_{59}Zr_{20}Ti_{16}Si_5$ [24]	830	876	1304	2	0.6365	46	0.4105	0.70706	0.09705	1.8481	0.42087	0.67178	1.6919	3.9691	5.896
	$Ni_{59}Zr_{20}Ti_{16}Sn_5$ [24]	819	854	1288	1	0.63587	35	0.40532	0.69022	0.07463	1.8209	0.40511	0.66304	1.6786	3.7133	5.5064
	$Ni_{59}Zr_{20}Ti_{16}Si_2Sn_3$ [24]	821	877	1272	3	0.64544	56	0.41902	0.73349	0.12417	1.9446	0.43964	0.68947	1.7136	4.6148	6.5952
	$Ni_{42}Ti_{20}Zr_{25}Al_8Cu_5$ [24]	748	803	1366	0.5	0.54758	55	0.37985	0.62811	0.089	1.2994	0.37701	0.58785	1.6211	1.895	4.4674
	$Ni_{42}Ti_{20}Zr_{22.5}Al_8Cu_5Si_{2.5}$ [24]	767	833	1367	2	0.56108	66	0.39035	0.65764	0.11	1.3883	0.39509	0.60936	1.6471	2.2406	4.9522
	$Ni_{42}Ti_{20}Zr_{21.5}Al_8Cu_5Si_{3.5}$ [24]	774	846	1366	2.5	0.56662	72	0.39533	0.67204	0.12162	1.4291	0.40346	0.61933	1.6596	2.4216	5.2211
	$Ni_{42}Ti_{20}Zr_{20.5}Al_8Cu_5Si_{4.5}$ [24]	763	856	1364	2	0.55938	93	0.40244	0.69575	0.15474	1.4243	0.414	0.62757	1.6813	2.5309	5.75
	$Ni_{42}Ti_{19}Zr_{22.5}Al_8Cu_5Si_{3.5}$ [24]	780	846	1363	3	0.57227	66	0.39477	0.66911	0.11321	1.4511	0.402	0.62069	1.6569	2.4688	5.1537
	$Ni_{60}Nb_{40}$ [24]	891	924	1478	1	0.60284	33	0.39004	0.6475	0.05622	1.5741	0.37629	0.62517	1.6399	2.6824	4.7154
	$Ni_{60}Nb_{35}Zr_5$ [24]	887	911	1458	1.5	0.60837	24	0.38849	0.64129	0.04203	1.5954	0.36306	0.62483	1.6354	2.7006	4.6051
	$Ni_{60}Nb_{30}Zr_{10}$ [24]	875	902	1413	2	0.61925	27	0.39423	0.65747	0.05019	1.6766	0.37657	0.63836	1.6501	3.0225	4.8731
	$Ni_{60}Nb_{25}Zr_{15}$ [24]	860	891	1390	1.5	0.61871	31	0.396	0.66331	0.05849	1.6811	0.38469	0.64101	1.6548	3.0773	4.981
	$Ni_{60}Nb_{20}Zr_{20}$ [24]	853	891	1391	0.5	0.61323	38	0.39706	0.66786	0.07063	1.6561	0.39301	0.64055	1.6578	3.0401	5.0735
	$Ni_{60}Zr_{20}Ti_{2.5}Nb_{12.5}Al_5$ [45]	836	897	1378	2	0.6067	61	0.4052	0.6952	0.1126	1.655	0.4172	0.6509	1.6796	3.2412	5.6561
	$Ni_{60}Zr_{20}Ti_5Nb_{10}Al_5$ [45]	826	896	1379	2	0.599	70	0.4064	0.7005	0.1266	1.6203	0.4209	0.6498	1.6837	3.1724	5.7914
	$Ni_{60}Zr_{20}Ti_{7.5}Nb_{7.5}Al_5$ [45]	824	885	1385	2	0.595	61	0.4006	0.683	0.1087	1.5775	0.41	0.639	1.669	2.917	5.4044
	$(Ni_{0.75}B_{0.2}Si_{0.05})_{96}Nb_4$ [46]	770	795	1446	0.5	0.533	25	0.35875	0.56708	0.03698	1.1760	0.32618	0.54979	1.5650	1.4444	3.6549
	$[(Ni_{0.9}Fe_{0.1})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [46]	762	795	1408	1	0.541	33	0.36636	0.58807	0.05108	1.2307	0.34545	0.56463	1.5845	1.6121	3.9034
	$[(Ni_{0.8}Fe_{0.2})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [46]	755	795	1381	2	0.547	40	0.37219	0.60463	0.06390	1.2700	0.35917	0.57567	1.5997	1.7479	4.1194
	$[(Ni_{0.7}Fe_{0.3})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [46]	750	795	1356	2.5	0.553	45	0.37749	0.61947	0.07426	1.3119	0.36989	0.58628	1.6131	1.8945	4.3263
	$[(Ni_{0.6}Fe_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$ [46]	745	795	1348	3	0.553	50	0.37984	0.62685	0.08292	1.3184	0.37558	0.58976	1.6198	1.9367	4.4403

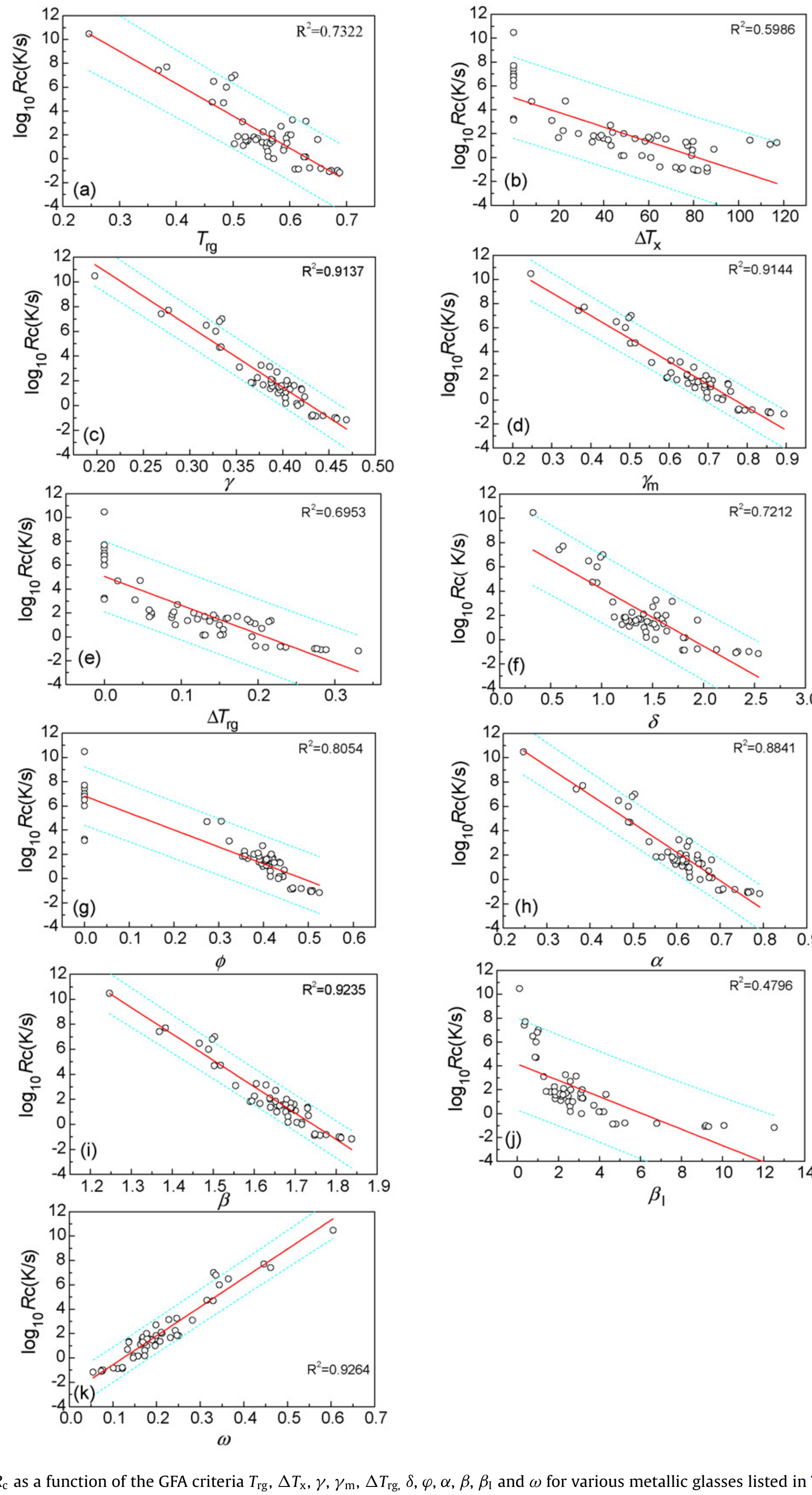

Fig. 1. Critical cooling rate R_c as a function of the GFA criteria T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_1 and ω for various metallic glasses listed in Table 1: (a) R_c vs. T_{rg}; (b) R_c vs. ΔT_x; (c) R_c vs. γ; (d) R_c vs. γ_m; (e) R_c vs. ΔT_{rg}; (f) R_c vs. δ; (g) R_c vs. φ; (h) R_c vs. α; (i) R_c vs. β; (j) R_c vs. β_1; (k) R_c vs. ω.

Table 3
The values of the linear correlation coefficient corresponding to plots of D_{max} against T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β, β_1 and $1/\omega$, respectively

	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_1	$1/\omega$
R^2	0.0783	0.1406	0.2946	0.3065	0.2704	0.1751	0.2880	0.2576	0.2924	0.3387	0.4141

Table 4
Characteristic temperatures of Pd-based BMGs, together with their R_c for glass formation

Composition (at.%) [ref.]	T_g (K)	T_x (K)	T_l (K)	R_c, exp (K/s)	γ–R_c (K/s)	γ_m–R_c (K/s)	β–R_c (K/s)	ω–R_c (K/s)
$Pd_{30}Pt_{17.5}Cu_{32.5}P_{20}$ [47]	540	614	807	0.067	0.0534	0.0239	0.0460	0.0825
$Pd_{44}Ni_{10}Cu_{26}P_{20}$ [48]	587	667	874	0.100	0.0493	0.0217	0.0423	0.0773
$Pd_{43.2}Ni_{8.8}Cu_{28}P_{20}$ [48]	579	693	859	0.009	0.0028	0.0005	0.0020	0.0062

R_c, exp is the experimentally measured value. ω–R_c, β–R_c, γ_m–R_c, and γ–R_c are the calculated values based on Eqs. (6)–(9), respectively.

above results, it is clear that our proposed ω criterion with a proper combination of the characteristic temperatures is a better indicator in reflecting GFA than T_{rg}, ΔT_x, γ, γ_m, ΔT_{rg}, δ, φ, α, β and β_1. This will be further confirmed by the following application of the ω criterion in Pd-based BMGs.

As is known, the best glass-forming alloys are found in Pd-based system. In order to explain their high GFA, the R_c has been measured for several Pd-based glasses, though tedious experiments are still unavoidable to determine R_c for each alloy composition [47,48]. These investigations showed that the formation of the centimeter-sized Pd-based glasses is due to their extremely low R_c. A summary of the characteristic temperatures and the calculated R_c based on Eqs. (7)–(10) for three Pd-based BMGs is given in Table 4, together with experimentally measured R_c. As shown in Table 4, it is evident that the estimated R_c using ω criterion is closer to the experimental data than that using other criteria, such as β, γ_m and γ, indicating that the new ω criterion has the strongest ability in representing R_c for glass formation among all the GFA criteria investigated in the present study.

4. Conclusions

A dimensionless criterion, i.e., $\omega = T_g/T_x - 2T_g/(T_g + T_l)$, is proposed to correlate the GFA of BMGs with the measurable thermodynamic properties. The reliability and benefits of the new criterion with respect to other criteria have been demonstrated in wide range of BMGs based on Cu, Ca, Mg, La, Pd, Ti, Pr, Y, Co, Au, Hf, Gd, Zr, Fe and Ni. The striking feature of this study is the discovery of the new ω criterion, which exhibits the strongest interrelationship with R_c or D_{max}, when compared with other criteria reported so far. In the meantime, the ω criteria can be calculated simply by data on T_g, T_x, and T_l. Therefore, it can be anticipated that the current criterion will be used as a useful and efficient guideline for exploring new BMG formers.

Acknowledgements

One of the authors (Z.L. Long) would like to acknowledge the financial support of Project supported by Provincial Natural Science Foundation of Hunan.

References

[1] W.L. Johnson, MRS Bull. 24 (1999) 42.
[2] A. Inoue, T. Zhang, A. Takeuchi, Mater. Sci. Forum 269–273 (1998) 855.
[3] Z.L. Long, B.L. Shen, Y. Shao, C.T. Chang, Y.Q. Zeng, A. Inoue, Mater. Trans. 47 (2006) 2566.
[4] A. Inoue, W. Zhang, T. Zhang, K. Kurosaka, Acta Mater. 49 (2001) 2645.
[5] V. Ponnambalam, S.J. Poon, G.J. Shiflet, J. Mater. Res. 19 (2004) 1320.
[6] Z.L. Long, Y. Shao, X.H. Deng, Z.C. Zhang, Y. Jiang, P. Zhang, B.L. Shen, A. Inoue, Intermetallics 15 (2007) 1453.
[7] A. Inoue, Acta Mater. 48 (2000) 279.
[8] A. Inoue, N. Nishiyama, K. Amiya, T. Zhang, T. Masumoto, Mater. Lett. 19 (1994) 131.
[9] O.N. Senkov, Phys. Rev. B 76 (2007) 104202.
[10] Z.P. Lu, H. Bei, C.T. Liu, Intermetallics 15 (2007) 618.
[11] D. Turnbull, Contemp. Phys. 10 (1969) 473.
[12] A. Inoue, W. Zhang, T. Zhang, K. Kurosaka, J. Mater. Res. 16 (2001) 2836.
[13] Z.P. Lu, C.T. Liu, Acta Mater. 50 (2002) 3501.
[14] A. Takeuchi, A. Inoue, Mater. Sci. Eng. A 304–306 (2001) 446.
[15] Z.P. Lu, C.T. Liu, Phys. Rev. Lett. Mater. 91 (2003) 115505.
[16] A. Inoue, T. Zhang, T. Masumoto, J. Non-Cryst. Solids 156–158 (1993) 473.
[17] Y. Li, S.C. Ng, C.K. Ong, H.H. Hng, T.T. Goh, Scripta Mater. 36 (1997) 783.
[18] A. Inoue, Mater. Trans., JIM 36 (1995) 866.
[19] A. Inoue, Y. Shinohara, J.S. Gook, Mater. Trans. JIM 36 (1995) 1427.
[20] X.H. Du, J.C. Huang, C.T. Liu, Z.P. Lu, J. Appl. Phys. 101 (2007) 086108.
[21] K. Mondal, B.S. Murty, J. Non-Cryst. Solids 351 (2005) 1366.
[22] Q.J. Chen, J. Shen, D.L. Zhang, H.B. Fan, J.F. Sun, D.G. McCartney, Mater. Sci. Eng. A 433 (2006) 155.
[23] G.J. Fan, H. Choo, P.K. Liaw, J. Non-Cryst. Solids 353 (2007) 102.
[24] Z.Z. Yuan, S.L. Bao, Y. Lu, D.P. Zhang, L. Yao, J. Alloys Compd. 459 (2008) 251.
[25] A. Hruby, Czech. J. Phys., Sect. B 22 (1972) 1187.
[26] W. Zhang, Q.S. Zhang, C.L. Qin, A. Inoue, Mater. Sci. Eng. B 148 (2008) 92.
[27] W. Zhang, F. Jia, Q.S. Zhang, A. Inoue, Mater. Sci. Eng. A 459 (2007) 330.
[28] G. Duan, K.D. Blauwe, M.L. Lind, J.P. Schramm, W.L. Johnson, Scripta Mater. 58 (2008) 159.
[29] T. Zhang, H. Men, S.J. Pang, J.Y. Fu, C.L. Ma, A. Inoue, Mater. Sci. Eng. A 449–451 (2007) 295.
[30] F. Jia, W. Zhang, H. Kimura, A. Inoue, Mater. Sci. Eng. B 148 (2008) 119.
[31] Z.P. Lu, C.T. Liu, Y. Wu, H. Tan, Y. Li, G.L. Chen, Intermetallics 16 (2008) 410.
[32] S.L. Zhu, X.M. Wang, F.X. Qin, A. Inoue, Mater. Sci. Eng. A 459 (2007) 233.
[33] C.T. Chang, B.L. Shen, A. Inoue, Appl. Phys. Lett. 88 (2006) 011901.
[34] J. Schroers, B. Lohwongwatana, W.L. Johnson, A. Peker, Appl. Phys. Lett. 87 (2005) 061912.
[35] L. Zhang, E. Ma, J. Xu, Intermetallics 16 (2008) 584.
[36] D. Chen, A. Takeuchi, A. Inoue, Mater. Sci. Eng. A 457 (2007) 226.
[37] Q.S. Zhang, W. Zhang, A. Inoue, Mater. Trans. 48 (2007) 3031.
[38] A. Makino, T. Kubota, M. Makabe, C.T. Chang, A. Inoue, Mater. Sci. Eng. B 148 (2008) 166.
[39] X.B. Liang, T. Erenc-Sedziak, M. Kowalczyk, T. Kulik, B.S. Xu, J. Mater. Process. Tech. 204 (2008) 465.
[40] F.S. Li, B.L. Shen, A. Makino, A. Inoue, Appl. Phys. Lett. 91 (2007) 234101.
[41] X.M. Huang, C.T. Chang, Z.Y. Chang, X.D. Wang, Q.P. Cao, B.L. Shen, A. Inoue, J.Z. Jiang, J. Alloys Compd. 460 (2008) 708.
[42] B.L. Shen, M. Akiba, A. Inoue, Phys. Rev. B 73 (2006) 104204.
[43] B.L. Shen, M. Akiba, A. Inoue, Appl. Phys. Lett. 88 (2006) 131907.
[44] A. Inoue, B.L. Shen, Mater. Sci. Eng. A 375–377 (2004) 302.
[45] J.B. Qiang, W. Zhang, A. Inoue, Mater. Sci. Eng. B 148 (2008) 114.
[46] B.L. Shen, C.T. Chang, A. Inoue, Appl. Phys. Lett. 88 (2006) 201903.
[47] N. Nishiyama, K. Takenaka, A. Inoue, Appl. Phys. Lett. 88 (2006) 121908.
[48] T.D. Shen, R.B. Schwarz, Appl. Phys. Lett. 88 (2006) 091903.