



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

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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 $T_{rg}(=T_g/T_l)$, $\Delta T_x(=T_x - T_g)$, $\gamma(=T_x/(T_g + T_l))$, $\gamma_m(=2T_x - T_g)/T_l$, $\Delta T_{rg}(=(T_x - T_g)/(T_l - T_g))$, $\delta(=T_x/(T_l - T_g))$, $\phi(=T_{rg}(\Delta T_x/T_g)^{0.143})$, $\alpha(=T_x/T_l)$, $\beta(=(T_x/T_g + T_g/T_l))$ 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.

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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 characteris-

tic 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

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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 Turnbull's criterion T_{rg} [11]. Base on the above analysis, the relation between GFA and T_n/T_g can be described as:

$$\text{GFA} \propto \frac{1}{T_n/T_g} \quad (1)$$

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.,

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

or

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

On the other hand, it is well known that the supercooled liquid region $\Delta T_x (=T_x - T_g)$ 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:

$$\log_{10}^{R_c} \propto \frac{T_g}{T_x} \quad (4)$$

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:

$$\omega = \frac{T_g}{T_x} - \frac{2T_g}{T_g + T_l} \quad (5)$$

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 indicator of GFA and scales inversely with R_c value, is in proportion to the reciprocal value of the ω parameter, $1/\omega$, i.e.,

$$D_{\max} \propto \frac{1}{\omega} \quad (6)$$

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 $T_{rg}(=T_g/T_l)$, $\Delta T_x(=T_x - T_g)$, $\gamma(=T_x/(T_g + T_l))$, $\gamma_m(=(2T_x - T_g)/T_l)$, $\Delta T_{rg}(=(T_x - T_g)/(T_l - T_g))$, $\delta(=T_x/(T_l - T_g))$, $\varphi(=T_{rg}(\Delta T_x/T_g)^{0.143})$, $\alpha(=T_x/T_l)$, $\beta(=T_x/(T_g + T_l))$, and $\beta_1(=T_x \times T_g/(T_l - T_x)^2)$ [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, $\beta(=T_x \times T_g/(T_l - T_x)^2)$ criterion is labeled as β_1 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_1 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_1 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, indicating 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_1 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:

$$R_c = 1.183 \times 10^{-3} \exp(54.639\omega) \quad (7)$$

$$R_c = 5.319 \times 10^{36}(-48.526\beta) \quad (8)$$

$$R_c = 3.947 \times 10^{14} \exp(-43.802\gamma_m) \quad (9)$$

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

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_1 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_i , R_c and the calculated T_{rg} , ΔT_x , γ , γ_m , ΔT_{rg} , δ , φ , α , β , β_l , and ω for the already reported metallic glasses (ref. [10])

Alloys	T_g (K)	T_x (K)	T_i (K)	R_c (K/s)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_l	ω
Zr ₆₆ Al ₈ Ni 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 ₈ Cu ₇ Ni 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 ₈ Cu 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 ₉ Cu 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 ₅ Al 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 ₅ Cu 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 ₅ Cu 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 ₅ Ag ₅ Y 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 ₃ Sn ₂ Nb 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 ₅ P 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 ₅ Nd 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 ₆ Si 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 ₄ Si _{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 ₆ Si _{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 2The T_g , T_x , T_i , D_{\max} and the calculated T_g , ΔT_x , γ , γ_m , ΔT_{rg} , δ , φ , α , β , β_i , 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_i (K)	D_{\max} (mm)	T_{rg}	ΔT_x	γ	γ_m	ΔT_{rg}	δ	φ	α	β	β_i	$1/\omega$
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 ₇ Y 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 ₇ Y 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 ₇ Y 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 ₁ Ni ₆ Sn 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 ₇ Ag 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 ₇ Be 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 ₇ Ag 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 ₇ Be 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 ₈ Si 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 ₉ Nb ₂ Ni ₈ Si 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 ₇ Nb ₄ Ni ₈ Si 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 ₅ Nb ₆ Ni ₈ Si 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 ₃ Nb ₈ Ni ₈ Si 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 ₈ Si 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 ₈ Ti 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 ₆ Zr 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 ₅ Zr 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 ₅ Zr 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 ₅ Ag 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-	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 ₇ Al 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 ₅ Al 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 ₃ Al 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 ₆ Al 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 ₈ Al 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 ₈ Al 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 ₈ Al 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 ₈ Al 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 ₈ Al 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 ₇ Ti 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 ₇ In 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 ₇ Ti 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	Mg ₆₅ Cu _{7.5} Ni _{7.5} Ag ₅ Zn ₅ Gd 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 ₅ Zn ₅ Gd _{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 ₅ Zn ₅ Gd ₅ Y 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 ₅ Zn ₅ Gd _{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 ₅ Zn ₅ Y 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 ₈ Nd _{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 ₅ Cu 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 ₅ Cu 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	5.5852
	La ₃₂ Ce ₃₂ Al ₁₆ Ni ₅ Cu 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 ₅ Cu 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 ₅ Cu ₇ Co 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 ₅ Cu ₅ Co 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 ₅ Cu 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_1	$1/\omega$
La	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 ₆ 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 ₇ Si ₃ Sc ₃ B _{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 ₇ Si ₃ Hf ₃ B _{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 ₆ Er 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 ₅ Cu 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 ₅ Al 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 ₈ Be _{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 ₂ Be _{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 ₈ Ni ₈ Be ₂₀ Y ₄ Mg 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 ₁ Mg _{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 ₈ Cu 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 ₈ Cu ₁₂ Fe ₈ Be 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 ₈ Be ₂₀ Y ₂ Mg 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 ₆ Fe ₂ Be ₂₀ Y ₂ Mg 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 ₇ Ag 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 ₇ Ag 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_1	$1/\omega$
Fe-	Zr ₄₈ Cu ₄₀ Al ₇ Ag 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 ₇ Ag 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 ₈ Al 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 ₂ Ag ₈ Al 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 _{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 ₆ Y 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 ₃ Cr ₁₅ Mo ₁₄ C ₁₅ B ₆ Y 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 ₅ Cr ₁₅ Mo ₁₄ C ₁₅ B ₆ Y 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 ₉ Cr ₁₅ Mo ₁₄ C ₁₅ B ₆ Y 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 ₇ Cr ₁₅ Mo ₁₄ C ₁₅ B ₆ Y 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 ₇ Zr ₈ Co ₇ Y 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 ₇ Zr ₈ Co ₆ Y ₂ Al 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 ₇ Zr ₈ Co ₅ Y ₂ Cr 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 ₅ Cr ₇ Mo ₁₂ Er ₂ C 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 ₂ B 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 ₅ Mo ₁₄ Er ₂ C 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 ₂ C 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 ₄ B 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 ₄ B 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 ₄ B 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 ₄ B 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 ₄ B 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 ₆ Y ₃ B 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 ₉ B 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 ₃ Ti ₃ Mo _{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 ₄ Mo ₄ Ga ₄ P ₁₂ C ₅ B _{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 ₆ B 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 ₁ Y ₆ B 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 ₂ Y ₆ B 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

Ni-	Fe ₆₉ Ni ₃ Y ₆ B 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 ₄ Y ₆ B 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 ₅ Y ₆ B 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 ₂ Y ₆ B 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 ₄ Y ₆ B 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 ₆ Y ₆ B 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 ₈ Y ₆ B 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 ₆ B 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 ₆ B 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 ₆ B 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 ₆ B 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 ₁ Y ₆ B 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 ₂ Y ₆ B 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 ₃ Y ₆ B 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 ₄ Y ₆ B 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 ₅ Y ₆ B 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 ₂ Ga ₂ P ₁₀ C ₄ B ₄ Si 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 ₄ Ga ₂ P ₁₀ C ₄ B ₄ Si 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 ₂ Ga ₃ P ₁₀ C ₄ B ₄ Si 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 ₄ Ga ₃ P ₁₀ C ₄ B ₄ Si 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 ₄ B ₄ Si 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 ₁ P ₁₀ C ₄ B ₄ Si 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 ₂ P ₁₀ C ₄ B ₄ Si 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 ₃ P ₁₀ C ₄ B ₄ Si 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 ₄ P ₁₀ C ₄ B ₄ Si 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 ₅ P ₁₀ C ₄ B ₄ Si 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 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 ₇ Al 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 ₇ Al ₄ Ta 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 ₂ Sn 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 ₈ Cu 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 ₈ Cu ₅ Si _{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 ₈ Cu ₅ Si _{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 ₈ Cu ₅ Si _{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 ₈ Cu ₅ Si _{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 ₅ Nb 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

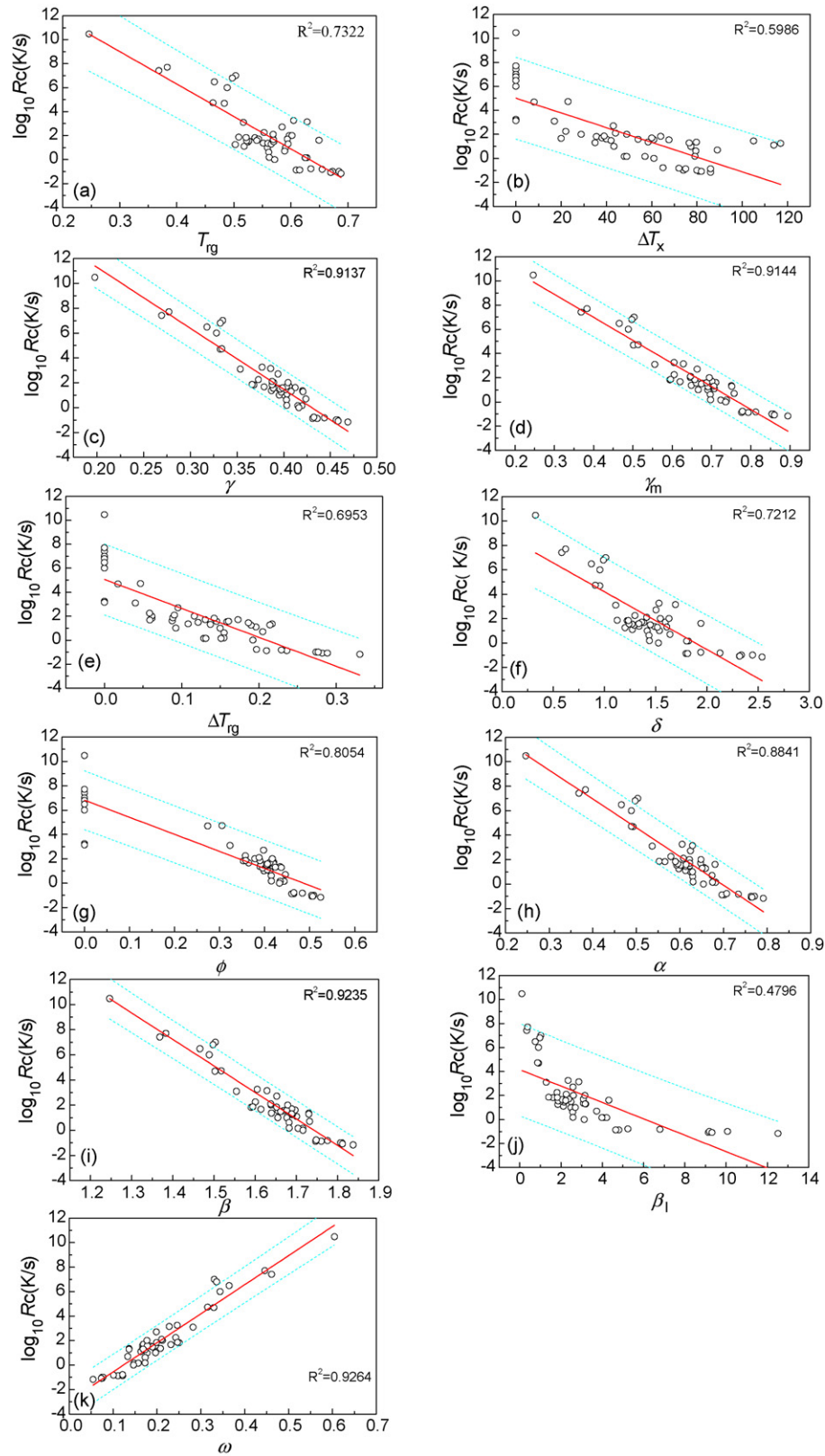


Fig. 1. Critical cooling rate R_c as a function of the GFA criteria T_{lg} , ΔT_x , γ , γ_m , ΔT_{lg} , δ , ϕ , α , β , β_l and ω for various metallic glasses listed in Table 1: (a) R_c vs. T_{lg} ; (b) R_c vs. ΔT_x ; (c) R_c vs. γ ; (d) R_c vs. γ_m ; (e) R_c vs. ΔT_{lg} ; (f) R_c vs. δ ; (g) R_c vs. ϕ ; (h) R_c vs. α ; (i) R_c vs. β ; (j) R_c vs. β_l ; (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_1 (K)	R_{c} , exp (K/s)	$\gamma-R_{\text{c}}$ (K/s)	$\gamma_{\text{m}}-R_{\text{c}}$ (K/s)	$\beta-R_{\text{c}}$ (K/s)	$\omega-R_{\text{c}}$ (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. $\omega-R_{\text{c}}$, $\beta-R_{\text{c}}$, $\gamma_{\text{m}}-R_{\text{c}}$, and $\gamma-R_{\text{c}}$ 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., $\omega = T_{\text{g}}/T_{\text{x}} - 2T_{\text{g}}/(T_{\text{g}} + T_1)$, 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_1 . Therefore, it can be anticipated that the current criterion will be used as a useful and efficient guideline for exploring new BMG formers.

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