1.INTRODUCTION - Forming Process

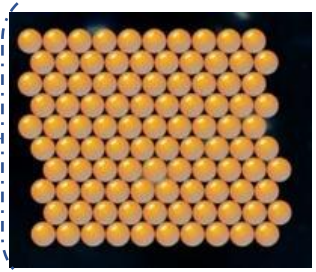
Molten metal of specific composition

Higher cooling rate

Lower cooling rate

Amorphous state

No grain boundary
Short range order, long range disorder (similar to liquid state)



Crystalline state

Grain boundary
Long range order

1.INTRODUCTION - Material Properties

High Intensity

（1.6 times higher tensile strength and 2 times higher bending and fatigue strength than titanium alloy, Co-based amorphous up to 6.0Gpa.）

High Hardness

(Fe based amorphous Vickers hardness of 12.53 GPa)

High Elasticity

（10 times higher elastic deformation than titanium alloys)

High Toughness

(Zr-based amorphous fracture toughness up to 60 MPa.m1/2)

Low Modulus of Elasticity

（Compared with crystalline alloys of similar composition, the strength and elastic deformation of amorphous is about 3 times that of crystalline alloys under the same modulus of elasticity.)

Other Functional Features

（Excellent corrosion resistance, soft magnetic properties, catalytic properties, superconductivity, high hydrogen storage properties.）

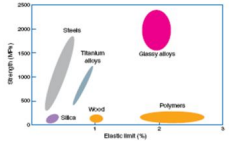


Fig. 3 Amorphous metallic alloys combine higher strength than crystalline metal alloys with the elasticity of polymers.

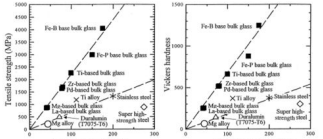


Fig. 9. Relationship between σ_f or Vickers hardness (H_v) and E for various bulk amorphous alloys.

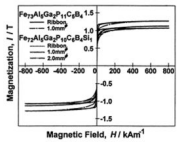


Fig. 24. Hysteresis I-H curves of the cast amorphous $Fe_{72}Al_5Ga_2P_{11}C_6B_4$ and $Fe_{72}Al_5Ga_2P_{10}C_6B_4Si_1$ cylinders with diameters of 1 and 2 mm.

Mechanical properties of Zr-based bulk amorphous alloy sheet (3mm thick) prepared by die-casting method

Alloy composition	Tensile strength	Tensile distortion	Young's modulus	Three-point Bending strength	Impact toughness	Bending fatigue strength
$/^{at}/_{0}$	/MPa	%	/GPa	/MPa	/KJ*m^{-2}	(3×10^{4})/Mpa
ZrAlNiCu	1 700	2 3	81	3 100	130	1 050
ZrAlNiCu	1 790	2 2	84	3 900	122	1 150
ZrTiAlNiCu	1 850	2 2	85	3 400	135	1 140

1.INTRODUCTION - Material Properties

Zr-based
(High-intensity, high impact, self-sharpening and pourable, can replace depleted uranium ammunitio)

Ti-based
(Lightweight and high strength to be used as aerospace structural components, good biocompatibility as a biomedical material)

Cu-based
(Excellent electrical conductivity for high-strength, high-conductivity leadframe materials.)

Fe-based
(Excellent soft magnetic properties can be used for a variety of high-frequency power components, pressure/magnetic/temperature sensing, cores and other electronic components.)

La-based
(Low glass transition temperature and 1500% superplasticity in the subcooled liquid phase zone, ideal for precision parts.)

Other systems
(Mg-based, Pd-based, Ni-based)

Parameters	Iron-based amorphous alloy	cold-rolled silicon steel	soft magnetic ferrite	Iron-based nanocrystalline alloy
Saturation magnetic induction	1.56T	2.0	0.5	1.25T
Curie temperature	410℃	730	230	560℃
Crystallization temperature	550℃			510℃
Electrical resistivity	130Ωμ-cm	50	106	130muOhm-cm
Density	7.18g/cm³	7.65	4.8	7.2g/cm³
Hardness	960kg/mm²		600	880kg/mm²
Saturated Magnetostriction Coefficient	27×10^{-6}	27	14	2×10^{-6}
Initial Permeability	10^3~10^4	1000	2000	$4\sim8\times10^4$
Maximum permeability	45×10^4	10000		60×10^4
Coercive force	< 4A/m	> 8.0	20	< 1.8A/m
Iron loss	P1/50=0.07P1/400=1.2	P1/50 > 0.3P1/400=5.8	P0.2/20k < 20	P0.2/20k < 10

Alloy	Gpa	Gpa	Mpa	Gpa
NiFeCrPB	2.73	/	8.63	141
NiFePBSi	2.35	2.38	7.77	129
FePCB	2.44	/	8.19	135
FeSiB	2.91	/	8.13	158
FePC	2.3	3.04	7.45	122
FeB	3.63	/	10.79	166
CoSiB	3.58	/	11.2	190
NiNb	1.93	/	8.82	125
CuZr	1.8	/	5.68	83.5

2.INTRODUCTION - Datasheet

PROPERTIES			BMG-PB001B	BMG-PB002B	BMG-PB003B	Titanium Ti-6Al-4V	Aluminum 6061-T6	Stainless Steel SUS304
MAIN ELEMENTS		UNIT	Zr,Cu,Ni,Al	Zr,Ti,Cu,Ni,Be	Zr,Al,Cu,Ni,Nb	Ti-6Al-4V	6061-T6	SUS304
PHYSICAL PROPERTIES	DENSITY	g·cm-3	6.82	6.12	6.82	4.4-4.5	2.7-2.8	7.9-8.0
	SPECIFIC HEAT CAPACITY	J·kg-1·K-1	0.335	0.395-0.46	0.34-0.347	0.526	0.896	0.500
	THERMAL EXPANSION	μm·m-1·K-1	9.1	8.6	8.7-9.2	8.6	23	17.3
	THERMAL CONDUCTIVITY	W·m-1·K-1	4.838	4.601	4.838	5.44	16.3	15.2
	THERMAL DIFFUSITY	mm^2/s	2.118	1.902	2.118	2.351	6.738	3.821
	ELECTRICAL RESISTIVITY	μΩ·cm	161-179	189-199	176-179	6.6	167	16.2
	CONDUCTIVITY	Ms/m	0.61-0.62	0.52-0.53	0.55-0.57	15.15	0.59	6.17
	ELECTRICAL CONDUCTIVITY	%IACS	1.05-1.07	0.89-0.91	0.96-0.98	26.12	1.02	10.64
	HARDNESS	HV	492-553	568-619	498-545	360-380	90-107	160-200
MECHANICAL PROPERTIES	COMPRESSION STRENGTH , ULTIMATE	MPa	1815-2052	1896-2044	1222-1623	1200-1280	520-720	500-600
	COMPRESSION STRENGTH , YIELD	MPa	1815-2052	1896-2044	1222-1623	900-970	210-300	150-200
	COMPRESSION MODULUS	GPa	31.2-32	32.5-33.2	29.2-31.2	\	\	\
	YOUNG'S MODULUS	GPa	92.9	94.9	81	114	68-69	193
	ELASTICITY	(% of Original Shape)	7-8	7-8	5-6	0.86	0.4	0.17
	ELONGATION,COMPRESSION	(% of Original Shape)	7-8	7-8	5-6	\	\	\
	DAMPING RATIO		0.00030-0.00035	0.00059-0.00069	0.00017-0.00032	\	\	\
	POISSON RATIO		0.30	0.30	0.30	0.342	0.33	\
CHEMICAL PROPERTIES	CORROSION RESISTANCE		unchanged of 48h	unchanged of 48h	unchanged of 48h			

2.INTRODUCTION - Datasheet

PROPERTIES			BMG-PB001B	BMG-PB002B	BMG-PB003B	Titanium Ti-6Al-4V	Aluminum 6061-T6
MAIN ELEMENTS		UNIT	Zr,Cu,Ni,Al	Zr,Ti,Cu,Ni,Be	Zr,Al,Cu,Ni, Nb	Ti-6Al-4V	6061-T6
PROCESSING PROPERTIES	MAIN FORMING PROCESS	\	Vacuum Die-casting	Vacuum Die-casting	Vacuum Die-casting	CNC	CNC
	SURFACE FINISH TYPE	\	Blasted, Brushed, Polished	Blasted, Brushed, Polished	Blasted, Brushed, Polished	Blasted, Brushed, Polished	Blasted, Brushed, Polished
	COLORING PROCESS	\	PVD, PAINTING, ELECTROPLATE	PVD, PAINTING, ELECTROPLATE	PVD, PAINTING, ELECTROPLATE	PVD, PAINTING, ANODIC OXIDATION	ANODIC OXIDATION
	RECOMMEND THICKNESS	mm	0.3-2.0	0.3-5.0	0.3-2.0	＞0.3	＞0.4
	MAXIMUM THICKNESS	mm	3.0	6.0	3.0	/	/
	MINIMUM THICKNESS	mm	0.25	0.25	0.25	0.3	0.4
	MINIMUM DRAFT	mm	0.5	0.5	0.5	0	0
	MINIMUM FILLET RADIUS	mm	0.2	0.2	0.2	0.2	0.4
	MINIMUM HOLE DIAMETER	mm	1.0	1.0	1.0	1.0	1.0
	DIMENSIONAL ACCURACY	mm	±0.04	±0.04	±0.04	±0.04	±0.04

2.INTRODUCTION - Datasheet

ALLOY		MAIN ELEMENTS	PHYSICAL PROPERTIES DENSITY	THERMAL CONDUCTIVITY	ELECTRICAL RESISTIVITY	MELTING TEMPERATURE
		\	g·cm-3	W·m-1·K-1	μΩ·cm	℃
BMG	PB001B	Zr, Cu, Ni, Al	6.74	~5	~180	~700
	PB002B	Zr,Ti,Cu, Ni, Be	6.12	~5	~200	~700
	PB003B	Zr, Cu, Ni, Al,Nb	6.82	~5	~180	~750
Stainless Steel	SUS304	Fe, Cr, Mn, Ni	7.93	16.2	72	1400~1455
	SUS316	Fe, Cr, Mo, Ni	7.98	15.1	73	1375~1400

BMG VS Stainless Steel

Advantage

High thermal conductivity, Low electrical resistivity, Could be die-casting, Lower density

Disadvantage

Low-melting-point --have low service temperature

2.INTRODUCTION - Datasheet

MECHANICAL PROPERTIES

ALLOY		HARDNESS	TENSILE STRENGTH, ULTIMATE	TENSILE STRENGTH, YIELD	SPECIFIC STRENGTH	YOUNG'S MODULUS	ELASTICITY
		HV	MPa	MPa	MPa·cm3/g	GPa	%
BMG	PB001B	492-553	1815-2052	\	93	7-8	\
	PB002B	568-619	1896-2044	\	95	7-8	\
	PB003B	498-545	1222-1623	\	81	5-6	\
Stainless Steel	SUS304	129	500-600	150-200	193	~0.15	100
	SUS316	205	1000	320	193	~0.15	>20

BMG VS Stainless Steel

Advantage

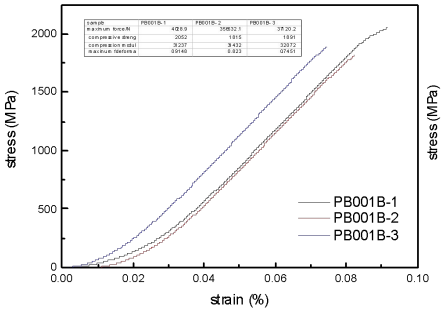
High hardness-Hard to scratch, always fresh

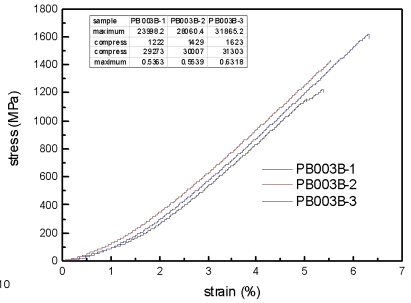
High strength -Stronger, thinner, lighter

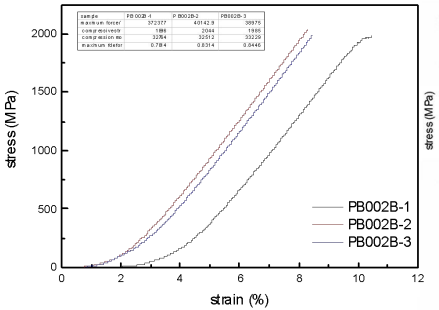
High elasticity -High elasticity is transmissible

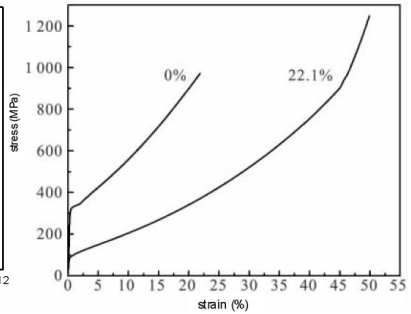
Disadvantage

Hard to machining-No plasticity and high strength









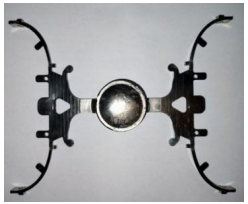
3.PROCESS - Process flow

Raw Material

- Zirconium, Copper, Aluminum, Titanium, Nickel etc.

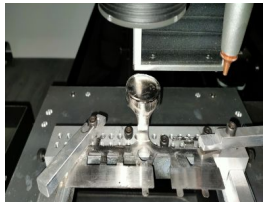
Alloying

- Zr base,Cu base, Fe base, Ti base amorphous alloy can be selected according to customer's product demand.



Die Casting

- Made by Vertical vacuum die casting machine.
- The molding cycle is about 2 minutes；The die life is about 20,000 times；The mold should be maintained once every 2-3 days.

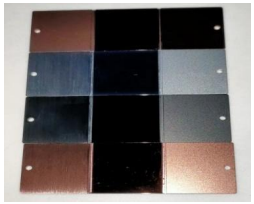


Cutting

- Remove the spare parts like gating by laser cutting
- The cutting cycle is about 10-30s

CNC

- Made by high end CNC machine and special cutting tool.
- Custom knives
- Machining accuracy ±0.04mm



Finishing

- Polishing, blasting, brush, PVD, painting, electroplate etc.
- A variety of process color treatment

3. PROCESS - Contrast

	BMG	Stainless steel	Steel aluminum composite die casting	Titanium alloy	Aluminum alloy
Cost	☆☆☆	☆☆☆	☆☆☆	☆☆☆☆	☆
Weight	☆☆	☆☆☆	☆☆☆	☆	☆
Intensity Hardness	☆☆☆☆	☆☆	☆☆	☆☆☆	☆
Environmental protection	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆	☆☆
Anodic oxidation Maturity	Unable	Unable	☆☆	Unable	☆
Electroplating Maturity	☆☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆☆
Processing difficulty	☆☆☆	☆☆☆	☆☆	☆☆☆☆	☆
Yield	☆☆☆ (70%)	☆☆ (30-40%)	☆☆☆ (70%)	☆☆ (30-40%)	☆☆☆☆ (80%)
Appearance	☆☆☆☆	☆☆☆	☆☆	☆☆☆	☆
Process maturity	☆☆☆	☆☆	☆☆☆	☆	☆☆☆☆
Processing way	Die Casting+CNC	Forging+CNC Only CNC	Die Casting+CNC	CNC	Diversified processing