Effect of Heat Treatment on Magnetic Properties of Fe-based Amorphous Alloys

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INTRODUCTION

Object Research the magnetic properties of Fe-Co-B-P-Cu amorphous ribbons by giving variations on heat treatment conditions.

Research

❖ Fe-based amorphous alloys are advantageous for industrial applications due to their outstanding soft magnetic properties: high saturation flux density(B_s), low coercivity(H_c), and high permeability.

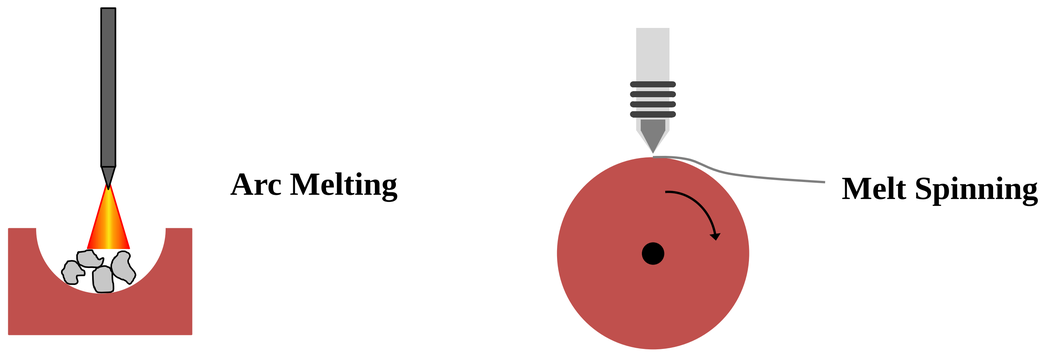
❖ Particularly, Fe-Co system exhibits high saturation flux density compared to Fe-only systems.

❖ When amorphous alloys fabricated by rapid solidification method are crystallized at an appropriate temperature, it becomes nanocrystalline alloys with tiny grains.

❖ Nanocrystalline materials are well known for their high saturation flux density and low coercivity, which leads to high permeability in comparison with Fe-based amorphous alloys.

EXPERIMENTS

■ Fabrication of amorphous ribbons



■ Heat treatment

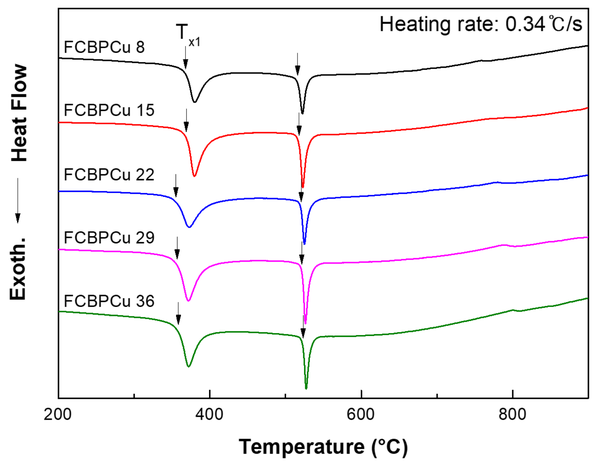
Amorphous ribbons are annealed for 10min at appropriate temperatures.

■ Analyze

Specimen's structural, thermal, and magnetic properties were examined by XRD, DSC, and VSM, respectively.

RESULT & DISCUSSION

■ Differential Scanning Calorimeter (DSC)



Alloys	Crystallization temperature (℃)		
	T_{x1}	T_{x2}	T_{x2}-T_{x1}
FCBPCu 8	368	515	147
FCBPCu 15	369	518	149
FCBPCu 22	355	520	165
FCBPCu 29	356	522	166
FCBPCu 36	358	523	165

Fig. 1 DSC curves for as cast Fe-Co-B-P-Cu alloys. The arrows mark the onset temperatures of crystallization, i.e. T_{x1} and T_{x2}

■ X-ray Diffraction Patterns (XRD)

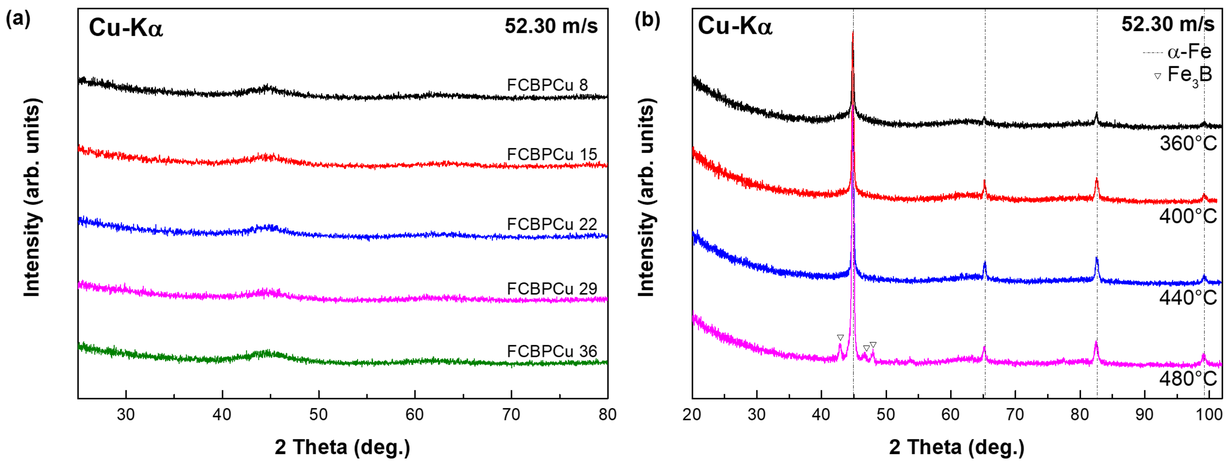
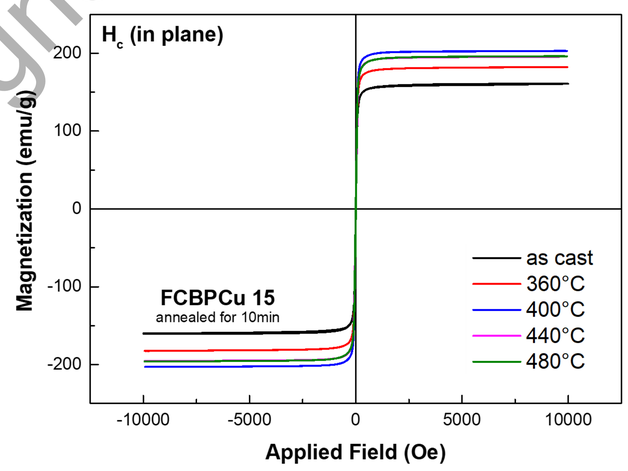


Fig. 2 XRD patterns of a) as cast and b) annealed FCBPCu 15 alloy taken at free surface of the ribbon.

■ Vibrating Sample Magnetometer (VSM)



Annealing Temperature [℃]	B_s [T]	H_c [Oe]
As cast	1.54	0.47
360	1.75	2.93
400	1.95	3.02
440	1.88	2.81
480	1.88	5.93

Fig. 3 Hysteresis loop for FCBPCu 15 alloy annealed at following temperatures.

■ Tendencies of Magnetic Properties

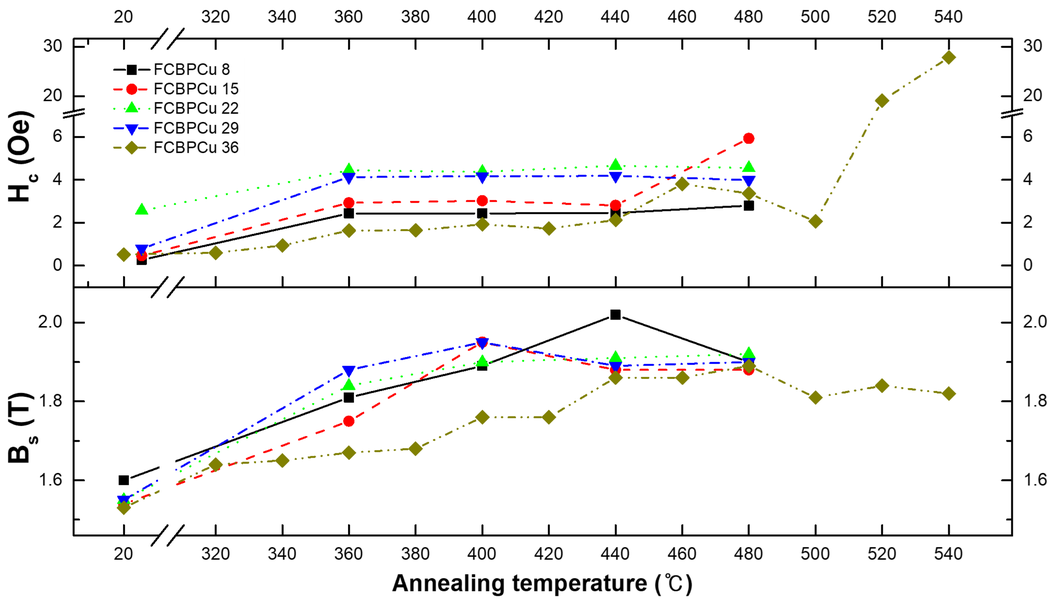


Fig. 4 Saturation Magnetic Flux Density(B_s) and Coercivity(H_c) as a function of annealing temperature.

SUMMARY

❖ Based on the DSC curve, the onset of primary crystallization is about $T_{x1} \approx 360$℃ for all alloys, while the secondary crystallization temperature T_{x2} slightly increases with Co content. (see Fig. 1)

❖ The temperature interval between T_{x1} and T_{x2} enlarges from 147℃ to 165℃ with the introduction of Co content, which means favorable for promoting the homogeneous α-Fe precipitates as well as excellent thermal ability.

❖ As can be seen from Fig. 2, the as cast ribbons are in the amorphous state. After annealing above the primary crystallization temperature, a bcc α-Fe phase is formed. When the annealing temperature is close to the second crystallization temperature, precipitation of Fe_3B phase occurs, which deteriorates the soft magnetic properties.

❖ Both Saturation magnetic flux density and Coercivity increase with annealing temperature for all investigated alloys.

❖ Saturation flux density reaches a maximum value of about $B_s = 2.02$ T for FCBPCu 8 alloy.