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APPEARANCE OF MASSIVE AND MARTENSITIC PHASES IN CuGa ALLOYS RAPIDLY QUENCHED FROM THE MELT

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INTRODUCTION

Since the pioneering work of Massalski /1/ in 1958, many papers have been devoted to the mode and morphology of massive or martensitic transformations from the high-temperature β-phase to equilibrium (α-Cu+γ) or (ξ+γ)-phases in CuGa alloys (from 20 at.% to 26 at.% Ga). The β-phase in CuGa alloys cannot be retained at room temeprature even by quenching to room temperature at cooling rates as high as $5 \cdot 10^4$ °C/s /2/. However, by splat cooling from the melt cooling rates as high as 10^6 °C/s and even more can be achieved /3/. We decided to use this technique to try to quench-in the β-phase at room temperature. The two piston and piston and anvil /4,5/ quenching techniques were used in this work.

RESULTS

The results show that we did not succeed to quench-in the β-phase as well, but three metastable phases appeared in quenched samples: a ξ_m-phase (the supersaturated extension of the equilibrium ξ-phase), and two martensitic phases (we called them M I and M II).

Two Cu-Ga alloys (having concentration 20.0 and 23.7 at.% Ga) were splat quenched and studied (the composition of the samples examined were measured by means of chemical methods). The as-quenched samples were examined by X-ray diffraction using Seeman-Bohlin and Guinier de Wolf focusing cameras and CuK_α and CoK_α radiations.

We obtained following results:

A) In Cu-20.0 at.% Ga alloy a martensitic M II phase appeared as the main feature in as-quenched samples. There was a very small amount of metastable ξ_m-phase present. After annealing the M II phase disappeared and equilibrium α-Cu solid solution and ξ-phase remained (Fig.1.).

b) In the Cu-23.7 at.% alloy different amounts of martensitic phases M I and M II, massive ξ_m-, and equilibrium ξ and γ-phases were present in as-quenched samples. After annealing for 30 min at 550°C and furnace cooling, in all samples there appeared only equilibrium ξ- and γ-phases (Table I). Measured d-values of M I, M II and ξ-phases are given in Table II.

The metastable martensitic phase M II was indexed as 9R ordered phase.

T A B L E I

Some characteristic distributions of phases in Cu-23.7 at.% Ga (ξ+γ-equilibrium phase field at room temperature) samples (in %, approximately).

sample no.	M I	M II	ξ	γ
1			100	
2	100			
3	70	10	20	
4	50	10	40	
5	20		80	
6	10	10	80	
7		30	70	
8		10	80	10

DISCUSSION

Considering the published results on the Cu-Ga system /1,6,7/ (samples quenched from the β-phase region), we can suppose also, that one of the martensitic phases we have found in our samples is ordered (M II). Preliminary TEM and diffraction measurements suggest that in samples of approximately eutectic composition (23.7 at.% Ga), as well in hypoeutectoid alloys (20.0 at.% Ga) ordering is present. The X-ray diffraction lines belong to the same phase denoted as M II. The best fitting of measured and calculated

T A B L E II

d_c - calculated values of equilibrium ζ- phase (a =0.26013 nm c = 0.42435 nm) and d_m -measured values of equilibrium ζ- phase and two metastable phase called M I and M II, d_c (9R) - calculated values of 9R martensitic structure (with stacking sequence ABCBCACAB) using hexagonal unit cell a = 0.26 nm and c = $9 \cdot d_{002}$ of ζ- phase (d-values of pure copper were used as internal standard)

	ζ - phase			M I		M II			
hkl	d_c	d_m	I	d_m	I	d_m	I	d_c(9R)	HKL
100	0.2252	0.225_3	vs	0.225_2	s	0.224_0	ms	0.2236	101
002	0.2122	0.212_0	s	0.223_7	s	0.212_0	s	0.2120	009
101	0.1989	0.199_0	vs	0.212_0	s	0.203_0	m	0.2036	104
102	0.1545	0.154_4	m	0.199_5	m	0.195_5	m	0.1939	105
110	0.1300	0.130_0	ms	0.198_0	m	0.162_9	mw	0.1637	108
103	0.1198	0.119_8	s	0.154_0	mb	0.147_0	mw	0.1455	1010
200	0.1126	0.112_6	w	0.131_0	mw	0.129_4	ms b	0.1300	110
112	0.1108	0.110_7	m	0.129_4	mw	0.122_0	m	0.1229	1013
201	0.1088	0.108_8	m	0.119_5	mw	0.117_1	m	0.1166	1014
004	0.1061	0.106_0	m	0.113_0	w	0.112_6	vw	0.1118	202
202	0.0995	0.099_5	m	0.111_5	w	0.110_8	ms b	0.1108	119
113	0.0957	0.095_8	m	0.110_3	w	0.109_0	vw	0.1095	204
				0.109_0	w	0.108_4	vw	0.1079	205
				0.108_0	vw	0.106_0	w	0.1060	0018
				0.106_0	w	0.100_9	vvw	0.1004	1017
				0.100_0	vw	0.097_9	vvw	0.0969	2010
				0.096_0	vw				

vs very strong s strong ms medium strong m medium mw medium weak w weak vw very weak vvw very very weak b broad

d_c(9R)-values (Table II) is obtained supposing 9R ordering (with stacking sequences ABCBCACAB) and using a hexagonal unit cell with a=0.26 nm and c=9·d_{002} of ξ-phase.

To determine the structure of M I phase more TEM experimental results are needed.

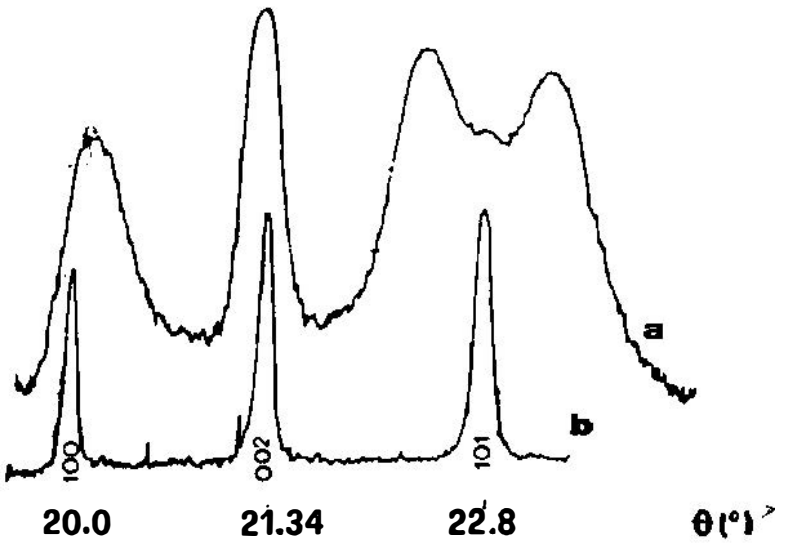

Fig.1. The microdensitometer traces of room temperature diffraction patterns of Cu-20 at.% Ga alloy (Bragg angles $19^{o}<\theta<24^{o}$):
a) as-quenched sample: martensitic M II (9R-ordered)(strong) and massive ξ_m-phase (very weak)
b) the same sample after annealing 30 min at 550^{o}C: approximately equal amount of equilibrium phases and α-Cu solid solution.

REFERENCES

/1/ T.B. Massalski, Acta Met., 6 (1958) 243.
/2/ J.E. Kittl and C. Rodriguez, Acta Met. 17 (1969) 925.
/3/ A. Tonejc and A. Bonefačić, J.Appl.Phys. 40 (1969) 40.
/4/ V. Franetović, O. Milat, D. Ivček and A. Bonefačić, J.Mat.Sci. 14 (1979) 498.
/5/ J.Dixmier and A. Guinier, Mém. Sci.Rev.Mét.64 (1967) 53.
/6/ L. Delaey and H. Warlimont, Z.Metallkde. 56 (1965) 437.
/7/ T. Sabury and C.M. Wayman, Trans.Met.Soc.AIME 233 (1965) 1373.