Journal of Alloys and Compounds, 194 (1993) 59–62
JALCOM 519

Room temperature and 500 °C isothermal sections of the Ag–Cu–Dy (0–33.3 at.% Dy) phase diagram

Zhang Kanghou, Chen Lili and He Chunxiao
Institute of Precious Metals, Kunming (China)

(Received September 19, 1992)

Abstract

The room temperature and 500 °C isothermal sections of the Ag–Cu–Dy ternary phase diagram containing 0–33.3 at.% Dy were determined by X-ray diffraction analysis and optical microscopy. Both sections consist of seven single-phase regions, eleven two-phase regions and five three-phase regions. No ternary intermetallic compounds are found.

1. Introduction

The Ag–Cu binary alloy system has been studied in detail; an Ag–Cu binary eutectic phase diagram is given in ref. 1. The Ag–Dy binary phase diagram has been investigated [2–7]: Gschneidner *et al.* [2] have determined the solubility of Dy in Ag, Steeb *et al.* [3] and McMasters *et al.* [4] have determined the crystal structure of $Ag_{51}Dy_{14}$, *i.e.* the first Ag-rich phase in the Ag–Dy system, and Gschneidner and Calderwood [7] have combined these investigations and obtained a more complete Ag–Dy binary phase diagram with three intermetallic compounds: $Ag_{51}Dy_{14}$, Ag_2Dy and AgDy. Franceschi [8] has studied the Cu–Dy binary system comprehensively. He reported a complete Cu–Dy binary phase diagram with six intermetallic compounds: $DyCu_7$, $DyCu_5$, Dy_2Cu_9, Dy_2Cu_7, $DyCu_2$ and DyCu. The compounds $DyCu_7$ and Dy_2Cu_7 are formed peritectically at 860 ± 5 °C and 905 ± 5 °C, with subsequent decomposition at 775 ± 5 °C and 845 ± 5 °C, respectively.

No investigations of the Ag–Cu–Dy ternary system have been reported. In this work we studied the Ag–Cu–Dy ternary system containing 0–33.3 at.% Dy, based on the corrected conclusions of refs. 7 and 8.

2. Experimental details

All the alloys were prepared from silver (99.99% pure), copper (99.99% pure) and dysprosium (99.9% pure). For degassing, stoichiometric mixtures of silver and copper were refined in vacuum using an induction furnace. Corresponding amounts of dysprosium were then added. The alloys were melted in boron nitride crucibles under a pure argon atmosphere. After remelting at least twice, the melts were cooled quickly, and homogeneous lumps of alloys were obtained.

All the samples were sealed in silica tubes filled with argon. To determine the isothermal section at 500 °C the specimens were homogenized at 500 °C for 30 days, and then quenched. To determine the section at room temperature, the specimens were treated for 10 days at about 100 °C lower than their melting points. The samples were then cooled to room temperature slowly within 30 days.

It was determined by chemical analysis that the weight losses of the alloy elements are less than 1% for both copper and dysprosium, and 1.5% for silver during the melting and heat treatment. The results of the experiments were corrected accordingly.

The X-ray diffraction experiments were performed in a Rigaku (RV-200 model) diffractometer, using Cu Kα radiation ($\lambda = 0.15405$ nm). Diffraction data were corrected with silicon powder as an internal standard.

3. Results and discussion

Gschneidner *et al.* [2] have reported that the solid solubility of dysprosium in silver at 805 °C is 1.3 at.% as determined by the X-ray parametric method. We have determined that the solid solubility of dysprosium in silver at 500 °C is about 0.8 at.% and that at room temperature is less than 0.5 at.%. Franceschi [8] has reported that no significant solubility of dysprosium in copper is observed as the lattice constant of the pure metal does not change on alloying with dysprosium.

0925-8388/93/$6.00

TABLE 1. Structural data for the Ag–Dy and Cu–Dy (0–33.3 at.% Dy) intermetallic compounds

Compound	Structure type[a]	Lattice parameter (nm)			Reference
		a	*b*	*c*	
$Ag_{51}Dy_{14}$	hP65 $Ag_{51}Gd_{14}$	1.2670		0.9289	[3]
		1.2635		0.9271	[4]
		1.2655		0.9275	This work
Ag_2Dy	tI6 $MoSi_2$	0.3694		0.9213	[3]
		0.3696		0.92317	This work
$DyCu_5$(LT)[b]	cF24 $AuBe_5$	0.7022			[8]
Dy_2Cu_9	Tetragonal	0.4999		1.394	[8]
		0.5002		1.399	This work
$DyCu_2$	oI12 $CeCu_2$	0.4303	0.6802	0.7289	[8]

[a]The structure type is preceded by its description in Pearson's notation.
[b]LT, low temperature.

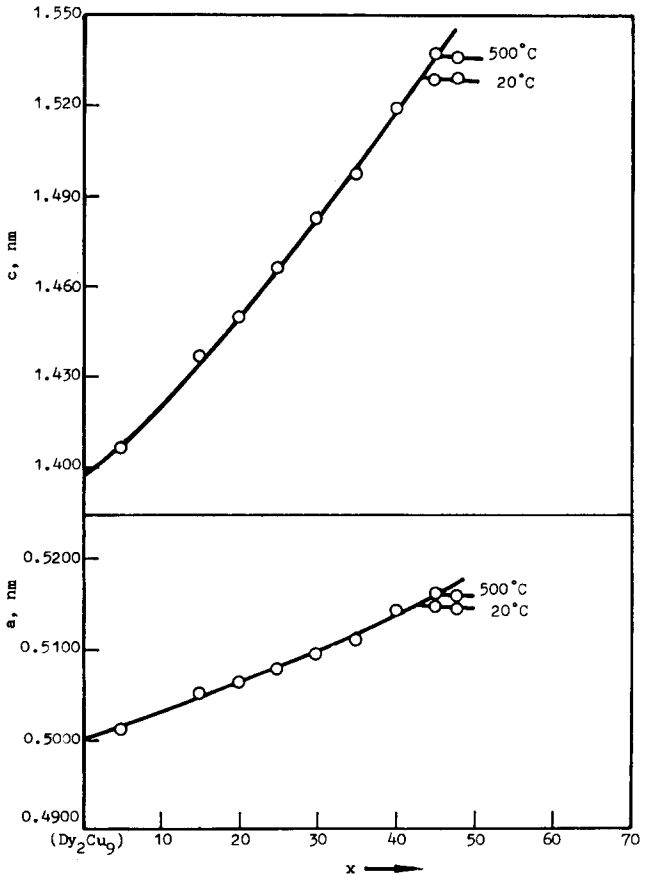

Fig. 1. Lattice parameters of Dy_2Cu_9 *vs.* composition of $Dy_{18.2}Cu_{81.8-x}Ag_x$.

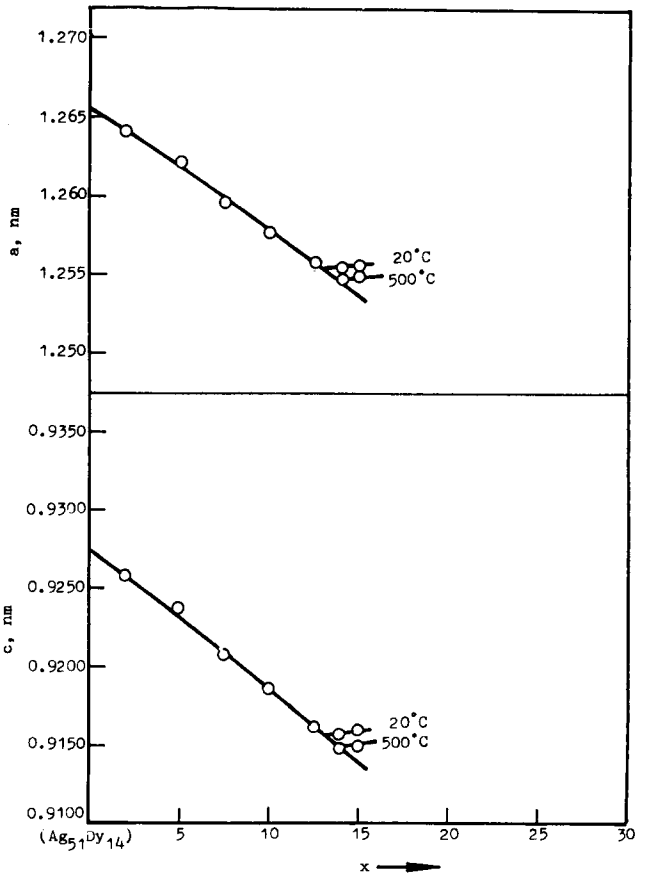

Fig. 2. Lattice parameters of $Ag_{51}Dy_{14}$ *vs.* composition of $Ag_{78.5-x}Cu_xDy_{21.5}$.

Table 1 lists the crystal structures and the lattice parameters of $Ag_{51}Dy_{14}$, Ag_2Dy, $DyCu_5$, Dy_2Cu_9 and $DyCu_2$. It was determined from lattice parameter measurements that the solid solubility of silver in Dy_2Cu_9 is about 43.0 at.% at room temperature and about 45.0 at.% at 500 °C. However, the content of dysprosium in this single-phase region (Dy_2Cu_9) remains within the limits of 18.0–19.5 at.%. Figure 1 shows the lattice parameters of (Dy_2Cu_9) in the alloys $Dy_{18.2}Cu_{81.8-x}Ag_x$ as a function of silver content at room temperature and 500 °C.

The solid solubility of copper in $Ag_{51}Dy_{14}$ is about 13.0 at.% at room temperature and 14.0 at.% at 500 °C. The solid solubility of copper in Ag_2Dy is about

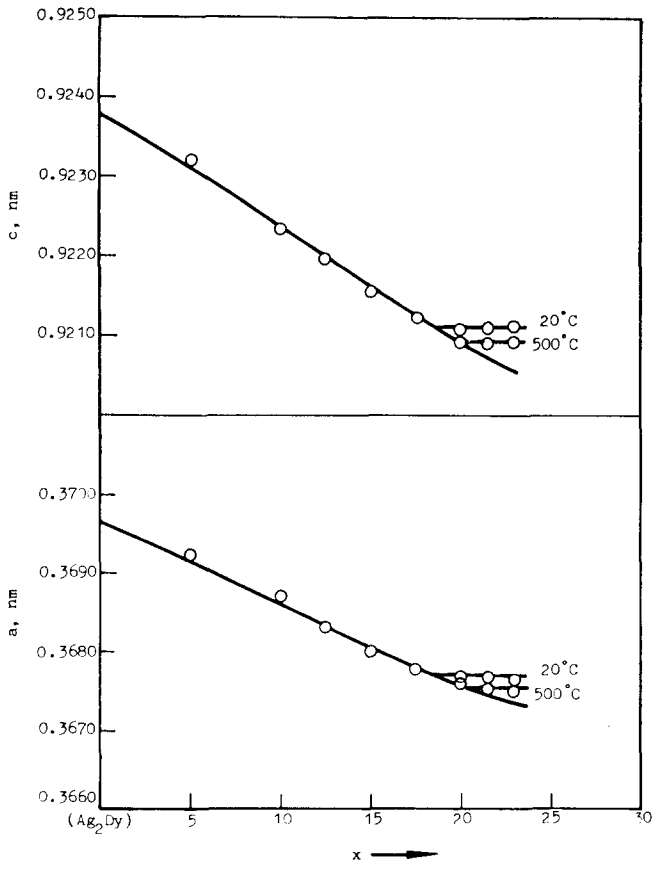

Fig. 3. Lattice parameters of Ag_2Dy *vs.* composition of $Ag_{66.7-x}Cu_xDy_{33.3}$.

18.0 at.% at room temperature and 20.5 at.% at 500 °C. Figures 2 and 3 show the lattice parameters of ($Ag_{51}Dy_{14}$) and (Ag_2Dy) in the alloys $Ag_{78.5-x}Cu_xDy_{21.5}$ and $Ag_{66.7-x}Cu_xDy_{33.3}$ as a function of copper content.

The solid solubility of silver in $DyCu_2$ is about 9 at.% at room temperature and about 12 at.% at 500 °C. The solid solubility of silver in $DyCu_5$ is about 4–5 at.%.

The other boundaries of the phase fields in the ternary phase diagram were determined by the X-ray diffraction disappearing-phase method, and checked by metallography. The compositions of the specimens are shown in Figs. 4 and 5 by the circular symbols.

The experiments confirm that there is a wide ternary phase region, (Ag) + (Cu) + Dy_2Cu_9, along the Ag–Cu binary system on the silver–copper-rich side of the Ag–Cu–Dy ternary phase diagram. In this region, the cold working properties of the alloys decrease rapidly with increasing dysprosium content.

To sum up, the room temperature and 500 °C isothermal sections of the Ag–Cu–Dy (0–33.3 at.% Dy) ternary phase diagram are shown in Figs. 4 and 5 respectively. Both partial sections consist of five single-phase regions (solid solution (Ag), (Cu), $DyCu_5$, Dy_2Cu_9, $DyCu_2$, $Ag_{51}Dy_{14}$ and Ag_2Dy), eleven two-phase regions ((Ag) + (Cu), (Cu) + Dy_2Cu_9, (Cu) + $DyCu_5$, $DyCu_5$ + Dy_2Cu_9, $DyCu_2$ + Dy_2Cu_9, $DyCu_2$ + Ag_2Dy, $DyCu_2$ + $Ag_{51}Dy_{14}$, $Ag_{51}Dy_{14}$ + Ag_2Dy, (Ag) + $Ag_{51}Dy_{14}$, (Ag) + Dy_2Cu_9 and $Ag_{51}Dy_{14}$ + Dy_2Cu_9) and five three-phase regions ((Ag) + (Cu) + Dy_2Cu_9, (Cu) + $DyCu_5$ + Dy_2Cu_9, (Ag) + $Ag_{51}Dy_{14}$ + Dy_2Cu_9, $DyCu_2$ + Dy_2Cu_9 + $Ag_{51}Dy_{14}$ and $Ag_{51}Dy_{14}$ + Ag_2Dy + $DyCu_2$). The single-phase regions of the isothermal section at 500 °C are larger than those at room temperature. No new ternary intermetallic phase was found. The basic form of the isothermal sections on the silver–copper-rich side of the Ag–Cu–Dy ternary phase diagram is similar to that of the Ag–Cu–Gd ternary system [9].

Acknowledgment

This work was supported by the National Natural Science Foundation of China.

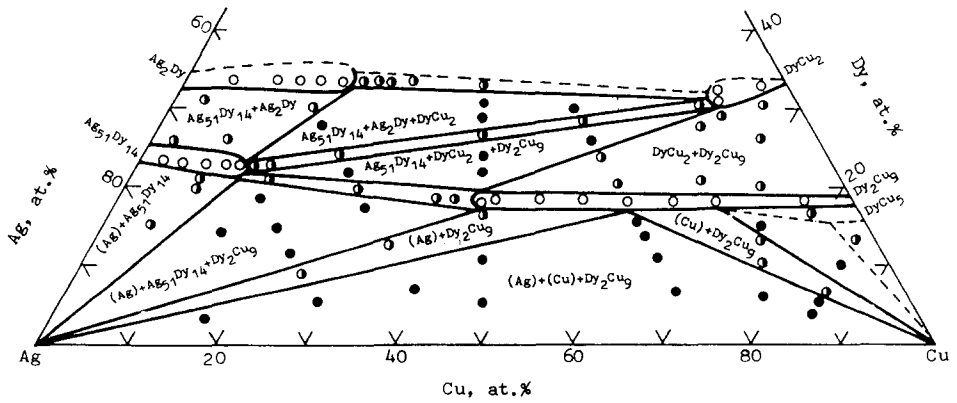

Fig. 4. Room temperature section of the Ag–Cu–Dy ternary system (0–33.3 at.% Dy) phase diagram: ○, single phase; ◑, binary phase; ●, ternary phase.

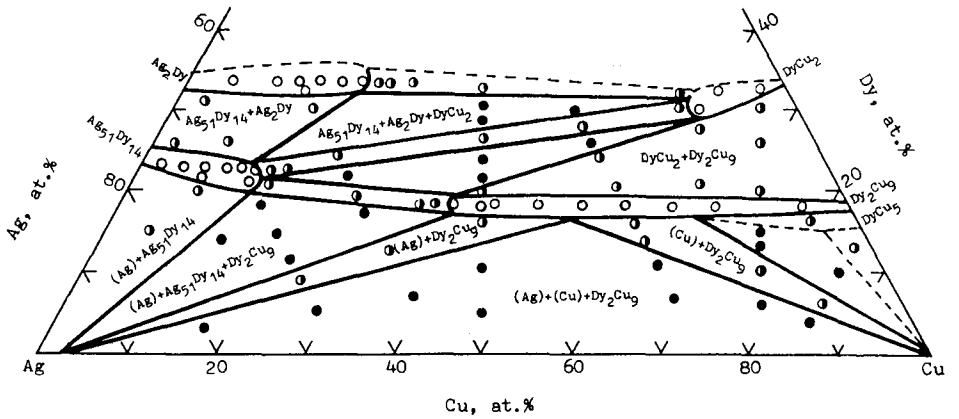

Fig. 5. Isothermal (500 °C) section of the Ag–Cu–Dy ternary system (0–33.3 at.% Dy) phase diagram: ○, single phase; ◑, binary phase; ●, ternary phase.

References

1 R. P. Elliott and F. A. Shunk, *Bull. Alloy Phase Diagrams, 1* (1) (1980) 41.

2 K. A. Gschneidner, Jr., O. D. McMasters, D. G. Alexander and R. F. Venteicher, *Metall. Trans., 1* (1970) 1961.

3 S. Steeb, D. Godel and C. Lohr, *J. Less-Common Met., 15* (1968) 137.

4 O. D. McMasters, K. A. Gschneidner, Jr. and R. F. Venteicher, *Acta Crystallogr., Sect. B, 26* (1970) 1224.

5 S. Delfino, R. Ferro, R. Capelli and A. Borsese, *J. Less-Common Met., 44* (1976) 267.

6 L. S. Guzei, A. G. Slavev, M. V. Raevskaya and E. M. Sokolovskaya, *Moscow Univ. Chem. Bull., 33* (1978) 47.

7 K. A. Gschneidner, Jr. and F. W. Calderwood, *Bull. Alloy Phase Diagrams, 6* (1) (1985) 15.

8 E. Franceschi, *J. Less-Common Met., 87* (1982) 249.

9 C. He, K. Zhang and L. Chen, *J. Alloys Comp., 179* (1992) L29.