

Lawrence Berkeley National Laboratory

Recent Work

Title

EFFECT OF TRACE ELEMENTS ON PRECIPITATION IN Al-Cu ALLOYS

Permalink

<https://escholarship.org/uc/item/0h27f577>

Authors

Das, S.K.
Thomas, G.
Rowcliffe, D.

Publication Date

1970-04-01

Submitted at 7th Int. Congress on
Electron Microscopy, Grenoble, France,
August 30-Sept. 5, 1970

UCRL-19137
Preprint

c.2

RECEIVED
LAWRENCE
RADIATION LABORATORY

MAY 13 1970

LIBRARY AND
DOCUMENTS SECTION

**EFFECT OF TRACE ELEMENTS ON
PRECIPITATION IN Al-Cu ALLOYS**

S. K. Das, G. Thomas and D. Rowcliffe

April 1970

AEC Contract No. W-7405-eng-48

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545*

LAWRENCE RADIATION LABORATORY
UNIVERSITY of CALIFORNIA BERKELEY

UCRL-19137
of 2

75

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

S. K. Das⁽¹⁾ G. Thomas⁽¹⁾ and D. Rowcliffe⁽²⁾

⁽¹⁾ Department of Materials Science and Engineering
University of California Berkeley

⁽²⁾ Brown Boveri Ltd., Baden Switzerland

The addition of small amounts of Cd, In and Sn to the Al-Cu alloys is known¹ to strongly influence the aging process. The formation of θ' is favored at the expense of θ'' . In the present study a series of Al-4Cu alloys with and without additions of Cd, In and Sn, and a commercial 2021 Al-alloy containing 6.3% Cu, 0.15 Cd and 0.05 Sn were investigated by transmission electron microscopy and diffraction. The ternary alloys had either 0.12% Cd or 0.05% Sn or In.

The structures obtained after aging for 24 hours at 163° are shown in fig. 1. The 2021 Al-alloy shows particles of $\sim 500\text{\AA}$ diameter with large strain fields [Fig. 1(a)]. The ternary Al-4Cu-0.05 Sn alloy also showed [Fig. 1(b)] similar θ' particles, but of slightly larger diameter ($\sim 770\text{\AA}$), after identical aging treatment. On the other hand the binary Al-4Cu alloy contained mixtures of θ'' (average dia. $\sim 330\text{\AA}$) and θ' [Fig. 1(c)] after the same aging treatment. The size and distribution of the θ' precipitates in 2021 Al-alloy appear to be similar to the θ'' in the binary, and their strain fields are also very similar. This suggests that the θ' particles in 2021-Al alloy and also in the ternary alloys are probably coherent at this aging temperature. Coherency could be maintained in θ' by Cd, In or Sn atoms segregating at the interface. This possibility is in accord with the diffraction pattern. (fig. 2). The presence of $\{100\}$ $\{300\}$, etc., θ' spots (including spots at x fig. 2b) could be explained if some of the 0, 1/2, 1/4 or 1/2, 0, 3/4 sites in θ' structure [the unoccupied sites," ref. (2)] are occupied by Cd, In or

Sn atoms. To maintain coherency it may be that more of such sites near the θ' -matrix interfaces will be filled than in the interior and so it may not be necessary to assume a different interface structure (as in ref. 1). An alternative interpretation of the pattern (fig. 2) involves double diffraction, although dark field analysis of possible double diffraction spots has been inconclusive, so we prefer the above explanation.

A comparison of the sizes of θ' particles in the various alloys shows that they are much smaller in the 2021-Al alloy compared to the other ternary alloys. This suggests that the growth rate of θ' in 2021-Al alloy containing maximum supersaturation of Cu and also Cd and Sn is the slowest. This can be explained if one assumes that in the alloys containing trace elements, the growth of the precipitate is controlled by the movement of Cu-vacancy-Cd (or In or Sn) clusters to it, as suggested by Noble.³ In the 2021-Al alloy the clusters may be of Cu-Vac-Cd-Sn, which may be larger in size compared to the clusters in the ternary. Thus, the larger cluster size may be responsible for the smaller particle diameter in 2021-Al alloy compared to other ternary alloys.

In all the alloys containing trace elements θ' precipitates are uniformly distributed [figs. 1(a) and (b)] and no nucleation on dislocations is observed. In binary Al-Cu alloys heterogeneous nucleation of θ' on dislocations is well known. The presence of Cd, In or Sn atoms at the interface of θ' may reduce its surface energy and hence favor homogeneous nucleation even at lower temperatures.

Fig. 3 shows the presence of both θ' and θ'' precipitates in the

Al-4Cu-0.05 In alloy after aging for 24 hours at 163°C. The θ precipitates are much bigger than the θ'' as clearly seen in dark field. For the same aging treatment the Al-4Cu-0.05 Sn alloy does not show any θ'' and only θ' is seen [fig. 1(b)]. This may be due to a greater binding energy between vacancy and Sn atoms than with In atoms.

ACKNOWLEDGEMENTS

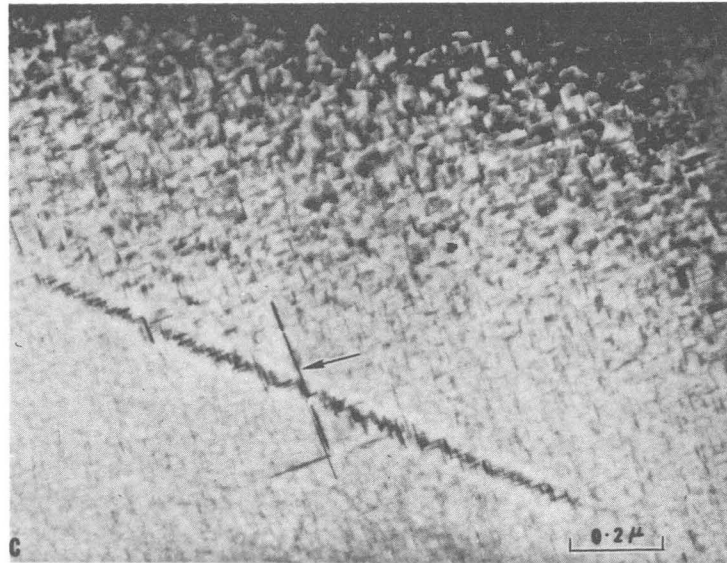
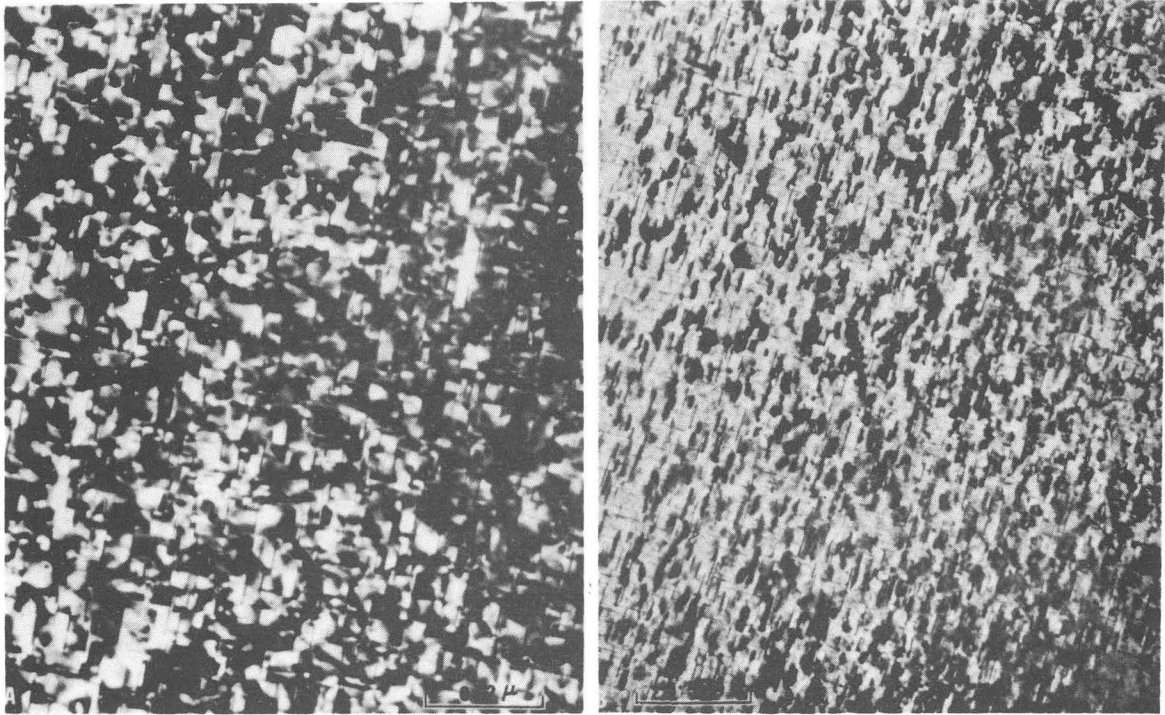
We wish to acknowledge the continued assistance of the U.S. Atomic Energy Commission through the Lawrence Radiation Laboratory.

REFERENCES

1. J. M. Silcock, T. J. Heal, and H. K. Hardy, J. Inst. Met. 84, 23 (1955-56).
2. J. M. Silcock and T. J. Heal, Acta. Cryst. 9, 680 (1956).
3. B. Noble, Acta Met. 16, 393 (1968).

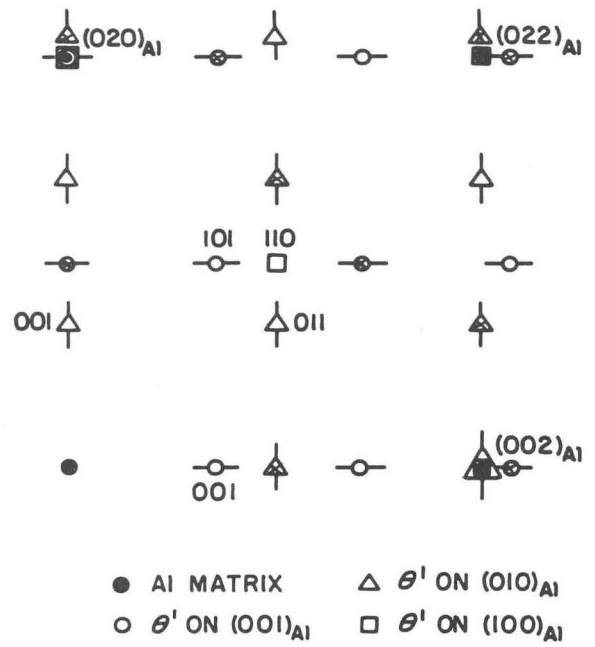
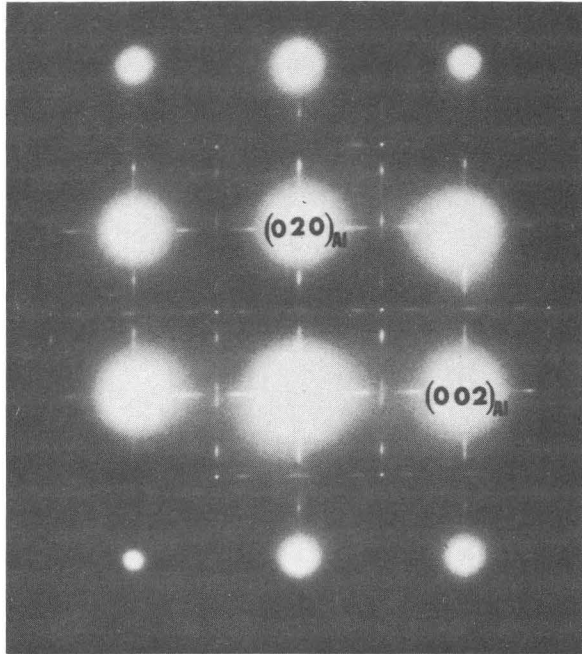
FIGURE CAPTIONS

- Figure 1. (a) Dark field micrograph of matrix reflection in 2021-Al alloy, θ' only.
(b) Bright field micrograph of Al-4Cu-0.05 Sn alloy, θ' only.
(c) Bright field micrograph of Al-4Cu alloy showing both θ'' and θ' (marked by arrow) precipitates.
All were aged for 24 hours at 163°C.
- Figure 2. (a) Selected area diffraction pattern from an area similar to Figure 1(a) but aged for 12 hours at 190°C. The c/a ratio for the θ' precipitates is ~ 1.5.
(b) Explanation of the pattern in (a).
- Figure 3. (a) Al-4Cu-0.05 In alloy aged for 24 hours at 163°C showing both θ' and θ'' precipitates.
(b) Selected area diffraction pattern of (a). The reflections due to θ' and θ'' are indistinguishable.
(c) Dark field of the streak [encircled area in (b)], showing mainly θ' precipitates. The θ'' precipitates reverse contrast faintly.



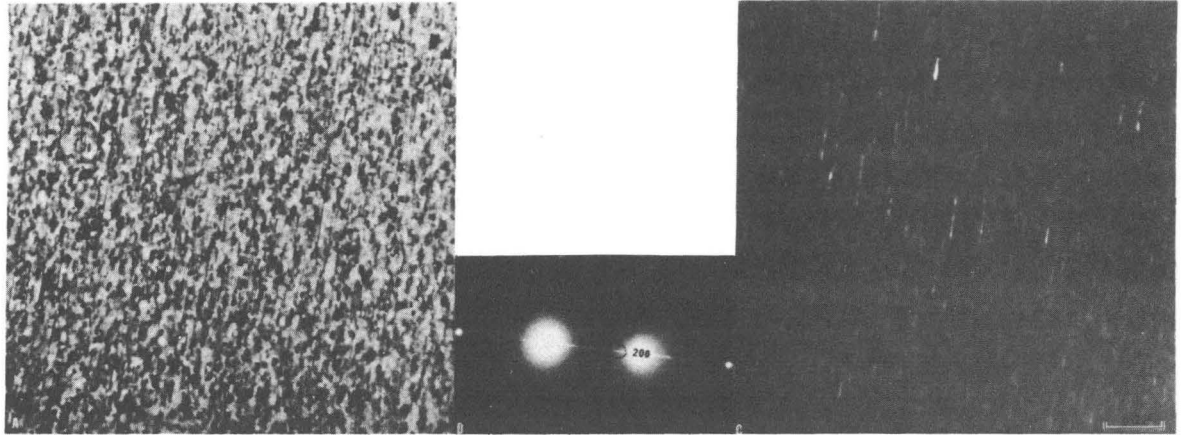
XBB6911-7113

Figure 1



XBB702-708

Figure 2



XBB6911-7112

Figure 3

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or*
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.*

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

TECHNICAL INFORMATION DIVISION
LAWRENCE RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720