~~APPENDIX~~

MISFIT DISLOCATIONS IN (111) Pd/(111) Cu BILAYERS

by

S. S. Chao and R. W. Vook

Submitted to the 37th Annual Electron Microscopy Society of American meeting to be held in San Antonio, Texas on August 13-17, 1979

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S. S. Chao and R. W. Vook

Department of Chemical Engineering and Materials Science
Syracuse University, Syracuse, New York 13210

Misfit dislocations were present in the earliest stages of epitaxial growth (111) Pd on (111) Cu at 25°C. Pd and Cu have a natural lattice misfit $f_o = (a_s^o - a_o^o)/a_o^o$ of 7.07%, where a_s^o and a_o^o are the unstrained lattice parameters of the substrate and overgrowth respectively. Three different kinds of misfit dislocations were observed and their corresponding Burgers vectors were determined.

Smooth single crystal (111) Cu films (1100 Å - 1500 Å thick) were evaporated on (111) NaCl/mica at a rate of ∿ 10 Å/sec at 250°C in a UHV-RHEED system whose base pressure was $1 \sim 2 \times 10^{-9}$ torr.[1] The Cu films were further annealed at 325°C for 10 minutes. Then these films were cooled to room temperature. Pd overgrowths with average thicknesses (measured by using a quartz crystal oscillator) ranging from 1 Å to 36 Å were deposited at a rate of ∿ 3 Å/min. Then the films were examined by RHEED, TEM, and TED.

The presence of three types of misfit dislocation networks in (111) Ag/(111) Cu bilayer films was first observed by Vook and Horng.[2] Similar networks were observed in the present study. Networks of type I misfit dislocations, illustrated in Fig. 1(a), consist of three sets of long, straight dislocations lying along the three $\langle 1\bar{1}0 \rangle$ directions in the (111) film plane. The Burgers vectors of type I dislocations were determined by standard dark field techniques. Fig. 1 (b) is a dark field micrograph taken with the $\vec{g} = 1\bar{1}1$ Pd spot after tilting the film 19.5° into the $\langle 11\bar{2} \rangle$ zone. It shows the invisibility of two out of three sets of dislocations. The Burgers vectors were found to be $\pm$ a/2 [110], $\pm$ a/2 [101], $\pm$ a/2 [011]. They lie in the three {111} planes which intersect the (111) interfacial plane. They are mixed edge and screw types and their average spacing is about 650 Å.

Type II misfit dislocations are shown in Fig. 2(a). The networks were irregular but had a tendency to form a hexagonal shape. Dislocation lines lie approximately along the three $\langle 11\bar{2} \rangle$ directions. The Burgers vectors were determined to be $\pm$ a/2 [1$\bar{1}$0], $\pm$ a/2 [10$\bar{1}$], $\pm$ [01$\bar{1}$]. They most likely slipped into the (111) interfacial plane during the initial flat island film growth. Their average spacing is about 500 Å. They are edge type. The arrow in Fig. 2 (b) indicates the invisible set of dislocations in the $\vec{g} = \bar{4}22$ dark field picture.

Type III interfacial dislocations lie along two of the three $\langle 1\bar{1}0 \rangle$ directions in the (111) film plane. The Burgers vectors were determined to be $\pm$ a/6 $\langle 12\bar{1} \rangle$. They are mixed partial dislocations lying in the (111) interfacial plane and make an angle of approximately 30° with respect to the dislocation lines. Their average spacing is about 120 Å, much smaller than those of types I and II. Figs. 3 (a) and 3 (b) are two dark field micrographs, each showing only one visible set of dislocations.

The financial support of the U.S. Department of Energy under contract EG-77-S-02-4496 is gratefully acknowledged.

1. C.T. Horng, and R.W. Vook, J. Vac. Sci. and Tech. 10, 160 (1973).

2. R.W. Vook, and C.T. Horng, Phil. Mag. 33, 843 (1976).

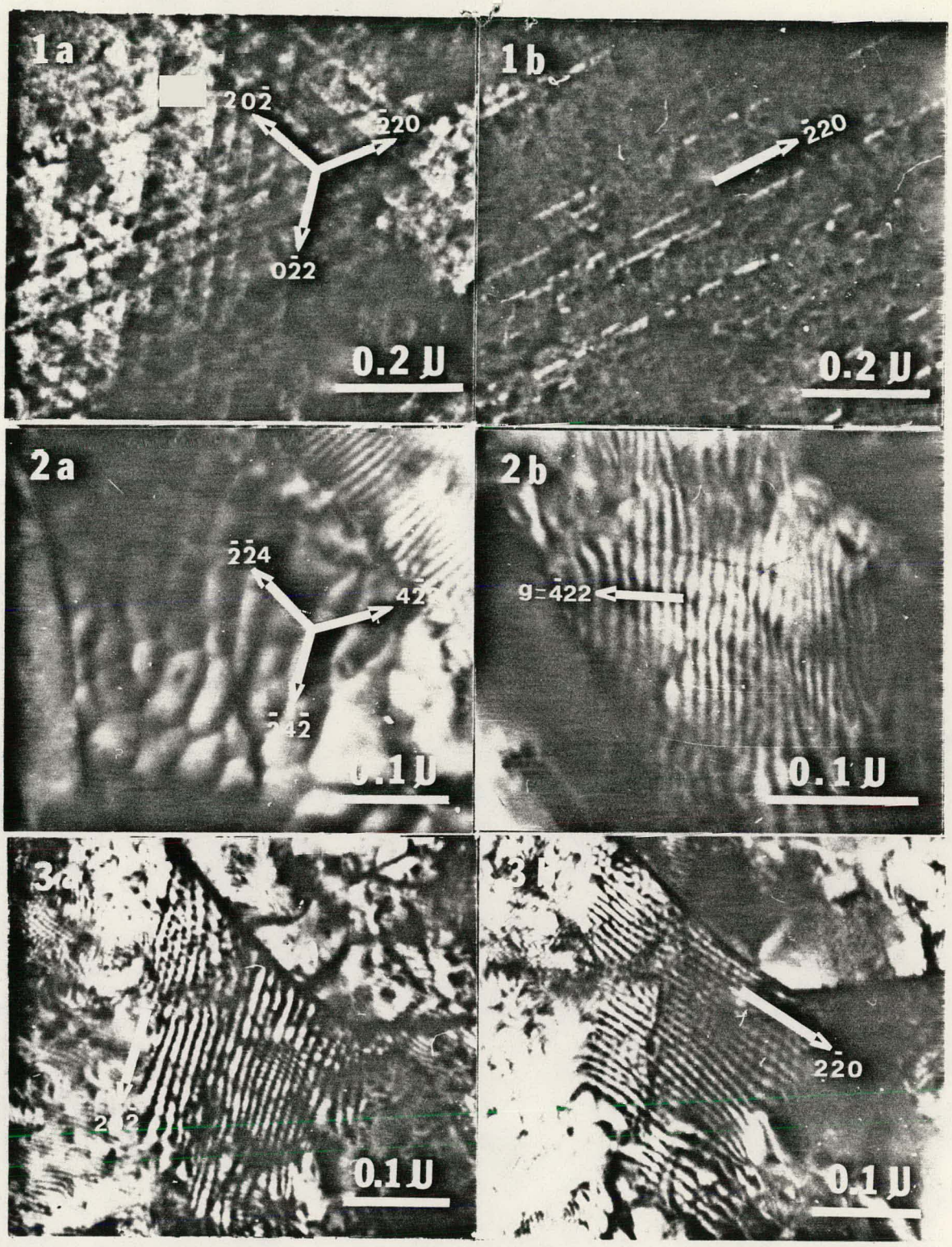

Fig. 1 (a) Type I interfacial dislocation network observed in a 36 Å (111) Pd/(111) Cu bilayer.
(b) Dark field picture taken from different area with $\vec{g} = \bar{1}\bar{1}1$ in [121] Pd zone.

Fig. 2 (a) Type II interfacial dislocation network. 8 Å Pd on Cu.
(b) $\bar{4}22$ reflection dark field from different area. Arrow indicates the invisible set of dislocations.

Fig. 3 (a) 202_0(b) $2\bar{2}0$ dark field micrographs of Type III dislocations. 10 Å Pd on Cu.