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COPPER-BERYLLIUM MICROSTRUCTURES

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Recently, the late R. Shiromizu (1) carried out studies to establish the limits of metastability in the Cu-Be system. Concurrently, we engaged in parallel research, but with a broader emphasis on the microstructures concomitant with quenching, aging and reversion. A complete report covering 0.16 to 2.1 wt.% Be will be published elsewhere; certain unique structures are presented below.

Alloys of >0.8 wt.% Be quenched from the α (f.c.c.) region exhibit weak {110} tweed strain contrast. Direct lattice imaging (2) did not detect discrete particles in this condition, whereas rather high densities of {100} G.P. Zone plates in regular stair-step array were revealed after aging at temperatures well below the G.P.Z. solvus. These zones are not visible by conventional TEM, but their presence is indicated by SAD effects and by the enhancement of the tweed contrast as is seen within grain A of Fig. 1a. However, aging just below the G.P.Z. solvus produces fewer zones and individual platelets can be observed nucleating out of the quenched-in tweed (Fig. 2a). Further aging results in a well-developed random assembly of coherent {100} zones and the apparent disappearance of the tweed (see Fig. 2b). This structure is identical to that found in aged Aℓ-4 wt.% Cu (3).

The tweed is not present in the α regions (marked B) of the discontinuous precipitation nodule seen in Fig. 1a. The nodule, comprised of equilibrium γ (CuBe) plus Be-lean α, heterogeneously nucleated along the grain boundary within grain A and grew into the adjacent grain by the migration of the high-angle boundary. Brief reheating of this structure to just above the eutectoid temperature results in complete reversion of the γ and the G.P.Z. and the subsequent precipitation of β ($\sim$6 wt.% Be); coarse β particles in the former nodule regions and finer particles within the grain proper (Fig. 1b).

Above the G.P.Z. solvus, the tetragonal metastable phase γ" was found to nucleate within the quenched-in tweed matrix both homogeneously and heterogeneously. At temperatures where the latter mode was dominant, dislocation strain fields were the initial nucleation sites. When these were saturated, subsequent nucleation was quasi-homogeneous, displaying a rather unusual "sympathetic" behavior. That is, coherent {100} γ" plates appeared randomly throughout the matrix in groups of 6 in the form of cuboidal configurations (Fig. 3). These in turn became new sites for heterogeneous nucleation. Calculations to rationalize this "multiple homogeneous nucleation" in terms of complex mutual coherency strain field interactions are now in progress (4).

References

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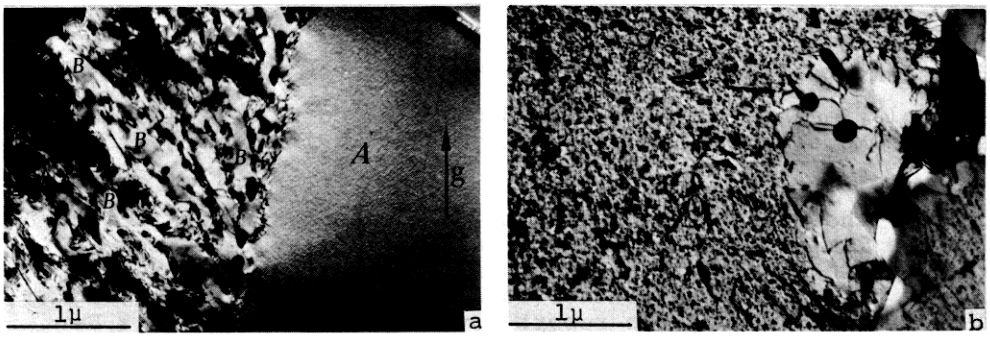

Fig. 1. Cu-2.1 wt.% Be. (a) Iced-brine quenched from 800°C, aged 6 min., 250°C. D.F., $\bar{g}$ = 002, foil [110]. Grain A containing G.P.Z. shows {110} tweed strain contrast. Discontinuous nodule contains Be-lean α(B) plus γ-CuBe. (b) Same treatment as in (a) then reheated to 593°C, held 20 sec. and quenched. Reversion of original structure followed by transformation to α(∿1.5 wt.% Be) plus β(∿6 wt.% Be). Bright field.

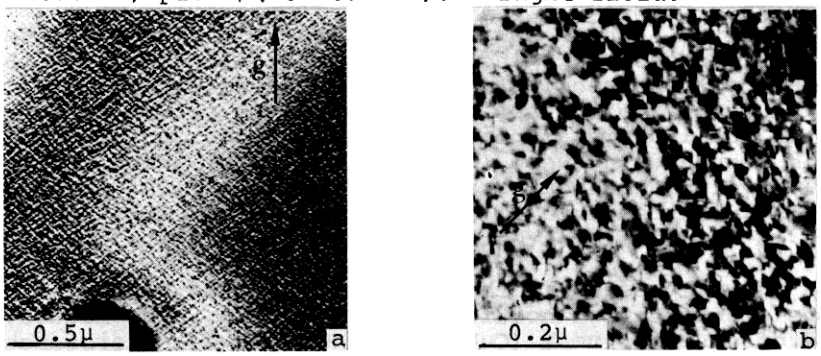

Fig. 2. Cu-2.1 wt.% Be, iced-brine quenched from 800°C. (a) Aged 20 sec., 390°C. B.F. 2-beam image, $\bar{g}$ = 002, foil [110]. (b) Aged 1 min., 390°C. B.F. 2-beam image, foil [010], $\bar{g}$ = 202. Individual (001) and (100) G.P.Z. evident by strain contrast.

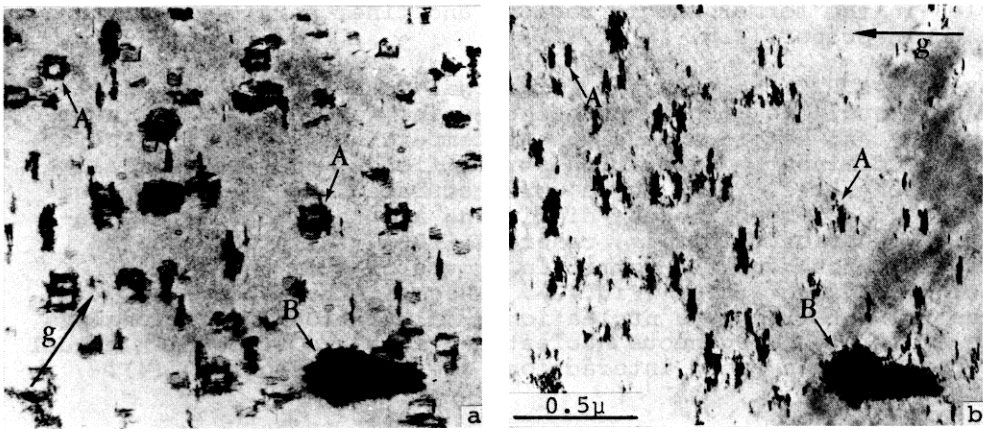

Fig. 3. Cu-1.3 wt.% Be, iced-brine quenched from 800°C, aged 208 hr., 270°C. B.F. 2-beam images, foil [110]. Coherent metastable {100} γ" plates in cuboidal configurations (marked A). (a) $\bar{g}$ = $1\bar{1}1$, all variants in contrast. (b) $\bar{g}$ = 002, only (001) variants in contrast. γ" also precipitated along dislocations (B).