Communications

The γ Phase Boundary of Cu Be Alloys

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The precipitation sequence[1] and metastable phase boundaries of Cu rich-Be alloys recently have been summarized.[2] However, the commonly reported invariant temperature for the γ boundary (605 °C) is in disagreement with some experimental observations. For example, Shiromizu and Mishima[3] reported a γ invariant temperature of 620 °C, while Thomas[4] and Fillnow and Mack[5] reported temperatures of 618 °C and 614 °C, respectively. These were obtained from temperature/time heating curves. The purpose of this work was to establish the position of the γ solvus for four Cu(rich)-Be alloys.

High purity Cu- 1.1, 1.5, 2.0, and 2.2 wt pct Be alloys were prepared in an induction furnace with an argon atmosphere. Chemical analyses were performed *via* atomic absorption and wet chemistry. Several homogenization and rolling treatments were performed until a final thickness of 1 mm was attained. After these treatments, the samples were homogenized at 800 °C for two hours and quenched in brine prior to 2 hour agings at several temperatures above and below the reported γ phase boundary. The furnace temperature was monitored by a Chromel/Alumel thermocouple (ice-brine junction) and was maintained within ±2 °C. The samples were then quenched into water. The resulting crystal structures and microstructures were elucidated by X-ray diffraction (XRD) and transmission electron microscopy (TEM). Differential Scanning Calorimetry (DSC) was performed on a Perkin-Elmer DSC Model 2, calibrated to within 1 °C.

Figure 1 is a DSC plot of the solutionized Cu 2 wt pct Be alloy. Note the presence of an invariant endothermic reaction at about 620 °C. This temperature was obtained for all heating rates less than or equal to 40 °C per minute.[6]

The γ solvi temperatures for alloys Cu-1.1 and 1.5 wt pct Be were determined to be consistent with those in the standard references.[7] Figure 2 shows our data from the X-ray analyses superimposed on the Cu-rich section of the phase diagram. However, the X-ray data for the 2.2 wt pct Be alloy show that the γ invariant temperature is between 614 °C and 624 °C. See also the X-ray results presented in Figure 3. The dotted line plotted in Figure 2 at 620 °C is consistent with the DSC results and X-ray diffraction results.

The resulting microstructures from TEM analyses of a 2.2 wt pct Be alloy after two-hour aging at 610 °C and 630 °C are shown in Figures 4(a) and 4(b). It was noticed that at 610 °C and 614 °C, the resulting microstructures were in the form of a mixture of α (solid solution) and γ grains; whereas, at 630 °C and 624 °C the β phase exhibited a fibrous-like microstructure. Selected area electron diffraction analyses resolved a B2 structure for the γ phase, A2 structure for the β phase, and the A1 structure for the parent phase,* consistent with the X-ray diffraction results.

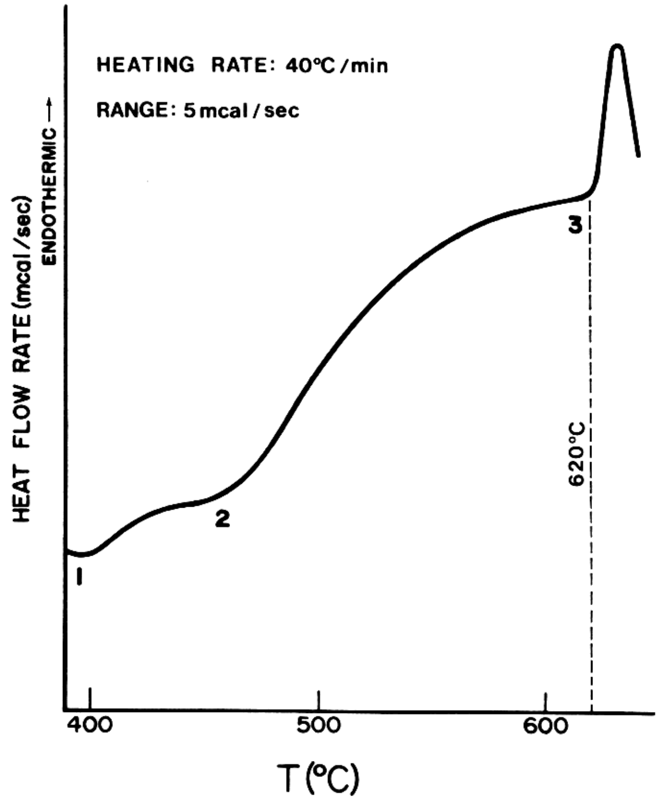

Fig. 1—DSC plot from an as-quenched Cu-2 pct Be alloy. The first and second endothermic reactions correspond to dissolution of GP zones and γ precipitates formed during heating. Notice an endothermic reaction at 620 °C due to the reversion of the γ phase.

*The A1, A2, and B2 phases (in Struckturbericht nomenclature) correspond to the fcc (Cu), bcc (W), and CsCl structures, respectively.

Differences in peak heights in Figure 3 at 614 °C and 610 °C are due to a volume fraction effect as confirmed by optical metallography, *i.e.*, the closer the holding temperature was to the γ invariant, the smaller was the volume fraction of the γ phase due to kinetic and thermodynamic effects. It was difficult to resolve γ peaks at temperatures approaching 620 °C for Cu-2.2 pct Be alloys, with the method here described. This is due to the very small γ volume fraction present at this temperature. Also, at temperatures above 620 °C and below 624 °C, longer aging treatments were necessary to resolve clearly β peaks *via* X-ray analyses.

In summary, this work shows that the γ invariant temperature for Cu (rich)-Be alloys is higher by at least 10 °C than the one generally reported. A more realistic value is 620 °C for the γ invariant as determined by reversion,[3] calorimetric experiments, and diffraction experiments. Our

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Manuscript submitted September 8, 1983.

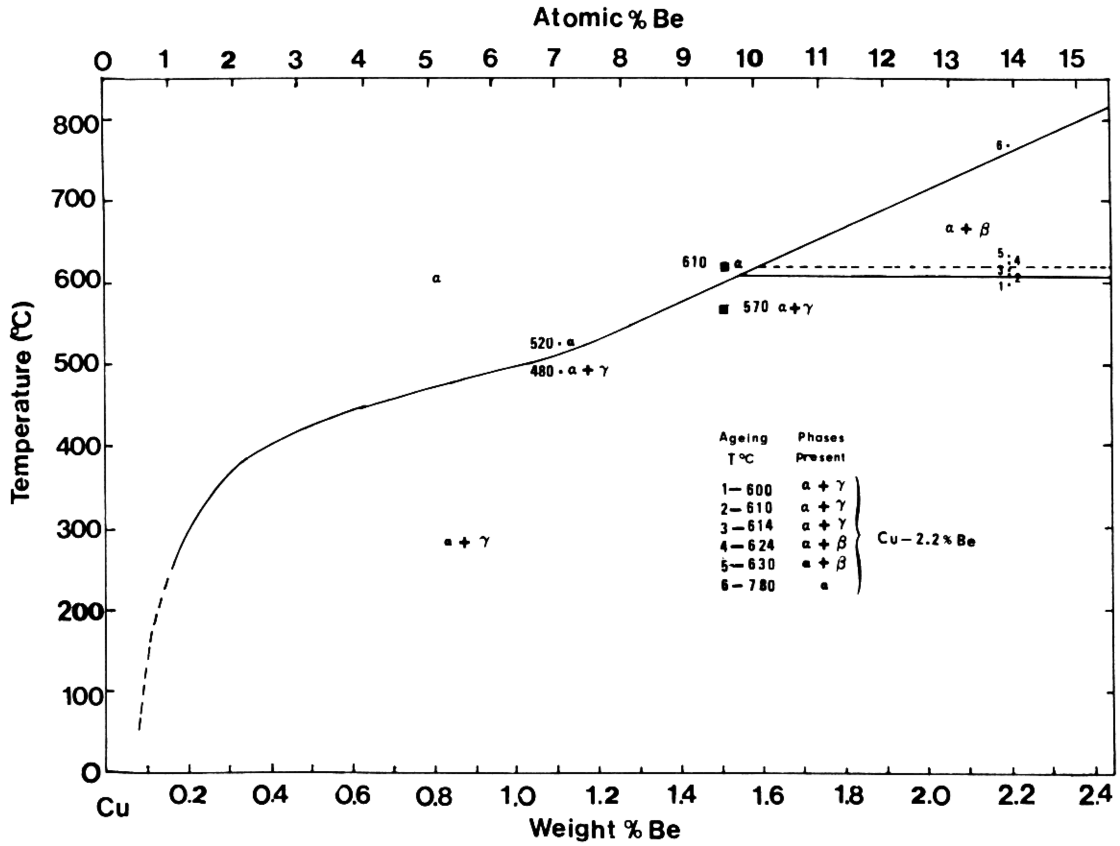


Fig. 2 — Cu (rich)-Be section of phase diagram. Notice temperatures at which aging treatments were performed and resolved phases *via* X-ray diffraction.

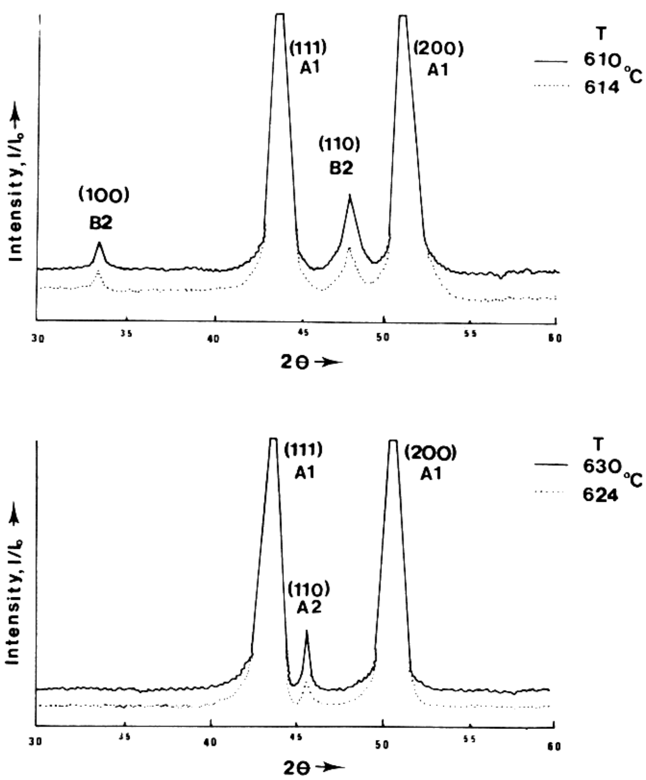
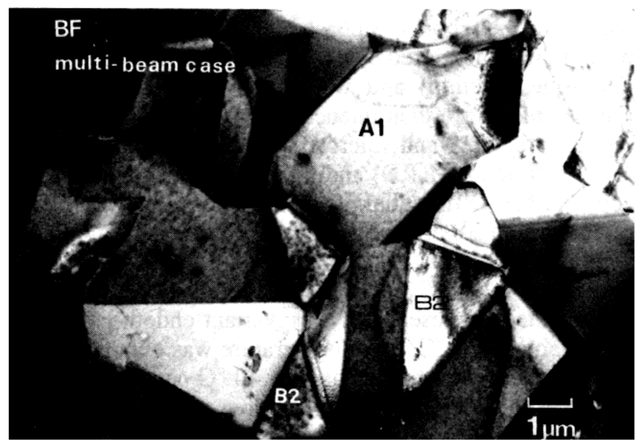
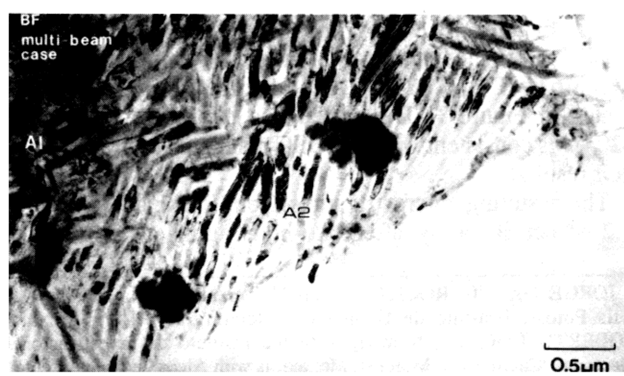


Fig. 3 — Results from X-ray diffraction analyses for a Cu-2.2 pct Be alloy. Notice at 610 °C and at 614 °C the γ (B2, CsCl) and α (Al, fcc) phases are present. At 624 °C and 630 °C the phases present are the parent α (Al, fcc) and the disordered β phase (A2, bcc).



(*a*)



(*b*)

Fig. 4 — (*a*) Cu-2.2 pct Be alloy aged at 610 °C for 2 h. Multi-beam case, bright field (100) γ zone axis. Notice α and γ grains. (*b*) Cu-2.2 pct Be alloy aged at 630 °C for 2 h. Multi-beam case, bright field. Notice a fibrous-like morphology of the β phase. Diffraction patterns from this microstructure were in the form of rings.

experimental results are consistent with the previously reported γ solvus for Cu-1.1 and 1.5 pct Be alloys.

The authors wish to thank the Comision Federal de Electricidad for their financial support to projects 3621, 3675, and 1708 at the Instituto de Investigaciones Electricas, Mexico. Our appreciation is extended to Mr. L. E. Tanner who kindly supplied the alloys examined here. One of the authors, Jorge Garcia-Rocha, thanks the Secretaria de Education Publica, IPN, ESIQIE, and the Instituto de Investigaciones Electricas, Mexico, for scholarships granted. This work was also funded in part by a grant from National Science Foundation (NSF DMR 81-05090).

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