The Columbium-Niobium Phase Diagram

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Abstract

Columbium and Niobium share similar physical and chemical properties but although Niobium is preferred by academic researchers and industry throughout the rest of the world, U.S. industry is reluctant to use Niobium and prefers to use Columbium instead. This study of the Cb-Nb phase diagram indicates that the two metals can be combined to produce a comparable alloy. The properties of the Cb-Nb alloy are independent of composition and therefore the most economic combination of Nb and Cb may be used depending on price and availability. In this way costs can be reduced by the increased competition between Cb and Nb suppliers.

Introduction

Nb and Cb are gaining in importance with their increased use in aircraft alloys, special steels and superconducting composites. Cb has been and still is the preferred of these metals in U.S. industry. Prices are rarely printed for Nb and must be specially requested (these alternative quotes frequently being met with derision). In practice, however, the price of Nb is fixed to that of Cb and there is not a competitive marketplace. The purpose of this study is to investigate the Cb-Nb phase diagram to see if the two metals can be usefully combined.

Experimental

High purity (99.96%) samples of Nb and Cb were combined and homogenized by repeated arc melting under a purified Ar atmosphere. The similarity in atomic number of the two elements made accurate quantitative analysis by x-ray microanalysis very difficult and thus the local chemical homogeneity was not assessed. Average compositions were determined from the initial quantities of Cb and Nb melted. Density measurements on the final ingots were in agreement with the calculated compositions. Standard heat treatment techniques were used to examine the phases present at different temperatures and compositions. Despite the high melting point of the two elements equilibrium was obtained in a remarkably short time even at low temperatures. Phase determination was by x-ray diffraction and quantities were measured from optical micrographs.

Results

The resulting phase diagram is shown in Figure 1. The form of the diagram is similar to that of the Tungsten-Wolfram system. The elements exhibited complete miscibility. There is no solidus-liquidus separation and the only phase observed was the β-Nb-Cb phase. The lattice parameters of the BCC β-phase were independent of composition and identical to those of Nb (a recent listing of Cb values could not be found).

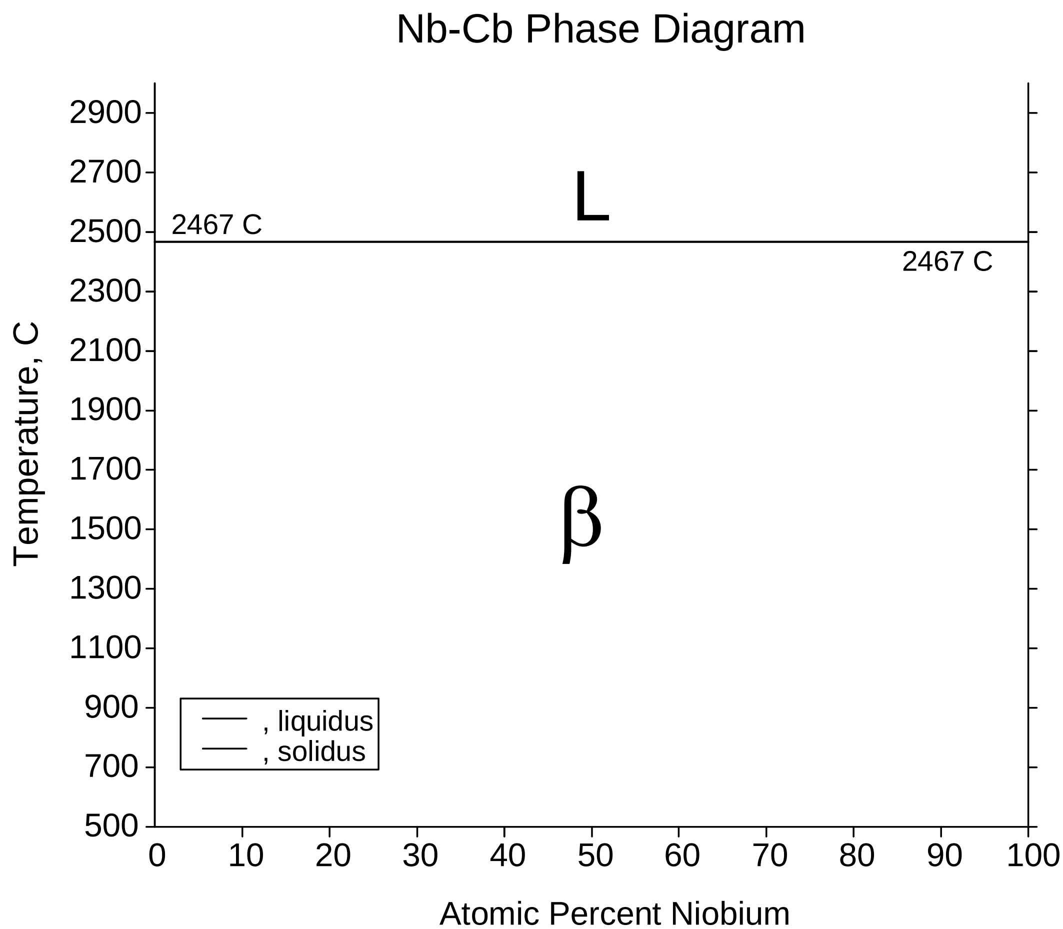

Figure 1. Cb-Nb Phase Diagram

Conclusions

The results of this study indicate that Nb and Cb can be successfully combined with a wide variety of compositions. The lack of a liquidus-solidus separation should prove to be most advantageous when a homogeneous solidification is required. The phase extends over a large composition range and it should be simple to produce a single-phase alloy of these two metals. The use of alloy Nb-Cb rather than pure Cb should not be seen as economically disadvantageous, there are no technical obstacles to overcome and the metals should be no more expensive than each other. This should result in a more competitive marketplace between the manufacturers of Nb and Cb.

Acknowledgments

No researchers have been harmed in the production of this paper, yet.

Additional Suggested Reading

P. E. Childs, “The Curious Case of Columbium,”
http://www.ul.ie/~childsp/CinA/Issue65/TOC43_Columbian.htm