Density and excess volume of the liquid Ti-V system measured in electromagnetic levitation

Benedikt Reiplinger[1] and Jürgen Brillo[1]

[1]Institut f. Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 51170 Köln, Germany

Due to their light weight, high strength, increased ductility, large corrosion resistance, and bio-compatibility, Ti-based alloys have raised significant interest in recent years. They are ideal candidates for operation under extreme conditions, such as high temperature or aggressive chemical environment. $\alpha + \beta$ titanium alloys in particular are of high interest for aerospace applications as well as for medical applications, with vanadium being one of the most prominent β stabilisers. The addition of vanadium can elevate the thermal as well as the corrosive stability of Ti-Al alloys, especially those of lower aluminum content.

The fast-growing interest in these alloys requires precise knowledge of thermophysical properties of the liquid phase as input for process optimization, phase calculation and atomic modelling. Density and the molar volume are two of the most fundamental thermophysical properties. The rather high melting temperatures of titanium and vanadium of 1941K (1668°C) and 2183K (1910°C), respectively greatly complicate their measurement using conventional container-based methods. Due to the highly reactive nature of the liquid Ti-V system, a container-less measurement needs to be implemented in order to avoid any reactions of the investigated liquid with existing container walls. In this work the already established optical dilatometry method is used for the density and molar volume determination of the liquid Ti-V system in electromagnetic levitation [1].

So far, there is not yet any model or rule of thumb in order to predict the molar volume of any liquid alloy, its density, its excess volume, or even the sign of the latter. Titanium alloys generally show a strongly non-ideal behavior with regard to their mixing properties, depending on the alloying element [2]. However, it has been shown that liquid alloys consisting of elements with similar electronic configuration, which is the case for titanium and vanadium, seem to exhibit almost ideal behavior with respect to the molar volume [3]. It is therefore especially interesting to investigate, how Ti-V behaves with respect to the molar volume and density.

The present work uses electromagnetic levitation in order to containerlessly measure density and thermal expansion of Ti-V as function of both, temperature and composition. Thereupon, the molar volume of the Ti-V system is discussed in relation to existing trends predicting the excess volume of metallic alloys. First data is presented.

References

[1] J. Brillo, G. Lohofer, F. Schmidt-Hohagen, S. Schneider and I. Egry, *International Journal of Materials and Product Technology,* 26, 247-73, (2006).

[2]J. J. Wessing and J. Brillo, *The Minerals, Metals & Materials Society and ASM International,* 48, 898-882, (2016)

[3]J. Brillo and I. Egry, *Japanese Journal of Applied Physics,* 50, 1-4, (2011).

Corresponding author: benedikt.reiplinger@dlr.de