

Surface Tension of Liquid Ti with Adsorbed Oxygen and Its Prediction

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Surface tensions of electromagnetically levitated liquid Ti-samples were measured under the influence of oxygen. The partial pressure of oxygen is controlled by means of yttria-stabilized zirconia tubes as well as Ar/H₂/H₂O buffer gas mixtures. In addition, Ti-O samples were prepared by adding different amounts of TiO₂ powder to pure Ti. No significant dependence of the surface tension on the applied oxygen partial pressure was found for the samples processed. However, the surface tension was found to strongly depend on the bulk oxygen mole fraction determined by chemical analysis. The observed dependence of the surface tension on oxygen mole fraction could be described and explained by two models developed in the present work. Both models apply Butler's equation. The first model is based on adsorption/desorption rate equations where it is assumed that mono-atomic oxygen is uniformly distributed in the melt with different concentrations in the bulk and on the surface. Non-ideal interactions $H \neq 0$ between oxygen and titanium are also taken into account as energy barriers that need to be overcome for desorption- as well as migration processes. The second model is an adaptation of Butler's equation to a simple compound forming model where Ti and TiO₂ are assumed the only stable compounds in the melt. Both models excellently agree with the experimental data and also with each other. The first model offers the additional advantage that it can also predict the composition of the surface and the bulk, the surface tension and the equilibrium oxygen partial pressure. Time-dependent non-equilibrium processes are also covered. Other than commonly anticipated it is overall concluded that, due to the strong attractive interaction between Ti and oxygen, the surface tension of Ti is much less sensitive to the presence of oxygen than the surface tension of other metallic systems.