Recent Advances in the Understanding of the Halogen Effect in the Oxidation of Intermetallic Titanium Aluminides

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Titanium Aluminide Alloys are interesting candidate materials for use at elevated temperatures in jet engines, land based gas turbines and automotive engines which is due to their good high temperature mechanical properties and the low specific weight of around 3.8 g/cm^3. A major drawback is, however, their insufficient long-term oxidation resistance at temperatures above 750 – 800°C which is the result of the formation of a mixed TiO_2/Al_2O_3 surface scale with only limited protective effect. Most attempts to improve the high oxidation resistance of these alloys went over the alloy modification route. A rather unconventional approach is the use of the "halogen effect" based on the surface enrichment of halogens and leading to the preferred formation of a pure Al_2O_3 scale of high protective effect at temperatures of up to more than 1000°C (if the optimum halogen dose is used). Several mechanisms have been proposed to explain this effect and the most elaborated one assumes the selective formation of gaseous Al-halogenides at the scale/metal interface which become converted into pure solid Al_2O_3 when diffusing in outward direction along the increasing oxygen partial pressure gradient. In the paper this mechanism will be discussed in detail and compared to the other proposed models. Results from nuclear physics measurement techniques will be shown quantifying the concentration and position of the halogens in the oxide/metal system as a function of exposure time and temperature. These results will be viewed in the light of a thermodynamic model describing the stabilities of the halogens involved. The experimental results and the thermodynamic model contribute to a meanwhile comprehensive even semi-quantitative understanding of the surprising halogen effect in the oxidation of TiAl alloys.