MM 37: Topical Session High Temperature Materials IV

Time: Thursday 10:15–12:00 Location: IFW A

Topical Talk MM 37.1 Thu 10:15 IFW A

Experimental and computational analysis of the solidification path in TiAl-based alloys — •Ulrike Hecht, Julien Zollinger, Anne Drevermann, and Victor Witusiewicz — Access e.V., Intzestr. 5, 52ß72 Aachen, Deutschland

Research into the solidification behavior of TiAl-based alloys focuses on (i) the sequence of phase formation and the associated microsegregation, (ii) the morphological features of the mushy zone and (iii) the effect of solidification on subsequent phase transformations in the solid state. Here we report on experimental and computational work that addresses the solidification kinetics of niobium containing TiAl-based alloys on the background of thermodynamic data. First, we briefly describe the thermodynamic database developed for the ternary system Ti-Al-Nb. This database was used to calculate the solidification path and the associated microsegregation for lever rule and Scheil-Gulliver conditions. Bridgman experiments and phase field simulations of dendritic growth bring further insight, mainly with regard to back-diffusion. Both methods were used to perform a statistic analysis of microsegregation and its evolution along the mushy zone of Ti-45Al-8Nb and Ti-47Al-7Nb. Experimental and computational results will be compared to one another and discussed with respect to the onset of peritectic *(Ti) formation in Ti-Al-Nb alloys.

MM 37.2 Thu 10:45 IFW A

Microstructure Formation during Solidification in Multicomponent Gamma-Titanium Aluminide Alloys — •Michael Oehring[1], Fritz Appel[1], Jonathan Paul[1], Renat Imayev[2], Valery Imayev[2], Viola Küstner[3], and Uwe Lorenz[1] — [1]GKSS Research Centre, Institute of Materials Research, Max-Planck-Str. 1, D-21502 Geesthacht, Germany — [2]Institute for Metals Superplasticity Problems, Russian Academy of Sciences, Khalturin Str. 39, 450001 Ufa, Russian Federation — [3]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, Germany

In order to exploit the potential of gamma titanium aluminide alloys as high-temperature material multicomponent alloys have to be developed that are adapted to industrial processing conditions. TiAl alloys solidifying solely via the beta-phase exhibit characteristic solidification microstructures, which often involve equiaxed instead of columnar structures, weak textures, and modest segregation. These features result from single-phase solidification and the subsequent solid-state transformations. In view of the development of improved cast alloys, the potential of the beta/alpha transformation with respect to microstructural refinement and its dependence on the addition of several alloying elements has been investigated. It was found, that particularly fine and very homogeneous microstructures can be obtained for certain alloy compositions. The microstructural refinement can be attributed to the alloying effect on the kinetics of the beta/alpha transformation and even can be achieved after slow cooling from high-temperature heat treatments.

MM 37.3 Thu 11:00 IFW A

In-situ investigation of crack propagation in γ-TiAl alloys using atomic force, focus ion beam and scanning electron microscopy — •Farasat Iqbal[1], Florian Pyczak[2], and Mathias Göken[1] — [1]Lehrstuhl Allgemeine Werkstoffeigenschaften, Friedrich-Alexander-Universität Erlangen-Nürnberg — [2]GKSS Research Centre Geesthacht, Geesthacht

The present study is focused on crack propagation mechanism in Ti-45Al-1Cr & Ti-45Al-5Nb alloys with lamellar microstructure. Atomic force microscopy (AFM) is a versatile technique to study the crack propagation in-situ. AFM was employed to investigate the local deformations near the crack tip. Scanning electron microscopy (SEM) supplements the in-situ observations and was used to get a basic understanding of the crack propagation path over larger distances.A focused ion beam (FIB) was used to investigate the structures and deformation traces underneath the surface.

It is concluded that the $\gamma/\alpha2$ interfaces act as favorable sites for new interfacial crack nucleation and also for interlamellar crack propagation. Nucleation of new cracks was often preceded by the interaction of deformation twins with interfaces and also by strong shear band activity in the γ-TiAl lamellae visible as significant surface topography in AFM.Mostly the underneath crack path follows the $\gamma/\alpha2$ interface similar to the situation observed at the surface. The local misorientation measured with Electron Backscattered Diffraction (EBSD) shows γ-lamellae as the region of high deformation as compare to neighboring $\alpha2$ -lamellae around the crack tip and its surroundings.

MM 37.4 Thu 11:15 IFW A

Estimation of creep rates from short term tensile test relaxations — •Jonathan Paul, Uwe Lorenz, Michael Oehring, Roland Hoppe, and Fritz Appel — GKSS Research Centre, Geesthacht, Germany

In high temperature applications the creep behaviour of TiAl components can be an important issue. In this respect alloy composition and processing are important factors which need to be optimised so that a proper balance of mechanical properties can be obtained. To obtain a large creep property database requires many tests to be performed at different stress levels and temperatures which of course is both time consuming and expensive.

To overcome this requirement during alloy and processing development, a method of estimating the minimum creep rate at a single temperature but at a series of stress levels from a single short term tensile test including repeated stress relaxations has been developed which is presented in this paper. The experimentally measured minimum creep rates are in reasonable agreement with those predicted from stress relaxation.

MM 37.5 Thu 11:30 IFW A

Investigations of γ-TiAl alloys for industrial application — •Gregor Hullin and Mathias Göken — Institute General Materials Properties, University Erlangen-Nürnberg, Erlangen, Germany

The aim of this work is to improve γ -TiAl alloys for application in automotive engines like turbo chargers or valves. Due to the lower density of TiAl alloys of about 4 g/cm3 the acceleration and the responding characteristics of a turbo charger can be improved. Furthermore the amount of harmful substances in the exhaust gases can be reduced by the elevation of the exhaust temperature. These two facts pose a challenge to find a capable TiAl alloy which has the potential to replace already existing Ni-based superalloys as turbine material. The turbine wheels are fabricated by a newly developed precision casting method. Due to this process high cooling rates can be achieved and therefore a very fine fully lamellar microstructure is produced. This structure in comparison to duplex microstructures has best balance of mechanical properties and is therefore appropriate for the use in turbo chargers. The mechanical properties are determined against casting parameters by doing creep experiments, compression and tensile tests. TiAl alloys remain limited in practical use to about 800°C because of the fast growing non-protective intermixed oxide scale. To make these alloys suitable at elevated temperatures a method to improve oxidation resistance is also under study.

MM 37.6 Thu 11:45 IFW A

Hot-Workability of Gamma-Based TiAl Alloys during Severe Deformation — •Ulrich Froebel — GKSS Research Centre, Institute for Materials Research, Max-Planck-Straße 1, D-21502 Geesthacht, Germany

Gamma-based titanium aluminides are intrinsically brittle up to relatively high temperatures. Inhomogeneous microstructures are particularly harmful in this respect, because critical values of constraint stress can develop after very small strains and lead to premature failure of the material. The structural and chemical homogeneity of components is hence extremely important for engineering applications and is most effectively accomplished by thermomechanical processing. The associated degree of microstructural transformation is determined by the imparted energy that triggers dynamic recrystallization. During traditional metal-forming processes such as extrusion and forging, the strain and thus the imparted energy, is inevitably limited due to geometrical constraints. This often leads to insufficient material consolidation, which is manifested by incomplete recrystallization and significant chemical inhomogeneity. Considerably increasing the deformation strain is therefore necessary to improve the homogeneity of components. In this context the feasibility of cyclic axial deformation, where the sample is deformed alternately in tension and compression or cyclic torsional deformation have been investigated. An assessment of the metallurgical potential of these techniques will be the subject of this presentation.