MM 31: Topical Session High Temperature Materials II

Time: Wednesday 14:45–16:30 Location: IFW A

Topical Talk MM 31.1 Wed 14:45 IFW A

Single-crystal nickel-base-superalloys: Correlation between high temperature properties and microstructure — •Thomas Link[1], Alexander Epishin[1], Udo Brückner[2], and Bernard Fedelich[2] — [1]Technical university Berlin, Germany — [2]Federal institute of material reasearch and testing Berlin, Germany

Nickel base-superalloys have a two phase microstructure: a disordered matrix hardened by 70 vol% of ordered precipitates. The strength depends on the properties of both phases but also on their morphology and on the condition of the interface. Dendritic solidification results in dendritic stresses, the different lattice spacings of both phases in coherency stresses. The morphology is described quantitatively and the stresses measured by X-ray diffraction. During high temperature creep deformation the morphology of the ordered phase transforms from cuboids to plates, the coherency stresses relax by interfacial dislocation networks and vacancy generation results in polyedrical pores. These processes are analysed by X-ray-diffraction, SEM, TEM and synchrotron X-ray tomography. Primary, secondary and tertiary creep are analysed by image analysis, TEM and molecular dynamics. Description of the plastic deformation needs microstructurally based models, which consider the evolution of the microstructure during service. A method, to characterise the relevant microstructural parameters is presented. The results of microstructurally based modelling are shown and a brief outlook on material development is given.

Topical Talk MM 31.2 Wed 15:15 IFW A

Atomic site location by channelling enhanced microanalysis (ALCHEMI) in gamma-prime strengthened Ni- and Pt-base alloys — Christian Liebscher, Rainer Völkl, and •Uwe Glatzel — Metallische Werkstoffe, Universität Bayreuth, D-95440 Bayreuth

The additions of alloying elements to Ni- and Pt-base alloys influence the micro structure and thereby the creep properties, whereas the mechanism is uncertain. Therefore atomic site location by channeling enhanced microanalysis (ALCHEMI) was used to determine the site partitioning of ternary and quaternary alloying elements in the L12-ordered gamma-prime phase. Two ternary Ni*Al alloys with Cr and Ti additions were investigated. The measured site partitioning showed that Cr and Ti atoms prefer the Al-sub lattice sites. For a ternary Pt*Al*Cr alloy, it was found that Cr atoms occupy Al sites. The influence of Ni as a fourth alloying element in a Pt*Al*Cr*Ni alloy on the site partitioning was also investigated. The detected results give evidence that in the quaternary alloy Cr and Ni atoms prefer the Pt sub lattice. First principles calculations were used to support the experimental data.

MM 31.3 Wed 15:45 IFW A

Temperature dependence of the lattice misfit of rhenium and ruthenium containing nickel-base superalloys — •Steffen Neumeier[1], Sigrid Schwub[1], Florian Pyczak[2], and Mathias Göken[1] — [1]Department of Materials Science & Engineering, Institute I, University Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Institute for Materials Research, GKSS Research Centre Geesthacht, Geesthacht 21502, Germany

To improve the temperature capability of nickel-base superalloys an increasing amount of refractory alloying elements, especially rhenium (Re) and ruthenium (Ru) has been added during the last decades. These 4th generation nickel-base superalloys possess an increased lattice misfit between the γ- and γ'-phase. Since the lattice misfit varies with temperature and its magnitude is decisive for the evolution of the γ/γ'-microstructure during creep deformation the lattice misfit of several experimental alloys with systematically varied contents of Re and Ru was investigated at temperatures up to 1100 °C using high-resolution X-ray diffraction. It was found that the lattice misfit depend strongly on the chemical composition of the alloys and the partitioning behavior of the alloying elements. Measurements of the hardness of both phases by nanoindentation in an atomic force microscope correspond well with the partitioning behavior. Also the temperature dependence of the lattice misfit is modified by Re and Ru. The change of the lattice misfit with temperature is significantly smaller in all Re-containing alloys compared to Re-free alloys and even less pronounced in Ru-containing alloys.

MM 31.4 Wed 16:00 IFW A

Thermodynamic calculations on the Pt-Al-Ni-Cr alloy system — •Johannes Preussner, Rainer Völkl, and Uwe Glatzel — Metallische Werkstoffe, Universität Bayreuth, Germany

Creep, oxidation and corrosion resistant platinum base alloys with room temperature ductility have been developed for high temperature applications. In this talk a thermodynamic modelling of the Pt-Al-Cr-Ni system will be presented with special focus on the Pt-rich side. The Cr-Pt binary system has been reassessed with the CALPHAD method, based on experimental data and first principles calculations. The four ternary alloy systems will be presented and compared with experimental data available. A four sublattice model has been chosen to describe the ordering reactions between the high temperature fcc phase and the low temperature L12 and L10 phases, which are stable at many different concentrations throughout a wide range of the Pt-Al-Cr-Ni alloy system.

MM 31.5 Wed 16:15 IFW A

Modelling of topologically close packed phases in Ni-based superalloys based on thermodynamic and kinetic CALPHAD calculations — •Ralf Rettig and Robert F. Singer — Institute of Science and Technology of Metals, Department of Materials Science and Engineering, University of Erlangen, Martensstr. 5, D-91058 Erlangen, Germany

Single crystal Nickel-based superalloys are important high temperature load bearing materials used in particular for turbine blades in industrial gas turbines and aero engines. These materials show unique high-temperature properties up to high homologous temperatures. Nevertheless modern superalloys are often susceptible to brittle topologically close packed (TCP) phase formation. The aim of the current development of gas turbines is to reduce carbon dioxide emission and fuel consumption and therefore to increase efficiency. To achieve that, the firing temperature has to be increased and materials have to be found that are capable of enduring higher temperatures. Prospective candidates are single crystal superalloys with additions of rhenium and ruthenium. In this study computer modelling based on thermodynamic and kinetic CALPHAD calculations is used to systematically explore the mechanisms of phase stability regarding TCP phase formation in complex single crystal superalloys containing rhenium and ruthenium. Methods are developed for quantitative prediction of TCP phase fractions in dependence of time, temperature and alloy composition and an evaluation with experimental results is presented.