MM 25: Topical Session High Temperature Materials I

Time: Wednesday 10:15–12:15 Location: IFW A

Topical Talk MM 25.1 Wed 10:15 IFW A

Intermetallic phases for structural applications at high temperatures — •Martin Palm — Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Str. 1, D-40237 Düsseldorf, Germany

Intermetallic phases - intermetallics for short - have evolved within the last 25 years from being only of interest to scientists because of their sometimes peculiar crystallographic structures and fascinating physical properties, to form the basis for a new class of materials that have proven their capability to be used for structural applications up to very high temperatures and in demanding environments. In general intermetallics often have relatively high melting temperatures, sometimes above those of the constituting elements, and in addition they may offer other attractive properties such as an outstanding corrosion resistance, remarkable low density and superior mechanical properties. Therefore, a considerable number of material developments have taken place in order to exploit their potential for structural applications at high temperatures. In the focus of these developments were the aluminides, namely Ni3Al, NiAl, Ti3Al, TiAl, Fe3Al and FeAl, though also silicides and some more specific intermetallics have gained attention. The presentation will give an overview about properties which make intermetallics that attractive for high temperature applications, a summary on individual material developments such as gamma titanium aluminides as well as addressing current research issues.

Topical Talk MM 25.2 Wed 10:45 IFW A

Deformation Behavior of Mo-Si-B Alloys — •Sharvan Kumar — Division of Engineering, Brown University, Providence, RI 02912, USA

Mo-rich Mo-Si-B alloys are being considered as possible candidates for ultra-high-temperature applications and therefore properties of interest include strength and ductility, toughness and fatigue response of both, the multiphase alloys as well as the Mo solid solution phase. In this presentation, the tensile and compressive creep response of two- and three-phase alloys, crack growth behavior during monotonic and cyclic loading, as well as the contribution of creep in adversely affecting fatigue response will be discussed. These studies helped identify regimes where the microstructure ahead of the crack tip revealed several instabilities including recrystallization, grain growth and creep cavitation. Further, it became apparent from these studies that the Mo(Si,B) solid solution plays a dominant role in influencing toughness and creep resistance, and therefore mandated detailed examination in isolation. Tensile studies on the single phase Mo-Si-B solid solution phase has confirmed dynamic strain aging (DSA), and comparative studies on pure Mo (containing comparable levels of O and C) point to the important role of B and Si in solution on DSA in the solid solution alloy. The presentation will close with a brief discussion on the more recent advances in this alloy system and the challenges, barriers and potential for further development.

MM 25.3 Wed 11:15 IFW A

Herstellung und Charakterisierung von einkristallinen lamellaren und faserverstärkten Werkstoffen in den Systemen Cr-Cr_3Si und NiAl-Mo(Cr) — •Titus Haenschke[1], Martin Heilmaier[2], Easo George[3] und Manja Krüger[1] — [1]Otto-von-Guericke-Universität, Institut für Werkstoff- und Fügetechnik, 39104 Magdeburg, Deutschland — [2]TU Darmstadt, Physikalische Metallkunde, 64287 Darmstadt, Deutschland — [3]Oak Ridge National Laboratory, Metals and Ceramics Division, Oak Ridge, TN 37831-6093, USA

Gerichtet erstarrte Legierungen in den eutektischen Systemen NiAl-9Mo, NiAl-34Cr und Cr-Cr_3Si sind vielversprechende Kandidaten, um Nickelbasis-Superlegierungen in konstruktiven Hochtemperaturanwendungen zu ersetzen. Im Rahmen dieser Arbeit wurden NiAl-X-Kristalle mit Wachstumsgeschwindigkeiten von 20 und 80 mm/h und Cr-Cr_3Si-Kristalle mit 60, 120 und 160 mm/h gezüchtet. REM-Analysen des Gefüges zeigten bei den NiAl-X-Systemen in Schnitten senkrecht zur Kristallwachstumsrichtung eine faserverstärkte gleichmäßige Struktur. EBSD-Analysen zeigten jedoch, dass nicht immer wie erwartet Einkristalle hergestellt werden konnten. Bei den Cr-Cr_3Si-Kristallen liegt eine gut ausgebildete lamellare Struktur vor. Die Durchführung von Drei-Punkt-Biege- und Druckversuchen bei verschiedenen Temperaturen diente zur Ermittlung mechanischer Kennwerte und der Spröd-Duktil-Übergangstemperatur. An gebrochenen Biegeproben fanden REM-Untersuchungen der Bruchfläche statt. Erste Druckversuche unter konstanter Spannung dienen der Abschätzung des zu erwartenden Kriechwiderstandes der untersuchten Werkstoffe.

MM 25.4 Wed 11:30 IFW A

Structure, Chemical Stability and Properties of NiAl-Al2O3 Interface Modified by hBN and MAX-Phase Interlayers — •Jia Song, Weiping Hu, Yunlong Zhong, Hao Chen, and Günter Gottstein — Institut für Metallkunde und Metallphysik, Kopernikus Strasse 14, 52056 Aachen, Germany

The interlayers from different materials were used in order to modify the interface structure/property and to improve the mechanical properties of NiAl composites reinforced by continuous single crystal Al2O3 fibers. It was found that the interface without interlayer had a good chemical stability during hot pressing (sample fabricating), resulting in high interface shear strength (about 250 MPa) at RT. But for the composites with interlayers, chemical reactions occurred in the interfacial area during diffusion bonding. In the interfacial area with a hBN interlayer the chemical reaction between BN and NiAl led to the formation of an AlN sublayer and precipitation of nanocrystalline NiAl particles in hBN. The interface shear strength is about 70 MPa. For composites with the V2AlC interlayer, chemical reactions resulted in a complete decomposition of interlayer and formation of varied reaction products. The corresponding interface strength is about 32 MPa. For the case of Cr2AlC interlayer, it was transformed into two sublayers: C-rich sublayer on the fiber side and Cr-rich sublayer next to the matrix. Fine Al2O3 and carbon particles were precipitated in the Cr-rich sublayer and in the Al2O3 fiber respectively. The interfacial shear strength is about 110 MPa. The possible influences by introducing the interlayers on mechanical performance of NiAl composites are discussed.

MM 25.5 Wed 11:45 IFW A

High Temperature Stability of Nanostructured Amorphous Si-C-N Materials — Wolfgang Gruber and •Harald Schmidt — TU Clausthal, Institut für Metallurgie, AG Materialphysik, Germany

Polymer-derived Si-C-N ceramics are a new class of multifunctional high temperature materials with applications in various branches of technology. After synthesis, these materials consist of amorphous nanodomains which are expected to have a crucial importance for the extraordinary high temperature stability. Annealing at temperatures above 1400 °C leads to formation of nanocrystalline precipitations. We investigated the thermal stability, nanodomain growth and crystallization behaviour of these ceramics using XRD and small angle scattering techniques as well as diffusion studies. A model based on diffusion controlled nanodomain growth is proposed to explain the high temperature stability.

MM 25.6 Wed 12:00 IFW A

Microstructure and properties of Co-Re-based experimental alloys for high temperature applications — •Debashis Mukherji[1], Joachim Rösler[1], Rainer Hüttner[2], Uwe Glatzel[2], Timo Depka[3], Christoph Somsen[3], Gunther Eggeler[3], Manja Krüger[4], and Martin Heilmaier[4,5] — [1]Technische Universität Braunschweig, Braunschweig, Germany — [2]Universität Bayreuth, Bayreuth, Germany — [3]Ruhr-Universität Bochum, Bochum, Germany — [4]Otto-von-Guericke-Universität Magdeburg, Magdeburg, Germany — [5]Technische Universität Darmstadt, Darmstadt, Germany

New high temperature materials are needed to substitute Ni-base superalloys above 1200°C. Co-Re based alloys are being developed at TU Braunschweig, for this purpose. Re (high melting) forms a continuous solid solution with Co and increases melting point of Co-alloys. Various hardening mechanisms is explored in Co-Re-Cr-C system; namely solid solution hardening by Re, precipitation strengthening by carbides and composite strengthening by - hard (Re-rich) and soft (Co-rich) phases. Unlike in the conventional Co-alloys, where the matrix is fcc, in Co-Re alloy the matrix is hcp phase. The morphology and distribution of second phases are important parameters for effective strengthening. For application in gas turbine the long term stability of the microstructure and high temperature mechanical properties are important. Study of microstructure stability and mechanical properties at high temperatures on two experimental alloys Co-17Re-23Cr and Co-17Re-23Cr-2.6C [compositions in at%] will be presented.