MM 15: Mechanical Properties III

Time: Monday 15:45–17:00 Location: H 0106

MM 15.1 Mon 15:45 H 0106

Microstructure and mechanical properties of γ' hardened Cobalt-base superalloys — •Steffen Neumeier, Alexander Bauer, and Mathias Göken — Institute I: General Materials Properties, University of Erlangen-Nürnberg, Germany

The material of choice for components in gas turbines like turbine blades and discs are Nickel-base superalloys. Due to their excellent mechanical properties, corrosion and oxidation resistance, they can bear high loads in harsh environments at high temperatures. The reason for the extraordinary mechanical strength at temperatures up to 80% of the melting temperature is the two-phase microstructure with a high volume fraction of the intermetallic γ' phase Ni_3Al ($L1_2$ crystal structure) coherently embedded in the γ phase, a face centered cubic Ni solid solution. Conventional solid solution and carbide hardened Cobalt-based alloys possess even a superior corrosion resistance, but they can be used only for low-loaded parts. In contrast to Nickel-base superalloys a similar γ/γ' microstructure, stable at high temperatures, could not be obtained in Cobalt alloys until the recent discovery of Sato et al. They found a stable γ' phase (Co_3(Al,W) with $L1_2$ crystal structure) in the ternary Co-Al-W system which has led to a new class of γ' hardened Co-base superalloys. In this paper the microstructure of several γ/γ' Co-base superalloys will be presented along with the mechanical properties at high temperatures. Creep experiments have shown that the creep strength is by far higher than that of conventional Cobalt based alloys and comparable to Nickel-base superalloys.

MM 15.2 Mon 16:00 H 0106

Modeling of anisotropic elasto-plastic material behavior with the phase-field method — •Daniel Schneider[1], Jan Höhn[2], Michael Selzer[1,2], Alexander Vondrous[2], and Britta Nestler[1,2] — [1]Institute for Applied Materials - Reliability of Components and Systems, Karlsruhe Institute of Technology — [2]Institute of Materials and Processes, Karlsruhe University of Applied Science

An extended phase-field model is formulated incorporating a formulation for elastic and anisotropic plastic effects ones on the evolution of microstructures. Thereby, the displacement field is computed by solving the local momentum balance dynamically. In order to calculate the plastic strain, a plasticity model is implemented consisting of an associated flow rule in combination with an anisotropic yield criterion and a linear hardening approximation.

Simulations with simple loads are performed illustrating the dynamic evolution of the stress and plastic strain in both, single phase systems as well as polycrystalline structures. Further, we present simulations of micro crack propagation induced by external forces with and without plastic deformations.

MM 15.3 Mon 16:15 H 0106

Theoretical study of dislocations in perovskite oxides — •Pierre Hirel[1,2], Matous Mrovec[1,2], and Christian Elsaesser[1,2] — [1]IAM-ZBS, Karlsruhe Institute for Technology, Engelbert-Arnold-Straße 4,76131 Karlsruhe (Germany) — [2]Fraunhofer-Institut für Werkstoffmechanik IWM, Wöhlerstr. 11, 79108 Freiburg (Germany)

Perovskite oxides such as barium-strontium titanate, lead zirconate-titanate, or potassium-sodium niobate are a technologically important and scientifically exciting class of materials. Many perovskites are ferroelectric and possess high dielectric constants, which make them attractive for modern microelectronic applications. A successful implementation however requires not only information about the intrinsic functional properties but also a thorough understanding of crystal defects that influence the functionality as well as the mechanical and structural stability of such components.

In the present work we investigate the properties of dislocations in perovskite materials by means of atomistic simulations, using both the highly accurate first-principles calculations and computationally efficient classical interatomic potentials. We analyze the structures of dislocation cores in comparison to high-resolution transmission electron microscopy observations. The calculated Peierls energies and stresses for these dislocations under different applied loads give insight into their mobilities and are related to their macroscopic mechanical behavior.

(1) P. Hirel et al., Acta Mater. 60 (2012) 329

MM 15.4 Mon 16:30 H 0106

Mechanical spectroscopy and dislocation dynamics on Al_2O_3 particle reinforced Al-Mg-Si (AA6061) Alloys — •Jens Bernhardt and Hans-Rainer Sinning — Institut für Werkstoffe Technische Universität, Braunschweig, Germany)

Damping measurements using the vibrating-reed technique were carried out on an industrially used Al-Mg-Si (AA6061) alloys and also on 22 % Al_2O_3 particle-reinforced AA6061. Three different maxima in damping were found over a temperature range from 100 K to 800 K. Two damping peaks, located between 100 K and 400 K, are clearly related to the plastically deformed state of the material. Cold rolling of homogenized, unreinforced AA6061 gave rise to a broad damping peak with a visible substructure. In plastically deformed fcc metals, this peak is well known as Hasiguti Peak and is related to an interaction between dislocations, point defects and the crystal lattice. For the reinforced, homogenized and undeformed alloy a similar broad peak was observed after a subsequent heat treatment. In this case the microplastic deformation due to the misfit between the thermal expansion coefficient of matrix and the reinforcing particles is responsible for the emergence of the peak in damping. A further discussion of damping peak properties should reveal more detailed information about the underlying mechanisms and therefore about the influence of the reinforcing phase on dislocation dynamics.

MM 15.5 Mon 16:45 H 0106

Relaxor properties of pure and cerium doped calcium barium niobate — •Chandra Shekhar Pandey[1], Jürgen Schreuer[1], Manfred Burianek[2], and Manfred Mühlberg[2] — [1]Institute for Geology, Mineralogy and Geophysics, Ruhr-University Bochum, Germany — [2]Institute for Crystallography, University of Cologne, Germany

Lead-free relaxors Sr0.61Ba0.39Nb2O6 (SBN-61) crystallizing in the partially filled tetragonal tungsten bronze (TTB) structure types have attracted much interest because of their outstanding properties. Calcium barium niobate, CaxBa1-xNb2O6 (CBN-x), also belongs to the partially filled TTB structure family having high Tc at ~ 537 K. However, its relaxor behavior have not yet been reported.

We studied the elastic properties of pure and Ce doped CBN-28 (congruently melting; Czochralski grown) between 300K-1503K using resonant ultrasound spectroscopy. The relaxor phenomena for as-grown CBN single crystals was further explored by thermal expansion measurements, which revealed the characteristic temperatures Tb (Burns temperature, initiation of polar naonoregions PNRs), T* (temperature for first freezing of PNRs), and Tm at ~1100 K, ~800 K, and ~600 K, respectively [1]. These findings were confirmed by characteristic elastic anomalies. Cerium doping in pure CBN results in significant lowering of Tc and Tb; however, the intermediate temperature T* remains almost the same [2].

[1] C. S. Pandey, et. al., Phys. Rev. B 84, 174102 (2011). [2] C. S. Pandey, et. al., Appl. Phys. Lett. (Accepted).