MM 53: Structural Materials (Steels, light-weight materials, high-temperature materials) - II

Time: Thursday 11:45–13:15 Location: BAR 205

MM 53.1 Thu 11:45 BAR 205

Impact of Microstructural Engineered Steels on Micro Tensile Testing — •Jonas Kutschmann[1], Thomas Pretorius[2], Andreas Offergeld[2], and Gerhard Wilde[1] — [1]Institute of Materials Physics, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, D-48149 Münster — [2]thyssenkrupp Steel Europe AG, Kaiser-Wilhelm-Straße 100, D-47166 Duisburg

Mechanical properties of different microstructures of steels are characterized by micro tensile tests and compared to other mechanical testing methods. Out of the heavy plates, provided by thyssenkrupp, miniaturized specimens with a dog-bone shape contour were cut. The specimen dimensions have a constant gauge length of 4mm, the gauge cross-section has a dimension of around 0.5 x 0.5mm^2. The microstructure was modified by annealing treatment. The tensile test results are correlated to Vickers hardness measurements, average grain sizes by EBSD and macro tensile tests for the ultimate tensile strength.

All steels show a linear correlation between Vickers hardness and tensile strength. The Hall-Petch relation generally states that an increasing grain size leads to a lower yield strength. A critical grain size is reached when the average grain size gets close to the cross-section dimensions of the gauge. Possible deviations from the linear behavior of the Hall-Petch relation or a more pronounced decrease in yield strength in that regime are discussed.

MM 53.2 Thu 12:00 BAR 205

Alloying impact on phase stability in $ZrAl_3$ — •Dominik Gehringer[1], Florian Schmid[2], Stefan Pogatscher[2], and David Holec[1] — [1]Department of Materials Science, Montanuniversität Leoben, Franz-Josef-Strasse 18, A-8700 Leoben, Austria — [2]Christian Doppler Laboratory for Advanced Aluminium Alloys, Chair of Nonferrous Metallurgy, Montanuniversität Leoben, Franz-Josef-Strasse 18, A-8700 Leoben, Austria

During homogenization, Al_3Zr-particles precipitate out of supersaturated Zr-alloyed aluminum alloys and serve for grain size stabilization via Zener drag and can contribute to an increased strength. Al_3Zr exhibits three different crystal structures, $L1_2$, $D0_{22}$ and $D0_{23}$ but only the $L1_2$ shows a favorable coherent interface with the aluminum matrix. Here we present an *ab initio* study of alloying impact on their stability by considering 16 doping elements. Three criteria were considered: site preference for the alloying elements, formation energies and stacking fault energies acting as a kinetic stabilization complementing the alloy design based solely on thermodynamics. In our contribution we will present the above described analysis in detail together with the suggested novel alloys. These predictions will be corroborated by our preliminary experimental results.

MM 53.3 Thu 12:15 BAR 205

Overcome the strength-ductility trade-off in steels by a novel short-range ordering strengthening concept — •Wenwen Song and Wolfgang Bleck — Steel Institute (IEHK), RWTH Aachen University

The enhancement of mechanical properties is of great importance for the modern steels design. By adopting the conventional strengthening mechanisms, strength can increase substantially, albeit at the expense of formability. In the present work, we propose a new pathway to overcome the strength-ductility trade-off by employing a novel short-range ordering (SRO) strengthening concept. The formation of the SRO in an Al-alloyed high-Mn steel was investigated by means of a combined method of ab initio calculations and various experimental approaches, e.g. in-situ high-energy synchrotron X-ray diffraction (SYXRD) and small angle neutron scattering (SANS). The results for the first time prove the presence of SRO in Fe-Mn-Al-C lightweight steels experimentally. The quantum mechanics based ab initio calculations provide an explanation of the SRO formation mechanism in Fe-Mn-Al-C steels. By an appropriate SRO formation control, the strength and ductility are enhanced either individually or simultaneously, which distinguishes the SRO strengthening concept from other conventional strengthening mechanisms. This SRO strengthening concept seems a promising strategy to overcome the strength-ductility trade-off and be further adopted in the current available continuous annealing production lines in the industry.

MM 53.4 Thu 12:30 BAR 205

Residual stresses in additively manufactured aluminum alloys — •Marc-André Nielsen[1], Emad Maadwad[1], Dieter Lott[1], Peter Staron[1], Sabine Bodner[2], Gerald Resch[3], Jozef Keckes[2], and Martin Müller[1] — [1]Institute of Material Research, Helmholtz-Zentrum Geesthacht, Germany — [2]Erich Schmid Institute, Montanuniversität Leoben, Austria — [3]Resch GmbH, Glojach, Austria

Additive manufacturing opened up new ways to produce parts with high geometric complexity, e.g. involving internal structures, leading to an increased interest in science and industry in the recent years. The mechanical behavior and load-bearing capacity of additively manufactured components, however, is still not really understood and subject of intensive research efforts. In particular, residual stresses (RS) play an important role e.g. for strength and fatigue properties. Therefore, RS distributions were investigated in various parts, fabricated from aluminium alloy powder (AlSi10Mg) using the Selective Laser Melting (SLM) technique. The produced samples consist of simple walls with a wall thickness of about 3 mm and different geometries involving, e.g., different edge curvatures. Residual stress fields were determined using high-energy X-ray diffraction. The diffraction studies were carried out in transmission geometry using a photon energy of 87.1 keV. The high energy allows to penetrate thicker samples. The influence of specimen geometry and production parameters on the RS state will be discussed and the RS in the investigated aluminum alloy will be compared with RS in 316L steel.

MM 53.5 Thu 12:45 BAR 205

Oxide Breakdown and Anodic Corrosion of Nickel Base Alloys — •Dominik Dworschak, Hsiu-Wei Cheng, and Markus Valtiner — TU Wien, Applied Physics, Vienna, AT

Transpassive and pitting corrosion behaviour of advanced materials such as nickel base alloys (NBAs) determines corrosion resistance in extreme environments. While Cr and Mo enhanced passivity is well characterized, mechanism of transpassive dissolution as well as pitting and subsequent repassivation, e.g. occurring during active corrosion or pickling, are unclear. Here, elemental dissolution currents during high anodic polarization and repassivation of a series of nickel base alloys were quantified using an ICP-MS flow cell. At high anodic potentials non-stoichiometric and decelerated dissolution rates depend on the selective segregation/dissolution of alloying elements and transpassive passive film formation. Oxide breakdown depends on the solution chemistry and local pH that establishes during dissolution. Samples after corrosion experiment were examined by X-ray photoelectron spectroscopy and high spatial resolution synchrotron X-ray fluorescence to revealing local nickel depletion, while chromium and iron were enriched in corroded areas. We also discuss the influence of ICP-MS cell design on the corrosion mechanism and hence on obtained results.

MM 53.6 Thu 13:00 BAR 205

Impact of paramagnetism on grain boundary energetics in FeMn — •Omkar Hegde, Tilmann Hickel, Christoph Freysoldt, and Jörg Neugebauer — Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Straße 1, 40237 Düsseldorf, Germany

To understand the impact of the magnetic disorder on defect energetics and kinetics is, though conceptually and computationally challenging, important for designing Fe-based alloys. Since magnetic degrees of freedom change faster than atomic degrees of freedom in the high-temperature paramagnetic state, the atoms move according to an averaged force instead of instantaneous forces attained from each spin configuration.

Therefore, a new computationally efficient method based on spin-space averaging [1] (SSA) has been developed to handle magnetic disorder next to defects. First, we focus on the vacancies in FeMn system, for which we demonstrate that paramagnetism significantly affects atomic relaxations as well as diffusion barriers and thereby we explain why Mn diffusion shows a different temperature dependence than Fe-self diffusion in α-Fe. Next, we expand our method to extended defects and present the impact of paramagnetism on the grain boundary energetics of Mn in FeMn. Finally, we combine our results to propose a pathway for Mn segregation to grain boundaries.

[1] F Körmann, A Dick, B Grabowski, T Hickel, and J Neugebauer, Phys. Rev. B 85(12):125104, (2012).