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ABSTRACTS – GROUP 3

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ABSTRACTS – GROUP 3

LIGHT MATERIALS

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367359

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Prof Dr Kondoh Katsuyoshi (Osaka University, Japan)

Co-author(s): Dr Issariyapat Ammarueda ; Prof Dr Umeda Junko (Osaka University, Japan)

Title: High Strength Ti-Zr Alloys With Balanced Ductility Fabricated By Powder Metallurgy And Additive Manufacturing Routes

Keyword(s):
Titanium, Zirconium, Strength, Ductility, Sintering, Extrusion, Additive manufacturing

Abstract:
The pre-mixed pure titanium (Ti) and zirconium hydride (ZrH2) powder was consolidated by PM process (sintering and hot extrusion) or AM process (selectively laser melting, SLM) to fabricate Ti-Zr alloys, which have excellent corrosion resistance and biocompatibility for human bodies. It was clarified that both materials showed uniform solid-solution of Zr atoms in α-Ti matrix and fine grains due to Zr solute drag, resulting in the significant improvement of tensile strength. In addition, the elongation more than 15% was also obtained in all samples. The quantitative analysis on Zr solution strengthening behavior of both materials was carried out using Labusch model.

Innovative Aspect(s):
The previous studies indicate Zr solutes in cast Ti materials are effective in the refinement of α-Ti grains for their strength improvement. However, they reveal no discussion on the quantitative analysis on Zr solid solution strengthening mechanism in Ti alloys. In this study, both of XRD analysis to estimate the lattice changes of α-Ti by Zr solutes and first-principles calculations to evaluate them by simulations are employed to clarify Zr solution strengthening behavior of Ti-Zr alloys by PM and AM process. In addition, Labusch model is applied to quantitatively estimate yield stress improvement by Zr solutes.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

Notes to author: .....

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367648

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Markovsky Pavlo (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine)

Co-author(s): Prof Janiszewski Jacek ; Dipl-Ing Cieplak Kamil (Jarosław Dąbrowski Military University of Technology, Poland) ; Dr Stasyuk Oleksandr ; Dr Bondarchuk Vadim ; Dr Savvakin Dmytro ; Prof Ivasishin Orest (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine) ; Prof Prikhodko Sergey (University California Los Angeles, USA)

Title: Quasi-Static And High Strain Rate Response Of Two-Layered Structures Of Titanium Based Composites Reinforced With TiC And TiB Particles

Keyword(s):
Titanium alloys and metal matrix composites, Layered structures, Strain rate, Phase composition, Microstructure, Mechanical characteristics

Abstract:
The two-layered structures consisting of the top layer of metal matrix composites (MMC) on the base of titanium alloy Ti-6Al-4V (Ti-64) reinforced with 5, and 10 % (vol.) of TiC or TiB particles and the base layer made of the alloy Ti-64 were prepared employing press-and-sinter Blended Elemental Powder Metallurgy (BEPM) approach. The mechanical behavior of these structures was studied under quasi-static and high strain rate compression loading. Dynamic tests (820÷2880 s-1) were implemented using the split Hopkinson pressure bar technique, whereas the quasi-static tests were performed at the strain rate of 10-3 s-1. The stress-shortening curves were analyzed and the effects of phase composition, microstructure, strain rate, as well as deformation energy were evaluated. The deformation mechanism was assessed basing on a detailed analysis of tested specimens' microstructure. The results are compared with those earlier obtained for uniform MMC tested at the same conditions.

Innovative Aspect(s):
Original manufacturing method. New two-layered materials with improved mechanical characteristics. Firstly obtained data about the mechanical behavior of such materials under quasi-static and high strain-rate loading.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367984

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Prof Ivasishin Orest (Jilin University, China)

Co-author(s): Dr Bondarchuk Oleksandr (International Iberian Nanotechnology Laboratory, Portugal) ; Dr Savvakin Dmytro (G.V. Kurdyumov Institute for Metal Physics, Ukraine) ; Mrs Xu Huiyan (Jilin University, China)

Title: Surface Processes On Dehydrogenation Of Titanium Hydride Powder Promoting Material Cleaning

Keyword(s):
Titanium hydride powder, Hydrogen, Impurities, Powder cleaning

Abstract:
Titanium hydride (TiH2) powder is used in powder metallurgy for manufacturing of titanium alloys and composites. In such approach, atomic hydrogen evacuated from hydrogenated powder during the vacuum sintering positively affects crystal structure of titanium, provides improved densification and cleaning of powder surface. We comparatively investigate impurities at the surface of titanium hydride and titanium powders, including oxygen compounds (titanium oxides, H2O). The X-ray photoelectron spectroscopy (XPS) was deployed to assess the forms of oxygen in both powders and their transformations during vacuum heating up to 600oC to elucidate the effect of TiH2 dehydrogenation process on the powder cleaning. The mass spectroscopy was used to follow the gases evolved during the TiH2 annealing; content of oxygen, nitrogen and hydrogen in powder before and after dehydrogenation was analyzed. Annealing protocol has been established to achieve better cleaning of the TiH2 powders and reduced impurity content in the sintered titanium-based products.

Innovative Aspect(s):
Forms of Oxyden and other impurities presented at the surface of titanium hydride and titanium powders are discussed. The difference in surface processes occur on heating of titanium hydride and titanium powders is described. Newly obtained results allow recommendation of dehydrogenation regimes to realize better cleaning of the hydrogenated titanium powder with atomic hydrogen evolved on sintering.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225368531

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Savvakin Dmytro (G.V. Kurdyumov Institute for Metal Physics, Ukraine)

Co-author(s): Prof Ivasishin Orest ; Dr Stasiuk Oleksandr ; Dr Oryshych Denys ; Dr Markovsky Pavlo (G.V. Kurdyumov Institute for Metal Physics, Ukraine) ; Prof Prikhodko Sergey (University of California Los Angeles, USA)

Title: Titanium-based Porous Structures For Energy Absorption Produced Via Different Powder Approaches

Keyword(s):

Abstract:

Porous materials are very efficient for energy absorption in different products, for instance, in combined armor for improvement of antiballistic protection characteristics. In present study, porous titanium-based structures were manufactured via three different powder metallurgy ways using titanium hydride (TiH2) powder which provides easy manufacturing of particles of desirable size and activated sintering owing to dehydrogenation. TiH2 powder was sintered with additions of ammonium and calibrated NaCl crystals as pore holding removable agents, while highly-porous Ti-Al structures were formed via liquid phase reactive sintering of TiH2 and Al powders. Microstructures and porosities of sintered dehydrogenated titanium and Ti-Al structures were comparatively studied. Mechanical characteristics were evaluated using compression testing, while resonant frequency method was employed to determine damping parameters and elastic modulus to characterize energy absorbing ability of porous structures. Desirable strength, ductile and energy absorbing characteristics of porous titanium-based structures were assessed, potential of application is discussed.

Innovative Aspect(s):

Three methods for manufacturing of porous titanium-based structures were comparatively tested to achieve desirable microstructure and energy absorption characteristics. Titanium hydride was used as the raw powder basing on its advantages for easy production of desirable powder size and sintering activation owing to dehydrogenation process on vacuum heating.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225370187

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Mrs Taurines Justine (MATEIS - UMR CNRS 5510, France)

Co-author(s): Dr Boulnat Xavier ; Prof Perez Michel (MATEIS - UMR CNRS 5510, France) ; Dr Dezellus Olivier (LMI - UMR CNRS 5615, France) ; Prof Deschamps Alexis (SIMAP - UMR CNRS 5266, France)

Title: Manufacturing Of Mg|Si Graded 6xxx Aluminium Alloys Using Spark Plasma Sintering Of Model Alloys Powder Blends

Keyword(s):
Compositionally-graded, High-temperature consolidation, Spark Plasma Sintering, 6xxx alloys, Combinatorial metallurgy

Abstract:
In this study, a compositionally-graded aluminium alloy was obtained by high-temperature consolidation using Spark Plasma Sintering (SPS) of Al-Si and Al-Mg model alloys atomised powders. The fabrication process includes: (i) SPS consolidation of multi-layer powder beds (ii) interdiffusion heat treatment (iii) homogenisation and quenching. Energy dispersive X-ray spectroscopy (EDX) and wavelength dispersive X-ray spectroscopy (WDS) ensure a well-controlled gradient in a single direction. X-ray tomography and microscopy analysis describe the microstructure evolution of the alloys depending on the chosen diffusion couple. Parts made with Al-2.6wt.%Mg and Al-2.5wt.%Si powder blends reach the targeted Mg-Si gradient length of 3 mm after an interdiffusion treatment of 10 days at 550°C, with a relative density of 99.5%. These graded alloys allow for systematic study of nanoscale-precipitation in 6xxx alloys with various Mg|Si ratios.

Innovative Aspect(s):
Obtaining compositionally-graded materials by high-temperature consolidation is an innovative approach.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371451

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Ing Toualbi Louise (ONERA, France)

Co-author(s): Dr Le Bouar Yann ; Dr Ing Davoine Cécile ; Dr Thomas Marc (ONERA, France)

Title: Evaluation Of The Impact Of Thermal Strain Hardening On The Precipitation Of Strengthening Phases During L-PBF Manufacturing Of A Model Aluminum Alloy: Towards The Definition Of An Alloy Grade Designed

Keyword(s):
Thermal strain hardening, Strengthening phases, Alloy design, L-PBF, TEM, Dislocation

Abstract:
The L-PBF process features very short interactions between the powder and the laser, resulting in very high solidification and cooling rates. During thermal cycling in L-PBF processing, phase precipitation and thermal strain hardening occur concomitantly, thus leading to high dislocation density correlated with anchoring to precipitates. It is therefore important to understand and control precipitation kinetics with respect to the thermal strain hardening phenomena generated by the thermal cycles of the L-PBF process. This issue concerns structural hardening aluminium alloys. The aim of this study is to understand the thermal, metallurgical and mechanical phenomena generated during the manufacture of a model aluminium alloy (Al-4Fe) by L-PFB, in order to evaluate the impact of thermal strain hardening on the precipitation of the strengthening phases. A fine microstructural characterization using scanning electron microscopy and transmission electron microscopy shows a strong the interaction between dislocation density and precipitation.

Innovative Aspect(s):
Better understanding of the hardening mechanisms related to the interaction between thermal strain hardening and precipitation of strengthening phases Better understanding of the microstructure change during L-PBF manufacturing Chemical optimizations to maximize the hardening of structures manufactured by the L-PBF process.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371604

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Ing Trapp Johannes (Fraunhofer IFAM, Germany)

Co-author(s): Dr Ing Schubert Thomas ; Dr Ing Weißgärber Thomas (Fraunhofer IFAM, Germany) ; Mr Storz Andreas (Sigma Materials GmbH, Germany) ; Dr Mitrica Dumitru (National Research & Development Institute for Non-ferrous and Rare Metals, Romania)

Title: Brake Discs Made Of Aluminum Matrix Composites

Keyword(s):
Aluminum Metal Matrix Composites, Spark Plasma Sintering, High Entropy Alloys, Complex Constitutional Alloys

Abstract:
Aluminum-based metal matrix composites show attractive properties to meet the growing demand for lightweight construction in automotive and aerospace industries. Limiting factors are difficulties in processing and machining as well as comparably low operating temperatures. The first issue is addressed using Spark Plasma Sintering to produce fully dense net-shape compacts. To increase operation temperature, we report on alloys that make use of higher melting Al3Fe phases in the AlFeX system and complex constitutional alloys, developed with the help of a systematic selection process: calculating the thermodynamic and kinetic criteria to predict the formation of solid solution structures and obtain the optimal alloy compositions. The latter, reinforced with alumina particles, show melting temperatures between 950 °C and 1200 °C while keeping the density below 4 g|cm³. Aiming for comp.ressive strength > 800 MPa and elongation to fraction > 1 % makes the material suitable e.g. for front wheel brake disc.

Innovative Aspect(s):
The work is both innovative in term of consolidation technology as well as material|alloying concept. Fast and reliable consolidation of aluminum-based powder by Spark Plasma Sintering requires the powder to have a certain minimum electrical conductivity before volumetric heating begins. Here, we show that different approaches con be chosen for the powder consolidation. Regarding the materials used, especially high entropy alloys and the thereof derived complex constitutional alloys are a promising class of alloys. For lightweight applications, they offer the possibility of producing low-density, high-melting, and still relatively ductile materials. To find the best alloy compositions, digital approaches to predict the solid solution structures are both necessary and used in the presented work. The resulting products can help solving pressing challenges in reducing our environmental impact.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371742

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Cunningham Chloe Rose (Fehrmann Alloys GmbH & Co KG, Germany)

Co-author(s): Ing Franke Rüdiger ; Mr Fehrmann Henning (Fehrmann Alloys GmbH & Co KG, Germany)

Title: Mechanical Properties Of A High Magnesium Aluminium Alloy Produced By Laser Beam Powder Bed Fusion

Keyword(s):

Abstract:

The application of aluminium components produced by additive manufacturing is attractive based on several potential benefits. The high design freedom allows the fabrication of topologically optimized parts to be manufactured providing previously obtainable performance results based on criteria such as strength-to-weight ratio. As additive manufacturing is gaining greater adoption in industry, more and more applications are arising that demand certain material properties that are not achieveable with the standard commonly applied additive manufacturing alloys such as AlSi10Mg. The Aluminium-Magnesium system is one alloying system that offers alternative material properties and performance characteristics. This research investigates the production of Al-Mg (11.0 wt.%) by Laser Beam Powder Bed Fusion technology. The mechanical properties of the printed samples in the as-built and the heat treated condition are reported. The additive manufacturing mechanical results are subsequently compared to those of the same material produced via conventional processing routes.

Innovative Aspect(s):

This is a novel alloying system that presents a processing challenge due to high magnesium content. The mechanical properties have not been published scientifically previously and aspects such as process parameters, magnesium losses and contribution to strength will be addressed.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371812

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Prof Dr Leshchynsky Volf (Łukasiewicz Research Network – Poznań Institute of Technology, Poland)

Co-author(s): Mr Rubach Rafał ; Dr Garbiec Dariusz (Łukasiewicz Research Network – Poznań Institute of Technology, Poland) ; Dr Łagoda Marek (Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Poland) ; Mr De Pamphilis Marco ; Dr Coella Alberto ; Prof Dr Matteazzi Paolo (MBN Nanomaterialia, Italy)

Title: Spark Plasma Sintering And KOBO Extrusion As Effective Route For Manufacturing Al-nSiC Composite Profiles

Keyword(s):
AMCs, FAST|SPS, KOBO extrusion

Abstract:
FAST|SPS-KOBO manufacturing technology is being developed within the Horizon 2020 project (LightMe) as a promising route for manufacturing aluminum alloy profiles. The main advantages of applying the KOBO cyclic extrusion severe deformation technique are the reduction of the processing energy and the great increase in intensity of the deformation and dynamic recrystallization processes. The SPS technique for manufacturing fully dense AA7075-3wt%nSiC metal matrix composite (AAMC) cylindrical preforms, followed by KOBO extrusion at ambient temperature allows the production of rods 8 mm in diameter and 800–1000 mm in length with a trimodal structure. The microstructure and mechanical properties of the AA7075-3nSiC composites with a bimodal grain laminated microstructure are investigated. The manufactured rods are characterized by a yield strength of >400 MPa, ultimate tensile strength of >510 MPa, tensile strain of 5.4–11% and Vickers hardness of approx. 1.2 GPa.

Innovative Aspect(s):
The combined FAST|SPS-KOBO extrusion technology allows the strength–ductility trade-off to be avoided, which is especially problematic for ultrastrong ultrafine-grained metals. The trade-off dilemma, consisting in designing a heterogeneous trimodal structure consists of bimodal grains and SiC nanoparticle reinforcement. The combined effect of a ductile coarse grain metallic matrix and a strong reinforcing phase allows the achievement of strength properties that are unattainable for traditional alloys. Al alloys are of prime importance because of their light weight, excellent resistance to corrosion, in addition to good thermal and nonmagnetic properties. Mechanical alloying allows heterogeneous AAMCs to be obtained. The results demonstrate that the SPS-KOBO extrusion technique results in the formation of a bimodal laminated fine gradient grain microstructure due to deformation and dynamic recrystallization. The new heterogeneous AA7075-3wt%nSiC AAMCs obtained by the combined FAST|SPS-KOBO techniques demonstrate that microstructural heterogeneities can assist in overcoming the strength-ductility trade-off.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371816

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Mr Rubach Rafał (Łukasiewicz Research Network – Poznań Institute of Technology, Poland)

Co-author(s): Dr Figiel Paweł ; Prof Dr Biedunkiewicz Anna (West Pomeranian University of Technology in Szczecin, Poland) ; Dr Garbiec Dariusz (Łukasiewicz Research Network – Poznań Institute of Technology, Poland)

Title: Microstructure And Mechanical Properties Of (Ti,Mo)C Reinforced Ti Matrix Composites Based On Powders After HEBM Prepared By Spark Plasma Sintering

Keyword(s):
(Ti,Mo)C, Titanium matrix composites, Spark plasma sintering, Microstructure, Mechanical properties

Abstract:
Spark plasma sintering is an advanced technique used to consolidate powder materials at low temperatures and short holding times in contrast to conventional sintering techniques. The obtained materials are characterized by high density and small grain growth. Titanium matrix composites with ceramic reinforcements embedded in a metal matrix combine the properties of metals, among others plasticity and ductility as well as the properties of ceramics, such as high hardness and wear resistance. By appropriately selecting the matrix and reinforcement in composite materials, various properties of the materials can be consciously designed. In this work, high-energy ball milled and then spark plasma sintered Ti-(Ti,Mo)C composites were manufactured and characterized. The materials are characterized by hardness of 800–1000 HV10 and fracture toughness of >5 MPa·m1|2.

Innovative Aspect(s):
The novelty of this research is the effect of using spark plasma sintering to manufacture new types composite materials on based titanium powder prepared by the high-energy ball milling method, reinforced with (Ti,Mo)C. Additionally, a novelty is the use of Mo to reinforce (Ti,Mo)C. This type of carbide may undergo decomposition during sintering into TiC and MoC forms, and the further consequence may be a reaction of molybdenum carbide with titanium, resulting in the formation of metallic molybdenum, contributing to stabilization of the β-Ti(Mo) phase. The occurring phenomena should contribute to a significant reduction in the size of the structural elements and increase the resistance to intercrystalline corrosion.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372016

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Mr Upadhyaya Prathviraj (South Eastern Applied Materials (SEAM) Research Centre, Ireland)

Co-author(s): Dr M. Uí Mhurchadha Sinéad (Waterford Institute of Technology, Ireland) ; Dr J. McCarthy Oliver ; Dr Kennedy Tríona (Stryker European Operations Limited, Ireland) ; Dr Raghavendra Ramesh (South Eastern Applied Materials (SEAM) Research Centre, Ireland)

Title: Characterisation Of WE43 Magnesium Alloy Manufactured Via Laser Powder Bed Fusion For Biomedical Applications

Keyword(s):
Bioresorbable materials, Temporary orthopaedic implant, Magnesium alloys, LPBF

Abstract:
WE43 magnesium alloy is a low density, biocompatible material that has been identified as a viable option for temporary orthopaedic implants due to its favourable mechanical and biodegradation properties. This bioresorbable material eliminates the requirement for an invasive second surgery to remove a traditional bioinert temporary implant after the bone has regenerated. Additive manufacturing allows for complex structures with biomimicry features to be produced. However, the additive manufacturing of Magnesium and its alloys is not a trivial task due to challenges associated with the processability of Magnesium. This paper presents a methodology to additively manufacture WE43 components. Furthermore, an additively manufactured demonstrator orthopaedic fixture is presented and the microstructure evolved within the part and the resulting mechanical and corrosion properties are characterised. This research is aimed towards the development of additively manufactured, bioresorbable orthopaedic implants, with potential to improve clinical outcomes for patients.

Innovative Aspect(s):
Laser powder bed fusion (LPBF) of magnesium alloys is a disruptive technology undergoing dynamic research developments. This research focuses on the LPBF of a Magnesium alloy, specifically for the development of next-generation bioresorbable orthopaedic implants. The study will present the successful LPBF of dense magnesium parts, and the effect of the evolved microstructure on resulting mechanical and chemical properties is characterised. This paper will present an example of a Magnesium orthopaedic fixture device manufactured via LPBF. It will demonstrate the advantages of additive manufacturing of Magnesium for these applications, as well as the bioresorbable properties of the material. This research will allow for the design and manufacture of geometries and features that are not possible using traditional manufacturing methods for a bioresorbable material.

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372056

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Roudini Ghodratollah (University of Sistan and Baluchestan, Iran)

Co-author(s):

Title: Magnesium - Steel Shots Interpenetrated Phases Composite

Keyword(s):
Magnesium, Steel shots, Compressive strength, Microhardness, Interpenetrated phase's composites

Abstract:
In this work, magnesium- steel metal matrix composites with interpenetrating phases were fabricated by squeeze casting infiltration method. For the composite fabrication, first the preforms of steel shots (1-2.5 mm) with sintered at temperatures 1000- 1200 ℃ and without sintered were made. Then, the preforms were infiltrated by molten magnesium by squeeze casting method. The microstructure of the preforms and composites were investigated using optical and scanning electron microscope (SEM) microscopy. Also, hardness and compression behavior of these composites were studied. The results showed that the interpenetrated phase composites have higher hardness and compressive strength as compared to the composites with non-sintered preforms.

Innovative Aspect(s):
The aim of this study is to fabricate IPCs magnesium composites and study the steel shots connectivity on the mechanical properties. Given the processing route chosen in this work, namely squeeze casting metal infiltration. Then the effect of size and connectivity of the steel shots reinforcements were evaluated on compression strength and hardness of the composites.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372083

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Ing Restrepo Alex (UNIVERSIDAD DE ANTIOQUIA, Colombia)

Co-author(s): Prof Dr Zuleta Alejandro (UNIVERSIDAD PONTIFICIA BOLIVARIANA, Colombia) ; Prof Dr Correa Esteban (UNIVERSIDAD DE MEDELLIN, Colombia) ; Prof Dr Bolivar Francisco ; Prof Dr Castaño Juan ; Prof Dr Echeverria Felix (UNIVERSIDAD DE ANTIOQUIA, Colombia)

Title: Development Of Ti- X%wt Mg Alloy With Low Alloy Content By Mechanical Milling Plus Hot Isostatic Pressure

Keyword(s):
Titanium-Magnesium, Powder metallurgy, High energy ball milling, Hot Isostatic Pressing

Abstract:
Several authors have shown promising results using Ti and Mg to develop materials that combine the benefits of these two metals such as their low density and absence of harmful second phases, which makes them attractive for aerospace and biomedical applications. However, titanium and magnesium are almost immiscible and there are great differences in processing temperatures of these two metals. Within the techniques reported in the literature for obtaining Ti-Mg alloys, powder metallurgy and high energy ball milling are possibly the most popular. In this work, Ti and Mg powders were mixed using a high energy ball mill and subsequently these mixes were sintered by Hot Isostatic Pressing under various conditions to obtain alloys Ti- Mg with Mg%wt close to the limit of solubility. The results showed the influence of the sintering parameters in the microstructure of the sintered material, which allowed us to obtain a Ti-Mg alloy.

Innovative Aspect(s):
An unconventional processing technique is used that combines high pressures and temperatures above the melting point of Mg which is very different from those techniques commonly reported to obtain this new alloy. A microstructure is obtained in titanium that allows us to approach the low solubility limit of magnesium in titanium. Metallic materials were obtained by powder metallurgy and sintering that possibly have good biomedical applications due to the addition of Mg.

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Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372148

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Feitosa Leandro (Sandvik Additive Manufacturing, Sweden)

Co-author(s):

Title: The Effect Of Powder Flowability On The Performance Of Ti-6Al-4V Alloys Produced Via Laser Powder Bed Fusion

Keyword(s):
Laser powder bed fusion, Ti-6Al-4V alloys, Humidity, Mechanical properties

Abstract:
As the additive technologies develop at a fast pace, stricter requirements for powder atomization and quality control are expected. This is due to a necessary improvement in densification and component performance for various industries, such as aerospace and automotive. The combination of good corrosion and high specific strength of Ti-6Al-4V alloys makes them suitable for such applications, though they can present high tendency to humidity absorption. In this study, fundamental knowledge is built through the production of powders with different treatments that generate different degrees of flowability, to understand the impact of humidity on powder flowability. These powders were used to build Ti-6Al-4V parts via laser powder bed fusion followed by post-processing treatments, with focus on reduction of porosity. Room temperature tensile strength and impact toughness are reviewed, assisted by microscopy study. A comparison is made between flowable and non-flowable Ti-6Al-4V powders and their effect on mechanical properties.

Innovative Aspect(s):
Due to the lack of standardization of humidity levels on AM powders, not enough knowledge has been publish on this regard, as to understand their effect on powder flowability and mechanical performance. This study aims to close this knowledge gap for Ti-6Al-4V, mostly used for laser powder bed fusion techniques.

TPC Reviewer name: .....

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372320

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Dr Biffi Carlo Alberto (CNR ICMATE, Italy)

Co-author(s): Dr Fiocchi Jacopo ; Dr Tuissi Ausonio (CNR ICMATE, Italy) ; Prof Casati Riccardo ; Dr Colombo Juan ; Prof Vedani Maurizio (Politecnico di Milano, Italy)

Title: Laser Powder Bed Fusion Of Ti6246 Alloy: Process Feasibility, Microstructural And Mechanical Characterization

Keyword(s):
Ti alloy, beta Ti alloys, selective laser melting, Additive manufacturing, process-ability, mechanical behaviour.

Abstract:
In the present work the processability of Ti6246 (Ti6Al2Sn4Zr6Mo) powder by laser powder bed fusion (LPBF) is explored. The suitable processing window was found by correlating the main process parameters, such as laser power and exposure time, and the material's relative density. Defects, such as lack of fusion and gas pores, were analyzed upon varying the investigated process parameters. The correlation between the resulting microstructures and the corresponding mechanical properties was studied by means of hardness tests, calorimetric analyses and scanning electron microscopy.

Innovative Aspect(s):
The innovation is due to the study of a novel Ti alloy for AM technologies. In details, the work is dedicated to the process development and the further microstructural and mechanical characterization.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

Notes to author: .....

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225377976

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Light materials

Author: Mr Metha Bharat (Chalmers University of Technology, Sweden)

Co-author(s): Prof Dr Bengtsson Sven (Höganäs AB, Sweden) ; Prof Dr Nyborg Lars ; Prof Dr Frisk Karin (Chalmers University of Technology, Sweden)

Title: New Aluminium Alloy For Laser Powder Bed Fusion

Keyword(s):
Aluminum Alloy, Printability, Peak hardening

Abstract:
The laser powder bed fusion process (LPBF) can produce parts with complex geometry. Light weight designs can be created and by usin light alloys further weight savings can be achived. However, minimizing printing defects using standard aluminium alloys, such as 2000, 6000 and 7000 class alloys, have proved to be difficult since they are all prone to solidification cracking. In the present study, two aluminium alloys are used: The first alloy is the AlSi10Mg alloy known for easy printing and consistent quality in LPBF printing. The second material is a novel Al-Mn base alloy designed to inherently resist solidification cracking, while also providing strong ageing response. The quality of printing and resulting mechanical properties are compared. The results show that the new material prints in a robust way and that the mechanical properties are superior to AlSi10Mg.

Innovative Aspect(s):
It is a new aluminium alloy designed specifically for LPBF. The material is not prone to cracking and can be peak hardened to significant levels.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

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WORLD PM2022
CONGRESS & EXHIBITION

ABSTRACTS – GROUP 3

HIGH TEMPERATURE MATERIALS

WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367611

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Mr Garbade Rohit (College of Engineering Pune, India)

Co-author(s): Dr Dhokey Narendra (College of Engineering Pune, India)

Title: Elevated Temperature Wear Resistance Of Novel Iron-based Austenitic Matrix Hardfacing Alloy

Keyword(s):
CALPHAD, Austenitic matrix, Laser cladding, Nitride precipitation

Abstract:
Among the hardfacing alloys, austenitic matrix is the preferred choice to tackle self-welding between components in Phototype fast breeder Reactor. The said composition Fe-20Cr-2C-18Ni-4Si-2Mn-2Ti-1B was derived from Thermo-Calc software using CALPHAD approach. Wear resistance of Iron-based hardfacing alloy was performed using a pin-on-disk machine at room and elevated temperatures and its relative performance was compared with the commercially available nickel-based alloy(74-W-60). Laser cladding was used as a method of powder deposition on SS316 substrate to maintain low dilution.The microscopic examination of weld-overlay exhibited carbide volume fraction about 40% primarily consisting of carbides and nitrides in the austenitic matrix which depicted increase in hardness in the range of 63-65HRC. Results showed that the wear resistance of iron-based alloy improved significantly as compared to nickel-based alloy. Surface response analysis of elevated temperature wear behavior was established having minimal wear loss regime which was correlated from worn surface topography and subsurface microstructural features.

Innovative Aspect(s):
Mechanical alloying of premixed powder with ferro alloying elements in nitrogen atmosphere.. Iron based austenitic matrix with multiphase hard precipitates.. Improved elevated temperature wear resistance.. Overall volume fraction of about 40% precipitates consisting of carbides and nitrides.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371435

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Vives Solange (Aubert & Duval, Spain)

Co-author(s): Dr Ing Mayer Charlotte (Aubert & Duval, France) ; Dr Ing Després Arthur ; Dr Ing Martin Guilhem ; Prof Dr Veron Muriel ; Dr Ing Blandin Jean Jacques (Université Grenoble Alpes, CNRS, Grenoble INP, SIMaP, France)

Title: Microstructure And Mechanical Properties Of Additively Manufactured Pearl® Micro AD730®

Keyword(s):
LPB-F, Ni based superalloy, Solidification cracking, Rupture creep resistance, Microstructure controle, Grain size, Gamma prime precipitates, Heat treatment, Mechanical resistance

Abstract:
While superalloys such as IN718 have been successfully used to build complexe parts in AM, applications requiring higher service temperatures necessitate the development of alloys with increased capability. AD730® was developed as a C&W alloy with increased capability relative to wrought IN1718. This work first reveals the impact of minor elements B and Zr on LPB-F processed AD730® (promotion of solidification cracking), and the role of B regarding rupture creep resistance. The as built microstructure is completely different from the as forged alloy. This work shows how heat treatment allows to tune the microstructure to address either high fatigue and mechanical resistance, or better creep needs. Compared to AM IN718, AM AD730® shows the desired improvement in temperature capability, analogous to that in the forged version. Still, differences between AM and cast and wrought AD730® are attributable to differences in grain size and gamma prime (γ') precipitates distribution.

Innovative Aspect(s):
This works shows some new aspects of the role of B and Zr in the LPB-F built superalloy. While both alloys promote solidification cracking at grain bourndaries (wich is not new), their role after a standard subsolvus heat treamtent is revealed by APB localisation. Only B remains at the GB and has a role in creep resistance. This work also shows some attemps to controle the microstructure by heat treatments and details the results in terms of grain size, gamma prime precipitates distribution and associated mechanical properties.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author: .....

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371630

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Prof Dr Torralba Jose M. (Universidad Carlos III de Madrid|IMDEA Materials Institute, Spain)

Co-author(s): Prof Dr Campos Mónica ; Mr Masari Facundo (Universidad Carlos III de Madrid, Spain)

Title: Corrosion Behaviour At High Temperature Of Alumina-forming Martensitic Steels For Energy Generation Systems

Keyword(s):
Stainless steels, Oxidation behaviour, High temperature applications, Alumina forming steels

Abstract:
It is possible to increase the operating pressure and temperature of power plants to improve efficiency and reduce CO2 emissions per unit of the generated electricity. To accomplish this, new materials must be identified to resist high-temperature corrosion. As an alternative to commercial Alumina-Forming-Austenitic (AFA) steels, new alumina-forming ferritic-martensitic or plain martensitic steels with nano-precipitates are studied. Their significant corrosion resistance is attributed to the formation of a protective Al2O3 layer. This makes it possible to be used at higher temperatures and for longer periods than conventional stainless steels that form a Cr2O3 surface layer. Based on thermodynamic simulations, two promising compositions, Fe-14.5Cr-12Ni-3.5Al and Fe-13Cr-10.5Ni-3.5Al were selected. Once atomized, were consolidated by field-assisted sintering techniques. Oxidation behaviour at high temperatures and experiments at lower temperatures and longer times have been performed at operating temperatures of around 750 °C. The further nano-precipitation of MX particles will provide a mechanical behaviour advantage.

Innovative Aspect(s):
This is a new and innovative family of stainless steels highly focused on high-temperature applications, fully developed by PM. The way to prevent the oxidation is also alternative, being the development of an alumina layer as different than in conventional stainless steel (through a chromium oxide layer). In the work are proposed two different approaches with different Cr|Ni contents to optimize the alumina forming capability. These new stainless steels are developed to fulfill the requirements of power plants but can be extended its use to many other applications.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371699

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Prof Dr Campos Monica (Universidad Carlos III de Madrid, Spain)

Co-author(s): Prof Hong Soon-Jik (Kongju National University, Republic of Korea) ; Prof Dr Torralba José Manuel ; Ing Mejía-Reinoso Alexander (Universidad Carlos III de Madrid, Spain)

Title: Design Of Novel Sintered W-Free Co-base Alloys

Keyword(s):
Cobalt-base superalloys, Microstructure, Precipitates

Abstract:
The microstructure of materials used in high-temperature components in power generation, aerospace, chemical, and process plant applications changes during operation, affects their mechanical properties. The reduction of density and the increase of the thermal stability range of the microstructure are two critical improvements to consider in new dual Co-based superalloys. Two viable choices for achieving dual γ|γ' microstructures were explored: the Co-Al-Mo and the Co-Ti-V system. Since the microstructural characteristics of Co γ′-strengthened superalloys are fundamental for the envisaged next-generation superalloys, the morphological evolution and coarsening behaviour of γ′ precipitates during isothermal ageing are investigated by varying the ageing time|temperature. Furthermore, the volume fraction of γ′ and whether there is a difference in the coarsening rate of γ′ precipitates due to a different diffusion rate between the γ matrix and the γ′ precipitate has been studied. This study provides a discussion of essential aspects for the optimized microstructures.

Innovative Aspect(s):
Due to the lack of strengthening mechanisms that are as effective as the L12-ordered γ' precipitates in Ni-based superalloys, traditional Co-based alloys have a limited use. In 2006, Sato et al. discovered Co-based superalloys, based on the ternary Co-Al-W system, with γ'-Co3(Al,W) precipitates with a coherent L12-ordered structure. Since Co has a higher melting point than Ni (1495 vs. 1455°C), these new superalloys have great potential to beat the high-temperature performance of existing Ni-based superalloys. This has generated extensive research and development interest in the design of Co-based alloys containing high volume fractions of γ' (~80%) and high solidus and liquidus temperatures (~150°C higher than those of Ni-based alloys). This research focuses on the replacement of part of the W by various γ' -forming elements.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371806

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Ing Thomas Marc (ONERA, France)

Co-author(s): Dr Ing Charkaluk Eric (Laboratoire de Mécanique des Solides - UMR 7649, Institut Polytechnique de Paris, France) ; Dr Ing Solas Denis (Institut de Chimie Moléculaire et des Matériaux d'Orsay, Université Paris Saclay, France) ; Dr Ing Szmytka Fabien (ENSTA Paris - Institut Polytechnique de Paris, France) ; Ing Locq Didier ; Ing Morel Ariel (ONERA, France) ; Dr Ing Hubert Olivier ; Dr Ing Muller Nicolas ; Dr Ing Tournier Christophe (Laboratoire Universitaire de Recherche en Production Automatisée, ENS Paris-Saclay, France)

Title: L-PBF And DED Processing Of A Ni-based Superalloy

Keyword(s):
Ni-based superalloys, Additive manufacturing, Microstructure, Mechanical properties

Abstract:
Different AM technologies such as L-PBF and DED do become really attractive for both repair and 3D part manufacturing. In particular, extensive work is in progress for the non weldable nickel-based superalloys which tend to exhibit cracks due to residual stresses build-up during AM thermal cycles. Within the framework of the project FAPS conducted at Paris-Saclay, the present investigation will highlight the processing conditions and build-up strategy that produce crack-free specimens for alloy AD730. The latter was developed by Aubert&Duval for cast+wrought gas turbine applications. In this work, a comparison between such conventional processing and AM will be provided in terms of mechanical performance. The results clearly show an anisotropic behaviour related to the sharp crystallographic texture induced by the epitaxial grain growth. The results will be discussed, with a perspective analysis of maturity for this AM processed-material, the process robustness, the potential technological developments and application prospects.

Innovative Aspect(s):
The capability to alleviate the crack sensitivity for a non weldable Ni-based superalloy using specific AM processing conditions.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371869

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Mr Bult René (Formatec Technical Ceramics BV, Netherlands)

Co-author(s): Mr Opschoor Jan (Admatec Europe B.V., Netherlands)

Title: Metal Injection Moulding Of High Purity Tungsten And Molybdenum

Keyword(s):

Abstract:
Shaping high melting refractory metals like tungsten and molybdenum from powder has been proven a tough challenge. A metal injection moulding (MIM) process has been developed for high purity and oxide dispersed strengthened tungsten and high purity molybdenum. Employing MIM allows for obtaining an isotropic microstructure having small grain sizes, controlled doping and isotropic material properties. Furthermore MIM is a net shape technique, avoiding machining steps, which may cause surface defects. A further challenge for this process is given with very small parts, requiring specific moulding machine and modifications on binder system and process parameters. In this presentation an overview of the manufacturing processes will be given, as well as the results of the mechanical and physical characterisation. Both materials show a fine and homogeneous microstructure with very high densities of 98-99%. Particularly the pure tungsten shows a very high thermal conductivity.

Innovative Aspect(s):
The production of most of the fine grained, isotropic and thermally stable tungsten and molybdenum grades is currently available only in lab scale amounts and therefore result in small sample sizes. One process to produce special tungsten and molybdenum grades in larger volume is powder injection molding (PIM). The process is especially suitable for the production of larger amounts of smaller components with a complex geometry.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371982

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Huser Gautier (SAFRAN, France)

Co-author(s): Dr Richard Sebastien ; Dr Menou Edern ; Dr Sallot Pierre (SAFRAN, France)

Title: Current And Prospective Status Of MIM At SAFRAN: A Multidisciplinary Approach

Keyword(s):
MIM, Nickel superalloy, Computational methods, Microstructure

Abstract:
The MIM (Metal Injection Molding) is a process with high production rate, net-shape capabilities that results in a cost effective way to obtain complex shape metallic parts. Nickel-based superalloys are particularly well suited for such production route, and are of great interest in the field of aerospace industry. The presentation will focus on actual developments of such applications in the field of aeronautics engine and challenges associated. A particular focus will be placed on Safran situation and the methodology of development of specific alloy grades adapted to the MIM process in order to maximize their mechanical properties. These new alloys are designed through a close loop method, starting with computational methods, MIM process and finally mechanical optimization. This methodology will be exemplified and comparisons between microstructure evolutions as well as properties of such alloys compared to conventional ones will be discussed.

Innovative Aspect(s):
Designing new nickel superalloys with computationals method adapted to the MIM process. Different nickel superalloys grade fabricated by MIM, study of their mechanical properties and comparison with conventionals superalloys.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372119

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Deirmina Faraz (Siemens Energy, Sweden)

Co-author(s): Ing Koenig Slawomir ; Dr Saeidi Kamran ; Ing Oscarsson Eva ; Ing Johansson Lennart (Siemens Energy, Sweden)

Title: Influence Of Boron On Stress-rupture Behavior Of A Modified HastelloyX Produced By Powder Bed Fusion-laser Beam

Keyword(s):
Additive manufacturing, Laser powder bed fusion, HastelloyX, Creep

Abstract:
HastelloyX is one of the most common materials used in powder bed fusion-laser beam (PBF-LB) to fabricate components operating at elevated temperatures. Boron is a key element in enhancing the creep properties of superalloys at high temperatures, however, similar to the welding practice, boron might impose a negative effect on the printability. In the present work, the influence of boron on stress-rupture behavior of a modified low carbon HastelloyX variant was studied. Powders with boron contents varying from 2 to 60 ppm were used to fabricate the samples. Time to rupture, elongation, and reduction of area were obtained from isothermal stress rupture tests performed at 816°C with static load of 103 MPa. In view of the fracture mechanism, and the stress-rupture test results, it can be concluded that increasing the boron content while decreasing the total grain boundary area of the printed material improves time-to-rupture during isothermal stress-rupture test.

Innovative Aspect(s):
Crack free components in HastelloyX using a modiefied chemical composition were achieved. Creep resistance is furthur improved by the controlled additions of boron, and the effect of boron on strss-rupture behaviour is elaborated, this can be useful in alloy design for additive manufacturing. Thermodynamic simulations are used to decide on the optimised chemical compostion in a cost-effective way.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367097

Requested paper type: Poster Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Shulga Andrey (National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Russia)

Co-author(s):

Title: A Multiscale Study Of Boron And Carbon Behavior In The Necking And Fracture Zones Of The High Temperature Ni-based PM HIP Superalloy Under High Temperature Tensile Testing

Keyword(s):
Ni-based superalloy, PM HIP technology, Rapidly quenched PREP powder, Boron, Carbon, Autoradiography, Microstructure, High temperature tensile test, Necking and fracture zones

Abstract:
A multiscale study of boron, carbon behavior and the microstructure of PM HIP compact from high temperature Ni-based superalloy produced using PREP-powder under tensile testing at high temperature was performed. This study of boron and carbon behavior related to the microstructure of the necking and fracture zones, was carried out by direct methods track autoradiography on boron using the nuclear reaction 10B(n, a)7Li and activation autoradiography on carbon using the nuclear reaction 12C(d, n)13N, metallography, SEM, EDX, OIM methods. The formation of a mesocrack was revealed as the localization of plastic deformation before fracture, followed by a significant migration of boron and, to a lesser extent, carbon, precipitation of boride and carbide phases in the loop of maximum shear stresses for the mesocrack and in shear bands. It is important, that Intensive boron migration begins in the diffuse neck. The results revealed are explained by dynamic strain aging.

Innovative Aspect(s):
High-temperature Ni-based superalloys and stainless steels for traditional, PM HIP, and AT technologies are characterized by the presence of microalloying interstitial elements carbon and boron. Direct nuclear methods of track autoradiography on boron and activation autoradiography on carbon make it possible to obtain the complete macro maps of their distribution and purposefully select ROI for both typical structure elements and for anomalous regions. The revealed phenomenon of mesocrack formation as localization of plastic deformation in the necking zone before fracture, followed by migration of boron and carbon, precipitation of boride and carbide phases in the loop of maximum shear stresses for the mesocrack and also in shear bands usually observed as the result of an increase of the local strain in the diffuse neck during high temperature testing of the solute strengthened alloys is important for better understanding of the facture mechanism of the high temperature superalloys and stainless steels

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371572

Requested paper type: Poster Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Pedash Oleksii (MOTOR SICH JSC, Ukraine)

Co-author(s): Mr Kasay Pavlo ; Dr Klochikhin Volodymyr ; Mrs Nataliia Lysenko (MOTOR SICH JSC, Ukraine) ; Prof Dr Naumyk Valeryi (NU "Zaporiz'ka polytechnika", Ukraine)

Title: Structure and properties of SLM-Manufactured specimens after LCF-Testing

Keyword(s):

Abstract:
Results of low cycle fatigue (LCF) testing, investigation of microstructure and fractures of specimens, which was obtain by SLM-process from Inconel 718 alloy powders has been carried out. LCF-testing was conducted with a predetermined interval of the strain for providing of fatigue life in 1000, 5000, 10000 cycles and with the obtained data's was built logarithmic curve in «Strain σ – Number of cycles N» coordinates. Results of the fractures investigation after LCF-testing at 20°C and 550°C shows that during the cyclic elasto-plastic deformation at room temperature multicentricity of crack initiations zones observes. Mainly fixed a viscous pattern of fracture with a fatigue grooves presence, which size increases in process of crack advance to the zone of fracture area. At elevated temperature in the zones of fatigue crack initiation and spreading quasibrittle character of destruction observes, and turns in viscous in the zone of fracture area.

Innovative Aspect(s):
With the obtained data's was built logarithmic curves in «Strain σ – Number of cycles N» coordinates, that allows, with sufficient reliability, determine a rational strain level at LCF-testing for providing predermined number of cycles at 20°C and 550°C.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372047

Requested paper type: Poster Presentation

Topic: Materials / **Subtopic:** High temperature materials

Author: Dr Barvitskyi Pavlo (Institute for Superhard Materials of the National Academy of Sciences of Ukraine, Ukraine)

Co-author(s): Prof Dr Prikhna Tetiana ; Ms Lokatkina Anastasia ; Dr Moshchil` Viktor (Institute for Superhard Materials of the National Academy of Sciences of Ukraine, Ukraine)

Title: Structure And Properties HfB2, ZrB2 -based Materials With SiC Additives

Keyword(s):
Refractory materials, High pressure, Hot pressing, Zirconium diboredes, Hafnium diboride

Abstract:
In this paper we present the results of research effective refractory materials for use in the aerospace industry. The IV-V groups of diborides of transition metals have a very high melting point, high mechanical and thermal properties, and therefore are recommended as ultra-high temperature ceramics. As a result, this material can be offered for a variety of constructural applications. The samples of our materials with the addition of silicon carbide synthesized under conditions of hot pressing(30MPa 1700-1900oC) and high quasi-isostatic pressures(4.1GPa 1800oC) were dense and practically non-porous. The addition of SiC (20...30 wt.%) to the HfB2 and ZrB2 led to a decrease in specific gravity, increase in hardness (as an example, for 17% and 46% as compare with pure ZrB2 and HfB2 - samples, respectively) and fracture toughness (for 40% and 21%, respectively). But such use of additives significantly reduced onset of melting temperature in vacuum). Also, the addition of SiC to the initial mixture significantly reduces the elasticity parameters.

Innovative Aspect(s):
Reducing the sintering temperature and increasing the temperature stability of HfB2- and ZrB2 based materials. Significant increase in hardness, fracture toughness and Young's modulus for refractory materials. New materials for aerospace industry, equipment and vehicles for the manufacture of abrasive nozzles, friction pairs for pumping oil and other aggressive liquids, constructional ceramics for nuclear power plants, etc.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION

ABSTRACTS – GROUP 3

OTHER PM MATERIALS

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225370879

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Mr Malladi Sri Bala Aditya (Chalmers University of Technology, Sweden)

Co-author(s): Mr Anilkumar Vishnu ; Prof Guo Sheng ; Prof Nyborg Lars (Chalmers University of Technology, Sweden)

Title: Influence Of Laser Based Powder Bed Fusion Parameters On Microstructure Of Non-equiatomic Metastable HEA

Keyword(s):
Metastable high entropy alloys, Laser based powder bed fusion, Microstructure, Martensitic transformations, Statistical analysis

Abstract:
High entropy alloys (HEAs) constitute a novel class of alloys containing multiple principal elements in nearly equiatomic proportions. This increases the configurational entropy and hence stabilizes the formation of solid solutions. The unprecedented compositional complexity has reportedly enabled HEAs to perform better than conventional alloys in various situations. Manufacturing HEAs using additive manufacturing techniques such as laser based powder bed fusion (LB-PBF) helps in preventing the formation of detrimental phases, owing to high solidification rates compared to conventional casting. Rapid melting and solidification during the layer by layer printing could also result in martensitic transformations in metastable HEAs. This work focusses on development of novel pre-alloyed non-equiatomic HEA based on CoCrFeNi grade. Detailed microstructural characterization and statistical analysis was performed to understand the influence of the LB-PBF parameters on the densification and microstructure of the metastable HEA in the as-printed state, with a focus on the resultant martensitic phase fraction.

Innovative Aspect(s):
Development of high entropy alloys tailored to additive manufacturing. Statistical approach to undertsand the microstructural evolution as a function of process parameters. Understanding of the martensitic phase fractions as function of the LB-PBF process.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371561

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Prof Dr Torralba José Manuel (Universidad Carlos III de Madrid and IMDEA Materials, Spain)

Co-author(s): Mr Venkatesh Kumaran S (IMDEA Materials and Universidad Carlos III de Madrid, Spain) ; Dr Garbiec Dariusz (Metal Forming Institute, Poland)

Title: Developing Competitive High Entropy Alloys By Spark Plasma Sintering Using Commercial Commodity Powders

Keyword(s):

Abstract:
High entropy alloys (HEAs) have garnered significant research interest due to their unconventional alloying approach which results in exceptional properties. Recently, powder metallurgy (PM) has appeared to be a promising alternative to ingot casting to fabricate HEAs. However, one of the main limitations of powder metallurgy to produce HEAs is the unavailability of fully pre-alloyed powders in the market which makes it expensive. So, in this work, commercial commodity powders like Ni 625, CoCrF75,316L, Invar36, and Fe49Ni which are readily available at competitive prices, were used to make HEAs. The selected powders were mixed in appropriate proportions and spark plasma sintered, following annealing at 1200oC for 24 hours, where a fully FCC phase was obtained. The developed HEAs also exhibit promising mechanical properties both at room and high temperatures. This work opens a completely new field of work with multiple possibilities to manufacture HEAs by PM route at competitive prices.

Innovative Aspect(s):
The concept of using commercial commodity powders in spark plasma sintering to develop novel HEAs instead of pure elemental|pre-alloyed powders is entirely new. The idea is highly innovative, and it will open numerous possibilities to fabricate new HEAs without depending on the availability of fully pre-alloyed powders. This makes it an efficient, cost-effective way that is suitable for industrial developments. Mo containing HEAs haven't been explored much for high-temperature applications, and this work showcases promising mechanical behavior of multiple Mo containing HEAs up to 750 deg C. Very few reports on tensile behavior of powder metallurgy HEAs. This work demonstrates the promising tensile behavior of Mo containing HEAs developed via powder metallurgy.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371709

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Mr Venkatesh Kumaran S (IMDEA Materials and Universidad Carlos III de Madrid, Spain)

Co-author(s): Prof Dr Torralba José Manuel (Universidad de Carlos III de Madrid and IMDEA Materials, Spain)

Title: Developing Competitive High Entropy Alloys By Selective Laser Melting Using Commercial Commodity Powders

Keyword(s):

Abstract:
High entropy alloys (HEAs) have garnered significant research attention due to their unconventional alloying approach which results in exceptional properties. Recently, additive manufacturing processes like Selective Laser Melting (SLM) have been used to fabricate HEAs with enhanced mechanical properties. However, SLM processes demand the use of fully pre-alloyed powders since using elemental powders directly might lead to pronounced segregations. However, there are no readymade pre-alloyed HEA powders in the market and pure elemental powders are expensive. So, in this work, commercial commodity powders like Ni 625,CoCrF75, 316L, Invar36, and Fe49Ni which are readily available at competitive prices, were used to make HEAs. The selected powders were mixed in appropriate proportions and printed using SLM. The resultant alloy was a CoCrFeNiMox, with an FCC phase and exhibited promising mechanical properties. This work opens a completely new field of work with multiple possibilities to manufacture HEAs by additive manufacturing at competitive prices.

Innovative Aspect(s):
Using fully commercial commodity powders in SLM to develop novel HEAs instead of pure elemental powders|pre-alloyed powders is entirely new. The idea is highly innovative, and it will open numerous possibilities to fabricate new HEAs without depending on the availability of fully pre-alloyed powders. This makes it an efficient, cost-effective way that is suitable for industrial developments. There has been no study on Mo containing HEAs printed in SLM, which makes this work unique. Very few reports on tensile behavior of powder metallurgy HEAs. This work demonstrates the promising tensile behavior of Mo containing HEAs developed via additive manufacturing.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371785

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Mr Tekin Mustafa (KTO Karatay University, Turkey)

Co-author(s): Dr Kotan Hasan (Necmettin Erbakan University, Turkey)

Title: Achieving Elevated Hardness In Rare Earth Elements Added FeCoCrNi High Entropy Alloys Fabricated By High Energy Mechanical Alloying

Keyword(s):
High entropy alloys, High energy mechanical alloying, Hardness, Rare earth elements, Annealing

Abstract:
High energy mechanical alloying route is one of the well-known production methods to obtain nanocrystalline structures with remarkable benefits comparing to others. Additionally, this attained enhanced properties may be further increased with addition of rare earth elements which induces formation of secondary precipitates throughout the heat treatment process. In this work, FeCoCrNi high entropy alloys (HEAs), revealing face centered cubic crystal structure, nanostructured by high energy mechanical alloying with the addition of Y and Zr. Subsequent to mechanical alloying and cold-compacting, the as-milled alloys were isochronally annealed at the temperatures between 500 and 900 °C for 1h in protective gas atmosphere. The crystal structures and mechanical properties of alloys were investigated by X-ray diffraction (XRD), and hardness tests as a function of additives and annealing temperatures. The results showed that increased hardness for FeCoCrNi HEAs were achieved in different proportions with addition of Y and Zr.

Innovative Aspect(s):
High entropy alloys has become candidates for structural and engineering applications due to their unique combinations of enhanced mechanical properties. In this study, FeCoCrNi high entropy alloys were produced by high energy mechanical alloying, and elevated hardness values of alloys were achieved with rare earth elements additions. Hence, the obtained hardness of values HEAs at increased annealing temperatures enables them to be used for high temperature applications without a considerable reduction in the mechanical properties.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371887

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Ing Fiocchi Jacopo (CNR ICMATE, Italy)

Co-author(s): Dr Biffi Carlo Alberto ; Dr Tuissi Ausonio (CNR ICMATE, Italy) ; Ing Elnemr Menatalla ; Prof Casati Riccardo (Politecnico di Milano, Italy)

Title: Laser Powder Bed Fusion Of A Novel CoCuFeMnNiTi High Entropy Alloy: Processing And Characterization

Keyword(s):
Laser powder bed fusion, High entropy alloy, Microstructure, Thermal treatment

Abstract:
In the present work the possibility of processing a CoCuFeMnNiTi high entropy alloy by laser powder bed fusion (LPBF) is explored. Such composition was specifically tailored with the aim of allowing the precipitation of strengthening second phases during post-processing ageing treatment. A suitable processing window was found by varying processing parameters and the obtained material was characterized under different perspectives. The as-built material consists of a single face centred cubic phase, whose ageing behaviour appears to be influenced by the experienced rapid solidification conditions. The correlation between the resulting microstructures and the corresponding mechanical properties was studied by means of hardness tests, calorimetric analyses and scanning electron microscopy. Finally, the mechanical response of the alloy was analysed, so as to investigate the activation of various plastic deformation mechanisms under different combinations of deformation extent and heat treatment condition.

Innovative Aspect(s):
A novel high entropy alloy is produced by laser powder bed fusion. The correlation between rapid solidification and ageing processes is explored. The refined microstructure influences the alloy's mechanical behaviour.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372388

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Mr Andersson Tom (VTT, Finland)

Co-author(s):

Title: Numerical Design Of High Entropy Super Alloy Using Multiscale Materials Modeling And Deep Learning

Keyword(s):

Abstract:
A new alloy designed for high temperature application with multiscale material modelling and deep learning is presented. Calphad type of analysis are combined with DFT simulations and tied together with machine learning tools are utilized in order to find the most promising alloy composition. Designed alloy is synthesized and test specimens are produced with laser powder bed fusion. Experimental material and mechanical characterization methods are compined wiht simulation tools to create a micromechanical model that is used for mechanical property and performance simulations. A workflow is created to combine the different length scales in order to asses the performance of the final component already in alloy design phase in such a way that the alloying components can be fine tuned to fulfill the design requirements of the respective products.

Innovative Aspect(s):
Numerical and experimental methods are compined and used with machine learning to find a new material alloy for high temperature application. Designed material is syntizid and characterized.

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Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225377382

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Other PM materials

Author: Dipl-Ing Vallejo Rodríguez Luis (VTT Research centre of Finland, Finland)

Co-author(s): Dipl-Ing Suhonen Tomi ; Dipl-Ing Metsajoki Jarkko ; Dipl-Ing Andersson Tom ; Dipl-Ing Lindroos Matti ; Dipl-Ing Ge Yanling ; Prof Dr Laukkanen Anssi (VTT Research centre of Finland, Finland)

Title: Micromechanical Modelling Of Additively Manufactured High Entropy Alloys To Establish Structure-properties-performance Workflow

Keyword(s):
Crystal Plasticity, Calphad, CFD, Multi-scale modelling, AMed HEA, Damage

Abstract:
Additive manufacturing is a manufacturing route able to produce complex components with minimal raw-material utilisation and high-level of process control. However, the rapid solidification rates, strong temperature gradients and extremely localised melting lead to non-equilibrium microstructures that imply a better understanding of solid-state transformation, solidification behaviour and structure-property-performance workflow of AMed materials. HEAs unique compositions and complex microstructures slow down considerably the AM parameter optimisation of these materials. Numerical simulations offer a better understanding of the structure-properties-performance of the materials with a reduced number or physical experiments. Hence, a multi-scale modelling approach is taken. For the alloy design phase, Calphad analysis together with DFT simulations and machine learning tools are used to find the most promising HEA compositions. Studying the different microstructural defects, deformation mechanisms that affect the strain hardening potential and damage susceptibility, Crystal-Plasticity models are developed to evaluate the performance of AMed HEAs and the overall workflow.

Innovative Aspect(s):
Multi-scale modelling approach of AMed high-entropy alloys (HEA) to study their process-structure-properties-performance.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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