1st RUSSIA-BRAZIL ONLINE SYMPOSIUM

NOVEL COMPLEX ALLOYS AND ADVANCED PROCESSES FOR OPTIMIZED FUNCTIONAL PROPERTIES

May 21-23, 2024

PROGRAM & BOOK of ABSTRACTS

SCOPE

This symposium focuses on the design, modeling, production and characterization of alloys with microstructural characteristics optimized for different applications. The following properties of the alloys are of particular interest:

corrosion and wear resistance;

mechanical strength and microstructure stability at high temperatures,

hydrogen storage in solids forming hydrides or solid solutions with hydrogen.

Presentations may include works on complex systems such as high-entropy alloys, metallic glasses, nanocrystalline alloys, and quasicrystals as well as results of the in-depth fundamental studies of conventional and well-established alloy systems processed by the advanced methods.

The symposium will promote collaboration between Russian and Brazilian researchers and strengthen scientific ties between the countries.

The participation of graduate and post-graduate students in the symposium is encouraged.

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Federal University of São Carlos, SP, Brazil

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SYMPOSIUM WEBPAGE

https://www.hydro.nsc.ru/science/events/russia-brasil-symposium.php

LIST OF PARTICIPANTS

	Name	Affiliation	Academic status	E-mail
1	Eric Marchezini Mazzer	Federal University of São Carlos, Brazil	Professor	eric.mazzer@ufscar.br
2	Gabriela Chimello Mayer Dias	Federal University of São Carlos, Brazil	Master student	gabrielamayerdias@hotmail.com
3	Jéssica Bruna Ponsoni	Federal University of São Carlos, Brazil	PhD student	jessicabponsoni@gmail.com
4	Tomila Vidyuk	Institute of Solid State Chemistry and Mechanochemistry SB RAS, Russia	Researcher	tomilka.v@gmail.com
5	Guilherme Zepon	Federal University of São Carlos, Brazil	Professor	zepon@ufscar.br
6	Lucas Otani	Federal University of São Carlos, Brazil	Professor	lucas.otani@ufscar.br
7	Bruna Fernanda Batistão	Federal University of São Carlos, Brazil	PhD student	brunafbatistao@gmail.com
8	Ana Soares	Federal University of São Carlos, Brazil	Master student	ana.soares.cruzz@gmail.com
9	Guilherme Yuuki Koga	Federal University of São Carlos, Brazil	Professor	gykoga@ufscar.br
10	Igor Nasennik	Novosibirsk State Technical University, Russia	PhD student	nasennik.2017@corp.nstu.ru
11	Guilherme Stumpf	Federal University of São Carlos, Brazil	PhD student	guicstumpf@gmail.com
12	Natalia Aleksandrova	Novosibirsk State Technical University, Russia	PhD student	aleksandrovanatalie99@gmail.com
13	Julian Arnaldo Avila	São Paulo State University, Brazil	Professor	julian.avila@unesp.br
14	Murilo Oliveira Alves Ferreira	University of São Paulo, Brazil	PhD student	moaferreira@usp.br
15	Jeferson A. Moreto	University of São Paulo, Brazil	Professor	jamoreto@usp.br

16	Daria Lazurenko	Novosibirsk State Technical University, Russia	Senior Researcher, Professor	pavlyukova_87@mail.ru
17	Dina Dudina	Lavrentyev Institute of Hydrodynamics SB RAS, Russia	Leading Scientist	ddudina@hydro.nsc.ru
18	Ivanna Kuchumova	Lavrentyev Institute of Hydrodynamics SB RAS, Russia	Researcher	ivannakz@mail.ru
19	Tatiana Ogneva	Novosibirsk State Technical University, Russia	Professor	pandorra.06@mail.ru
20	Witor Wolf	Federal University of Minas Gerais, Brazil	Professor	witorw@demet.ufmg.br
21	Francisco Gil Coury	Federal University of São Carlos, Brazil	Professor	fgcoury@ufscar.br
22	Alberto Moreira Jorge Junior	Federal University of São Carlos, Brazil; University Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, France	Professor	jorge.moreira@dema.ufscar.br
23	Brenda Juliet Martins Freitas	Federal University of São Carlos, Brazil	Researcher	brenda@ppgcem.ufscar.br
24	Luana Cristina Miguel Rodrigues	Federal University of São Carlos, Brazil	PhD student	luanarodrigues@estudante.ufscar.br
25	Nicolas Rojas Arias	Federal University of São Carlos, Brazil	PhD student	nicolas.rojas@estudante.ufscar.br
26	Caio Lucas Gueiros Pedrosa Martins,	Federal University of São Carlos, Brazil	PhD student	caiolgpm@estudante.ufscar.br
27	Victor Hugo Mafra Monfredo Ferreira	Federal University of São Carlos, Brazil	PhD student	victormonfredo@estudante.ufscar.br
28	Vinícius Pereira Bacurau	Federal University of São Carlos, Brazil	PhD student	vinicius.bacurau@estudante.ufscar.br
29	Gisele Ferreira de Lima Andreani	Federal University of São Paulo, Brazil	Professor	gisele.lima@unifesp.br
30	Abdoul-Aziz Bogno	Federal University of São Carlos, Brazil	Researcher	ablaziz@gmail.br

Program

May 21, 2024

Time: São Carlos, SP, Brazil	**Time: Novosibirsk, Russia**	**Duration (min)**	**Speaker**	**Presentation type**
Session Chair: Dina Dudina				
9-00	19-00	5 + 5	Guilherme Koga & Dina Dudina	Welcome speech
9-10	19-10	25 + 5	Daria Lazurenko	Invited
9-40	19-40	15 + 5	Lucas Otani	Oral
10-00	20-00	15 + 5	Brenda Martins	Oral
10-20	20-20	8 + 2	Gabriela Mayer	Young scientist
10-30	20-30	8 + 2	Natalia Alexandrova	Young scientist
10-40:11-00 (20-40:21-00) Break (20 min)				
Session Chair: Guilherme Koga				
11-00	21-00	25 + 5	Jeferson Moreto	Invited
11-30	21-30	15 + 5	Tomila Vidyuk	Oral
11-50	21-50	15 + 5	Eric Mazzer	Oral
12-10	22-10	8 + 2	Luana Rodrigues	Young scientist
12-20	22-20	8 + 2	Nicolas Rojas	Young scientist

May 22, 2024

Time: São Carlos, SP, Brazil	**Time: Novosibirsk, Russia**	**Duration (min)**	**Speaker**	**Presentation type**
Session Chair: Daria Lazurenko				
9-00	19-00	25 + 5	Witor Wolf	Invited
9-30	19-30	15 + 5	Dina Dudina	Oral
9-50	19-50	15 + 5	Guilherme Zepon	Oral
10-10	20-10	8 + 2	Igor Nasennik	Young scientist
10-20	20-20	8 + 2	Vinicius Bacurau	Young scientist
10-30:11-00 (20-30:21-00) Break (30 min)				
Session Chair: Brenda Martins				
11-00	21-00	25 + 5	Guilherme Koga	Invited
11-30	21-30	15 + 5	Ivanna D. Kuchumova	Oral
11-50	21-50	15 + 5	Francisco Coury	Oral
12-10	22-20	8 + 2	Nicolas Rojas	Young scientist
12-20	22-30	8 + 2	Guilherme Stumpf	Young scientist
12-30	22-30	8 + 2	Ana Soares	Young scientist

May 23, 2024

Time: São Carlos, SP, Brazil	**Time: Novosibirsk, Russia**	**Duration (min)**	**Speaker**	**Presentation type**
Session Chair: Tomila Vidyuk				
9-00	19-00	25 + 5	Alberto Moreira Jorge Jr.	Invited
9-30	19-30	15 + 5	Gisele Lima Adreani	Oral
9-50	19-50	15 + 5	Tatiana Ogneva	Oral
10-10	20-10	8 + 2	Nicolas Rojas	Young scientist
10-20	20-20	8 + 2	Murilo Oliveira	Young scientist
10-30:11-00 (20-30:21-00) Break (30 min)				
Session Chair: Lucas Otani				
11-00	21-00	25 + 5	Julian Ávila	Invited
11-30	21-30	15 + 5	Abdoul-Aziz Bogno	Oral
11-50	21-50	8 + 2	Bruna Batistão	Young scientist
12-00	22-00	8 + 2	Jéssica Ponsoni	Young scientist
12-10	22-10	8 + 2	Caio Martins	Young scientist
12-20	22-20	8 + 2	Victor Ferreira	Young scientist

Advancements and Applications of Cu-Based Shape Memory Alloys

Eric Marchezini Mazzer

Federal University of São Carlos, Department of Materials Engineering, Rodovia Washington Luиs, km 235 SP-310, 13565-905 São Carlos, SP, Brazil

e-mail: eric.mazzer@ufscar.br

Copper-based (Cu-based) shape memory alloys are a key class of functional materials renowned for their shape memory effects and superelasticity due to reversible martensitic transformations. Despite extensive research since the mid-20th century, these alloys still present numerous unresolved scientific and technological challenges. This talk will focus on the advancements in Cu-based shape memory alloys, emphasizing their potential applications in elastocaloric devices, which use stress-induced temperature changes for cooling purposes. Significant progress has been made in developing new alloy compositions and processing routes, enhancing the understanding of phase transformations and improving mechanical and functional properties. Studies on thermoelastic phase transformations have been deepened through thermodynamic and thermo-mechanical research, while metallurgical features like grain size, morphology, ordering, and the presence of precipitates and second phases have been explored using phenomenological approaches. The talk will highlights the elastocaloric effect's potential as a promising alternative to traditional refrigeration. This technology leverages the latent heat released or absorbed during phase transformations, posing an energy-efficient and environmentally friendly cooling solution. Recent developments in the processing and composition of Cu-based shape memory alloys suggest substantial promise for enhancing the performance and applicability of elastocaloric systems. This paper synthesizes these developments and discusses their implications for the future of cooling technologies, aiming to contribute to the field’s understanding and further exploration of these versatile alloys.

Investigation of Ti-Nb-Cr Alloys for Hydrogen Storage Applications

Gabriela C.M. Dias[1], Michael Felderhoff[3], Guilherme Zepon[1,2]

[1] Graduate Program in Materials Science and Engineering (PPGCEM/UFSCar) - Rodovia Washington Luiz, km 235, Federal University of São Carlos, São Carlos, São Paulo CEP: 13565-905, Brazil

[2] Department of Materials Engineering (DEMa/UFSCar) - Rodovia Washington Luiz, km 235, Federal University of São Carlos, São Carlos CEP: 13565-905, Brazil

[3] Department of Heterogeneous Catalysis, Max-Planck-Institut für Kohlenforschung, Kaiser-Wilhelm Platz 1, Mülheim an der Ruhr, 45470, Germany

There is a global effort to meet the growing energy demand while simultaneously reducing fossil fuel consumption. The use of hydrogen as an energy carrier is a promising solution, but its efficient and safe storage remains a challenge for large-scale implementation. In this regard, solid-state hydrogen storage, particularly through metallic hydrides, stands out. Systems based on solid solutions with a body-centered cubic (BCC) structure, such as Ti-V-Cr, Ti-V-Nb-Cr, and Ti-Nb-Cr systems, are highlighted, with the latter still lacking in-depth studies. Pressure-Composition-Isotherm (PCI) diagrams, using a model reported in the literature [1], indicate that increasing the Nb/Ti ratio in the Ti-Nb-Cr system destabilizes the formed hydrides and results in an increase in plateau pressure in the PCI diagrams. This change would lead to lower desorption temperatures, providing significant practical advantages in various applications. In this work, the impact of chemical composition on the structure and hydrogen storage properties was analyzed by producing and characterizing the $Ti_{1.0}Nb_{1.0}Cr_{1.0}$, $Ti_{0.8}Nb_{1.4}Cr_{1.0}$, $Ti_{0.6}Nb_{1.8}Cr_{1.0}$ and $Ti_{0.4}Nb_{2.2}Cr_{1.0}$ alloys. All exhibited BCC structure with a fraction of C15 Laves phase. SEM and EDS analyses revealed dendritic microstructures with chromium microsegregation in the interdendritic regions. Hydrogen storage measurements were conducted using Sieverts-type apparatus. The compositions showed maximum capacities of 2.79 wt.%, 2.30 wt.%, 2.23 wt.%, and 2.09 wt.%, respectively, achieved in less than 2 minutes at room temperature. The hydrogenated alloys exhibited a face-centered cubic (FCC) structure accompanied by the C15 phase. Furthermore, the Pressure-Composition-Temperature (PCT) diagrams showed an increase in absorption and desorption plateau pressures with the rising Nb/Ti ratio, from 0.01 bar for the $Ti_{1.0}Nb_{1.0}Cr_{1.0}$ alloy to approximately 1 bar for the $Ti_{0.4}Nb_{2.2}Cr_{1.0}$ alloy. Moreover, the enthalpy of desorption plateau (ΔH_{plat}), derived from Van't Hoff plots, became less negative as the Nb/Ti ratio increases, providing evidence of hydride destabilization.

[1] G. Zepon, B.H. Silva, C. Zlotea, W.J. Botta, Y. Champion, Thermodynamic modelling of hydrogen-multicomponent alloy systems: Calculating pressure-composition-temperature diagrams, Acta Mater 215 (2021). https://doi.org/10.1016/j.actamat.2021.117070.

Strategy to Design Multicomponent Alloys with C14 Laves Phase for Different Hydrogen Storage Applications

Jéssica Bruna Ponsoni

Federal University of Sao Carlos, Rodovia Washington Luiz, km 235, Sao Carlos, São Paulo – CEP: 13565-905, Brazil

Alloys with C14 Laves phase show great promise as hydrogen storage materials. Their remarkable ability to absorb substantial amounts of hydrogen at room temperature, with fast kinetics and improved cyclability turns them a great option for hydrogen storage technology [1]. The applicability of these alloys as a hydrogen storage media is governed by their thermodynamic properties, which can be tuned by the chemical composition design. In this context, design methods with predictive properties modeling becomes paramount in navigating the vast compositional field of multicomponent alloys effectively. In this study, a strategy based on computational approach was employed to design C14 Laves phase alloys for different hydrogen storage applications. The approach was based on empirical and thermodynamic models [2, 3]. The empirical model considered geometrical and electronic factors based on the chemical alloy composition. The Calculation of Phase Diagrams (CALPHAD) method was applied as a thermodynamic-based tool to predict phase formation and stability of the compositions. In addition, a model to predict the thermodynamics of the metal-hydrogen systems was proposed to calculate the pressure-composition-temperature (PCT) diagrams of multicomponent C14-type Laves phase alloys which made it possible to determine pressure-temperature operation conditions for the designed alloys. The design strategy was experimentally verified by synthesizing the designed alloys by arc-melting, followed by structural characterization and hydrogen storage properties measurements. The $(Ti_{0.5}Zr_{0.5})_1(Mn_{0.5}Cr_{0.5})_2$, $(Ti_{0.5}Zr_{0.5})_1(Fe_{0.33}Mn_{0.33}Cr_{0.33})_2$, and $(Ti_{0.33}Zr_{0.33}Nb_{0.33})_1$ $(Mn_{0.5}Cr_{0.5})_2$ alloys were studied. The results show that these C14 Laves phase multicomponent alloys are within an ample range of equilibrium pressure at room temperature. Further, the alloys exhibited good reversible storage properties, being promising candidates for different hydrogen storage applications, such as room temperature tanks, hybrid tanks and Ni-metal hydrides batteries.

[1] F. Marques, M. Balcerzak. Energy Environ. Sci. 14, 5191-5227 (2021).

[2] G. Zepon, Acta Materialia, 215 (2021) 117070.

[3] J.B. Ponsoni, Acta Materialia, 240 (2022) 118317.

Synthesis of Tungsten Carbides in a Copper Matrix by Spark Plasma Sintering and Properties of the Consolidated Materials

Tomila Vidyuk

Institute of Solid State Chemistry and Mechanochemistry, Siberian Branch of Russian Academy of Sciences, Kutateladze str. 18, Novosibirsk, 630090, Russia

Spark Plasma Sintering (SPS) is a novel method of fast consolidation of powders by means of the pulsed electric current passage and the application of pressure. During SPS, metal matrix composites can be in-situ synthesized by the formation of new phases in a matrix. In this study, reactive SPS was applied to obtain the WC-W_2C-Cu composites from elemental powders. Due to their high hardness, high electrical conductivity and high wear resistance, WC-W_2C-Cu compositions are promising as electrical contact materials, electrodes for resistance welding and electrical discharge machining. In the W-C-Cu system, the inertness of the copper matrix to carbon and the carbide-forming element prevents the synthesis of WC and W_2C phases. In order to facilitate the interactions between the starting components, high-energy mechanical milling was conducted. SPS of mechanically milled powders is a way of obtaining nanostructured materials. A WC-W_2C-Cu composite was fabricated from the W-C-Cu powder mixture milled for 10 min and subjected to SPS at a temperature of 980 °C for 5 min. The structure of the sintered composite is unconventional: Cu-rich regions are located between the composite areas, in which the tungsten carbide particles are distributed uniformly. The formation of this structure is related to inter-particle melting during SPS. The WC–W_2C–Cu composite showed a following properties: a Vickers hardness of 300 HV, an electrical conductivity of 24% of the International Annealed Copper Standard, a residual porosity of less than 5%, a coefficient of friction in pair with a WC-6Co counterpart of 0.46, and a specific wear rate of the material of 0.52×10^{-5} mm^3 N^{-1} m^{-1}.

Tuning the Hydrogen Storage Properties of High Entropy Alloys using Thermodynamic Computational Methods

Guilherme Zepon

Department of Materials Engineering, Federal University of São Carlos, Rod. Washington Luis, sn, km 235, Zip code: 13565-905, São Carlos, Brazil

In the last few years, many high-entropy alloys (HEAs) have been investigated as potential materials for hydrogen storage since many HEAs can form high-entropy hydrides. Since the hydrogen storage properties of properties of metal hydrides are greatly depended on the type of phase formed, and chemical composition, the vast composition field of HEAs open an exciting path for developing promising materials with tunable properties to achieve best performance for each specific hydrogen storage applications. In this work, it will be presented how computational thermodynamics tools can be used to boost the discovery of HEAs with targeted hydrogen storage properties. The thermodynamic tools employed are the CALPHAD method implemented in commercially available software and databases; and thermodynamic models for calculating pressure-composition-temperature (PCT) diagrams of HEAs-H systems developed by our research group and implemented in open-source codes. Examples of single body-cubic centered (BCC) and single C14-Laves phase HEAs designed with these tools will be presented.

Spray Forming of Lightweight Steels with Distinct Matrices Reinforced by *in situ* TiB_2 Formation

Lucas B. Otani[a], André L. Vidilli[a,b], Guilherme Y. Koga[a,b], Vicente Amigó[c], Claudemiro Bolfarini[a,b]

[a]Department of Materials Engineering, Federal University of São Carlos (UFSCar), Rodovia Washington Luís, km 235, 13565-905, São Carlos, SP, Brazil

[b]Federal University of São Carlos, Graduate Program in Materials Science and Engineering, Rodovia Washington Luís, km 235, 13565-905, São Carlos, SP, Brazil

[c]Institute of Materials Technology (ITM), Universitat Politècnica de València (UPV), Valencia, Spain

*Corresponding author: lucas.otani@ufscar.br

Advanced high-strength steels (AHSS) include various alloys with distinct properties, and the main motivation for their development is found in the automotive sector. The possibility of increasing the specific strength of these materials can potentially reduce the structural weight of automobiles, leading to lower greenhouse gas emissions. Among these alloys, the low-density steels are the subject of study by various authors, particularly those in which Mn, Al, and C are added to reduce the alloy's density. However, the main drawback of the Al presence is its tendency to decrease the modulus of elasticity. To counteract this, the *in situ* formation of intermetallic materials, notably TiB_2, has been proposed to enhance the elastic modulus of various materials, including steels, titanium, and aluminum alloys. The objective of this study was to investigate the effects of adding 5% and 10 vol.% of *in situ* formed TiB_2 to two high-Mn low-density steels containing 15 and 20 wt.% Mn. The alloys were processed via spray forming followed by hot rolling to achieve a highly homogeneous microstructure with good intermetallic distribution. The results revealed that the solidification range influenced the morphology of the reinforcing particles. Higher amounts of Ti and B led to a greater fraction of TiB_2 particles, maintaining the elasticity modulus above 200 GPa for composites with a ferritic matrix. Tensile tests indicated that the alloy with a predominantly austenitic matrix did not exhibit the expected increase in ductility, typically expected from TRIP and TWIP alloys. Additionally, wear resistance was significantly improved by the introduction of the reinforcing particles and is one of the main contributions of the present study.

Microstructural and Mechanical Characterization of the High Strength AA2017 Alloy Produced by Laser Powder Bed Fusion

Bruna Fernanda Batistão[1,*], Piter Gargarella[1,2,3]

[1] Federal University of Sao Carlos, Graduate Program in Materials Science and Engineering, Sao Carlos, SP, Brazil

[2] Federal University of Sao Carlos, Department of Materials Engineering, Sao Carlos, SP, Brazil

[3] Federal University of Sao Carlos, Center of Characterization and Development of Materials, Sao Carlos, SP, Brazil

* e-mail: bruna.batistao@estudante.ufscar.br

High Strength Al-Cu alloys are extensively used in aerospace and automotive applications due to their exceptional specific strength, as well as good fatigue and corrosion resistance. However, the use of Laser Powder Bed Fusion (L-PBF) to process Al-Cu alloys remains challenging due to their extensive solidification interval, which often results in hot cracking during processing. Therefore, this study aimed to employ L-PBF to process the AA2017 alloy, the oldest and most well-known alloy in the Al-Cu system. Box Behnken Design and Analysis of Variance (ANOVA) were used to analyze the influence of the processing parameters (laser power, scanning speed, and hatch distance) on porosity. The optimized parameter resulted in low porosity (0.17±0.06%) and low crack density. The microstructure was characterized by optical microscopy, scanning electron microscopy, and electron backscatter diffraction, showing the typical α-Al columnar grains along the building direction and Al_2Cu precipitates. Precipitates with a concentration of Mg and Si, and Fe and Mn were also observed and identified by X-ray diffraction and transmission electron microscopy, and compared with the phases formed in the solidification of the alloy according to Thermocalc computational thermodynamics software (version 2021b), TCAL3 database, and the literature. The AA2017 alloy processed by L-PBF also presented a yield strength, ultimate tensile strength, and elongation at fracture of 184 ± 5 MPa, 314 ± 46 MPa, and 8 ± 6 %, respectively. The influence of the building direction on the quasi-static mechanical properties of the AA2017 alloy produced by L-PBF was also investigated through compression tests.

Austenitic stainless steels affected by manganese sulfides: surface recovery by LASER remelting

Ana Soares

Federal University of São Carlos, Brazil

Austenitic stainless steels, especially AISI 316L, are recognized for their high mechanical strength, toughness, and corrosion resistance in several applications. However, manganese sulfide (MnS) in AISI 316L is the main cause of susceptibility to pitting corrosion. Steels with high concentrations of MnS require costly processes to improve corrosion resistance. Studies performed by Chao et al. (2017) indicate the MnS and other precipitates reduction to manufactured 316L components by laser powder bed fusion when compared to wrought condition. Since electrochemical corrosion is a process initiated on the surface, Laser Surface Remelting (LSR) can be a fast and effective method for MnS elimination, given the process characteristics: high energy density and cooling rates. This work has as its objective the recovery of steels affected by MnS through LSR for different applied energy densities. The steels as received and treated-LSR were microstructurally characterized with a thorough investigation of their precipitates by scanning electron microscopy. Pitting corrosion susceptibility was evaluated by cyclic potentiodynamic polarization and electrochemical impedance spectroscopy in 0.6 M NaCl solution. This study verified the effectiveness of LSR as a surface engineering technology for the recovery of the pitting corrosion resistance of austenitic stainless steels compromised by sulfides.

Acknowledgements

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References

[1] CHAO, Q. et al. On the enhanced corrosion resistance of a selective laser melted austenitic stainless steel. Scripta Materialia, v. 141, p. 94–98, 2017.

Advanced Ferrous Alloys and Coatings for Demanding Applications

Guilherme Yuuki Koga

Federal University of São Carlos, Brazil

Ferrous alloys are the first choice among metallic materials given a myriad of possibilities to design its structure in different length-scales to meet strict requirements. It is notorious the importance of steels on the success of developing modern societies. Iron (Fe) and its alloys are essential for improving the quality of life and enabling affordable and mass use technologies. Strength and toughness are vital requirements for most structural applications but are often mutually exclusive. Steel metallurgy proved to surpass this conflict through technologies at a reasonable cost, and research over the decades has enabled unprecedented levels of mechanical properties, including damage tolerance. Besides the economic and structural aspects, wear and corrosion resistance are also basic attributes of alloys aiming to withstand aggressive environments. In some cases, having corrosion and wear resistance is the first criterion for materials selection. This work summarizes the progress of advanced ferrous alloys and coatings in terms of alloy design, powder production, protective coatings, and how the microstructural features dictate the basket of properties, with focus on the tribological and electrochemical aspects.

Structure Research of a Composite Material Based on a High-Entropy Metallic Glass of the Composition ZrHfTiAlCoNiCu Obtained by the SPS-method

[1,2] Igor E. Nasennik

[1]Novosibirsk State Technical University, Novosibirsk,

[2]Siberian Circular Photon Source (SKIF), Boreskov Institute of Catalysis SB RAS, Kol'tsovo, Russia

One of the main directions of research in the field of structural materials science today is multi-component alloys. Among them, special attention from the scientific community is drawn to high-entropy alloys, which consist of several components taken in equal (or approximately equal) proportions. One of the most promising directions of research in multi-component alloys is volumetric metallic glasses. Until recently, these directions predominantly developed independently of each other, but relatively recently high-entropy alloys of the TiZrCuNiBe, PdPtCuNiP, TiZrHfCuNiBe, SrCaYbMgZn systems, and others have been proposed, prone to amorphization under conditions of high-speed cooling.

This class of materials has several significant advantages compared to classical alloys. For example, the absence of a crystalline structure leads to the elimination of intergranular corrosion effects, significantly increasing the service life of these materials in aggressive external environments. High hardness values contribute to increased wear resistance.

The study investigated the composite material Al-$Zr_{35}Hf_{17.5}Ti_{5.5}Al_{12.5}Co_{7.5}Ni_{12}Cu_{10}$, obtained by spark plasma sintering at a pressure of 40 MPa. The high-entropy metallic glass composition $Zr_{35}Hf_{17.5}Ti_{5.5}Al_{12.5}Co_{7.5}Ni_{12}Cu_{10}$ was obtained by vacuum suction casting in argon arc furnace.

After obtaining the composite material, hardness tests, compression tests, and three-point bending tests were conducted to determine the nature of changes in mechanical properties during deformation.

The study was supported by the Ministry of Science and Higher Education of the Russian Federation as a part of the state task FSUN-2024-0005 "Structural transformations in surface layers of metal alloys under extreme thermal and deformation impacts".

Investigating the Chemical Short-Range Order in Medium/High-Entropy Alloys through an Innovative Design Approach

Guilherme Stumpf
Federal University of São Carlos, Brazil

The concept of high-entropy alloy (HEA) design opens up new avenues for expanding the potential compositions of alloys. Face-centered cubic (FCC) HEAs and MEAs (medium-entropy alloys), such as the CrCoNi alloy, have shown promise in various engineering applications. Yet, understanding the structural behaviors of HEAs/MEAs remains a challenge. The intricate nature of multiple principal elements, lacking a distinct solvent, has spurred significant interest in HEA/MEA literature. Studies suggest that subtle local preferences among elements can induce chemical fluctuations, leading to chemical short-range order (CSRO). However, characterizing this phenomenon proves to be complex and contentious. To address these fundamental questions, a novel design strategy was proposed: incorporating alloying elements that promote CSRO while enhancing detectability. To achieve this, different CrCoNi-X alloys (where X represents a unique alloying element) were synthesized using electric arc-melting. The samples were then homogenized to a single-phase FCC state. Subsequently, a final "CSRO aging" heat treatment below 500 °C was performed to minimize random chemical distribution tendencies. Comprehensive characterization of both aged and fully recrystallized samples was conducted using various techniques including SEM, DSC, TEM (with electron diffraction and EDS), and In-situ Dilatometry with High-Energy XRD. The results reveal diverse CSRO distributions, providing insight to the chemical bonding dynamics among different atomic pairs and Waren-Cowley parameters.

Acknowledgments

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References

[1] Coury, F.G. et al. Nature 622, 742 (2023).

Investigation of Titanium Trialuminide-Based Alloys with $L1_2$ crystal Structure Stabilized by Fe, Co and Ni

Natalia Aleksandrova

Novosibirsk State Technical University, Novosibirsk, Russia

Titanium trialuminide-based alloys attract the attention of many research groups as high-temperature structural materials due to the low density, high specific strength, excellent heat resistance and oxidation resistance. However, the tetragonal $D0_{22}$ crystal structure of $TiAl_3$ characterized by low symmetry makes this material extremely brittle at room temperature. One of the methods to solve this problem is the alloying of $TiAl_3$ with transition metals such as Cr, Mn, Fe, Co, Ni, Cu or Zn. This makes it possible to transform the tetragonal $D0_{22}$ lattice into a more ductile cubic $L1_2$ structure.

In this work, alloys of the $Ti(X, Al)_3$-type were investigated, where X is a transition metal (Fe, Co or Ni). Samples were obtained by arc melting. To ensure a homogeneous distribution of the elements, the alloys were remelted several times. The elemental composition was determined using energy dispersive X-ray analysis. The composition of the alloy corresponded to $Ti_{26}X_{11}Al_{63}$.

The phase analysis carried out by X-ray diffraction method revealed the formation of the cubic $L1_2$ $TiAl_3$. However, each alloy contained minor precipitates of the second phase with stoichiometry of $TiXAl_2$. The appearance of this phase can decrease in the ductility of the alloy. To estimate the stability of the alloy constitutions and reveal the possibility to find appropriate heat treatment regimens for illumination of the minor phase the density functional theory calculations were carried out.

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Parametrization of Inconel 718 Alloy Processed by a Laser-Based Directed Energy Deposition: Effect of Solubilization and Aging Treatments on the Microstructure Evolution and Mechanical Behavior

Thiago Cavalcante[1,2], Douglas Bon[1], Fábio Mariani[1], Reginaldo Teixeira Coelho[1], Jessica Calvo[2], Jairo Alberto Muñoz[2], Julian Arnaldo Avila[3]

[1] Universidade de São Paulo (USP), Escola de Engenharia de São Carlos, Departamento de Engenharia de Materiais, Brazil, 13563-120

[2] Materials Science and Engineering Department, Universitat Politècnica de Catalunya, Eduard Maristany 16, 08019, Barcelona, Spain

[3] Universidade Estadual Paulista (UNESP), Faculdade de Engenharia, São João da Boa Vista, São Paulo, Brazil, 13876-750

The laser-based Directed Energy Deposition is an additive manufacturing (AM) method with high accuracy and deposition rates [1]. Due to the development of materials for gas turbine engines, focused on materials with high mechanical properties and corrosion resistance, Inconel alloys were designed, such as the Inconel 718 (IN718) [2]. The precipitation hardening heat treatments recommended for IN718 focused on appropriate temperatures and times to promote the precipitation of the fine γ' and γ" coherent phases to enhance the mechanical properties. Previous works coincide in applying a solubilization treatment before the double aging, carried out in two stages (DA: 8h at 720°C followed by another 8h at 620°C). The solubilization heat treatment at temperatures above 1000°C, followed by double aging (DA), aims to produce fine precipitation of the γ' and γ" phases that increase the mechanical resistance of IN718 [3]. However, heat treatments suggested by books for conventional processed IN718 do not apply to AM parts. As a result of the thermal cycle that each part undergoes, the phase transformation kinetics are affected in subsequent heat treatments, which in turn affects the thickening of γ', γ" precipitates and the formation of deleterious phases such as δ and Laves that can happen at different times. Consequently, in this work, we develop a processing window and later explore the effects of heat treatments, such as the homogenization (H – 1100 °C for 1,5 h), solubilization (S – 1000 °C for 1h), and DA and combinations (S, H, DA, S+DA, H+DA, and H+S+DA). The microstructural evolution and mechanical properties were assessed, and the best overall microstructural and mechanical properties were achieved with the H+S+DA.

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Enhancing the Corrosion Resistance of the 316L SS by using Reactive Sputtering Technique

Murilo Oliveira Alves Ferreira, Jéferson Aparecido Moreto

Materials Department, São Carlos School of Engineering, University of São Paulo (USP), São Carlos, São Paulo, Brazil

One material that have been studied as a replacement of the conventional Ti-6Al-4V alloy to be used as biomedical implantable device is the 316L stainless steel (316L SS) due to its great mechanical properties and lower coast. However, in comprising to other widely used alloys in these field, the corrosion properties of the 316L SS display unsatisfactory performance. In this sense, one alternative for improving the corrosion resistance of the 316L SS is the surface functionalization by thin films. This work aims to investigate the influence of both niobium pentoxide (Nb2O5) and carbon nanostructured coatings deposited by reactive sputtering technique on the 316L SS surfaces, seeking to improve the corrosion resistance. The coated and uncoated specimens were morphologically and structurally characterized by using OM, SEM/EDX, DRX, FTIR, Raman spectroscopy as well as XPS techniques. The corrosion behaviour was assessed by using OCP, PPc, EIS and immersion tests in 0.6 mol L-1 NaCl solution. The average contact angles were used to evaluate the surfaces free energy by using the Van Oss interfacial tension component theory approach. Results demonstrated that the surface treatments positively influenced the corrosion resistance of the 316L SS, and the coatings act as a protective barrier against corrosion process and increased the wettability of the surfaces in relation to the base material. Considering applications in aggressive media, the 316L SS/Nb_2O_5 specimen exhibits superior performance when compared to the bare material and 316L SS/carbon.

Corrosion and fatigue-corrosion studies on the 2198-T851 aluminium alloy containing Nb_2O_5 coating

Jeferson A. Moreto

Materials Engineering Department, São Carlos School of Engineering, University of São Paulo (USP), São Carlos, São Paulo, Brazil

In this lecture, we will discuss the influence of niobium pentoxide-based coatings (Nb_2O_5) deposited by using reactive sputtering technique on enhancing the mechanical and corrosion resistance of the 2198-T851 (Al-Cu-Li) aluminium alloy widely used as aircraft materials. To achieve this, we will unveil a comprehensive array of corrosion findings, including open circuit potential (OCP), potentiodynamic polarization curves (PPc), electrochemical impedance spectroscopy (EIS) and immersion tests for long periods. Additionally, we will showcase fatigue-corrosion tests conducted on the 2198-T851 alloy, comparing specimens with and without Nb_2O_5 thin films in air and an aggressive medium. The corrosion and fatigue-corrosion tests were accompanied by extensive morphological characterisation, including optical microscopy (OM), atomic force microscopy (AFM), and scanning electron microscopy (SEM)/energy dispersive X-ray spectroscopy (EDS). The Nb_2O_5 coating was able to improve the corrosion and fatigue-corrosion resistance of the 2198-T851 aluminium alloy. This study marks an initial step towards more comprehensive investigations into the impact of Nb_2O_5 coating on improving the corrosion and mechanical properties of the 2198-T851 aluminium alloy.

Estimation of the Structure and Properties of the Two-Layer TiAl-Based Coating by Energy-Dispersive Synchrotron X-ray diffraction and Density Functional Theory

Daria Lazurenko

Novosibirsk State Technical University, Russia

Ti and its alloys are the important structural materials for such industries as aircraft and rocketry, and chemical engineering due to its low density, high mechanical strength, and excellent corrosion resistance. However, under operating conditions that involve friction loading and (or) exposure to high temperatures, titanium is hardly suitable due to its intense interaction with atmospheric gases, low creep resistance, and a tendency to seizure in friction pairs. Cladding of Ti with titanium aluminides which are characterized by higher hardness and operating temperatures can significantly improve the properties of its contact surfaces.

In this study, non-vacuum electron beam cladding was applied for producing protective coatings on Ti workpieces. The 3.8 mm thick TiAl-based coatings alloyed with Cr and Nb was obtained on Ti alloy substrates in two passes of the electron beam. To evaluate inhomogeneity of the cladding layer, energy-dispersive synchrotron X-ray diffraction in combination with energy-dispersive X-ray spectroscopy was applied. It was found that in the direction from the top of the coating to the substrate, the dilution of the cladding layer with Ti increased. It influenced the phase constitution of the coating and led to a variation in the chemical composition of the different phases (Ti_3Al, β-phase, and TiN). Experimental data were approved by density functional theory (DFT) simulations. A variation of operational performance of the cladding layer was also predicted from the simulation. Wear resistance and oxidation resistance are expected to decrease in the direction from the top of the cladding layer toward the substrate. The combination of DFT simulation and materials characterization techniques proposed in this study can be used for preliminary diagnostics of the gradient structures and be performed without laborious experiments.

Origin of the Liquid Phase Formation during Spark Plasma Sintering: Stimulated and Concurrent Processes

Dina V. Dudina[1,2,3], Alexandr A. Shtertser[1], Tomila M. Vidyuk[2], Nina Yu. Cherkasova[3], Boris B. Bokhonov[2]

[1] Lavrentyev Institute of Hydrodynamics SB RAS, Novosibirsk, 630090, Russia; e-mail: dina1807@gmail.com

[2] Institute of Solid State Chemistry and Mechanochemistry SB RAS, Novosibirsk, 630090, Russia

[3] Novosibirsk State Technical University, Novosibirsk, 630073, Russia

Spark plasma sintering (SPS) is usually regarded as a solid state sintering technique. However, in many studies, the formation of a liquid phase during SPS was observed as an effect concurrent to the powder consolidation. The direct evidence of melting at the inter-particle contacts has been accumulated for a number of systems. In some cases, the formation of a liquid phase is intentionally stimulated. At the laboratory scale, SPS in the presence of a liquid phase has been successfully used for the fabrication of ceramics, metal matrix composites and alloys. In this presentation, based on the literature data and results obtained by the authors, the origin of the liquid phase formation during SPS will be analyzed in alloys and metal-ceramic composites.

Effects of WC Addition on Microstructure and Functional Properties of Fe-based Alloy Metallic Glass Coatings Obtained by Detonation Spraying

Ivanna D. Kuchumova[a*], Igor S. Batraev[a,b], Vladislav S. Shikalov[c], Tomila M. Vidyuk[c], Arina V. Ukhina[d], Vladimir Yu. Ulianitsky[a], Alexandr A. Shtertser[a]

[a] Lavrentyev Institute of Hydrodynamics SB RAS, 15, Lavrentyev Ave., Novosibirsk, 630090, Russia

[b] Novosibirsk State Technical University, K. Marx Ave. 20, Novosibirsk, 630073, Russia

[c] Khristianovich Institute of Theoretical and Applied Mechanics SB RAS, 4/1, Institutskaya St., Novosibirsk, 630090, Russia

[d] Institute of Solid State Chemistry and Mechanochemistry SB RAS, 18, Kutateladze St., Novosibirsk, 630128, Russia

In the present work, the possibility of obtaining coatings with a matrix of metallic glass reinforced with WC particles by detonation sputtering was demonstrated. The SHS7574–WC powder mixtures with 10 vol.% WC 20 vol.% WC, 30 vol.% WC, and 40 vol.% WC were used for coating deposition on carbon steel substrate. The SHS7574 alloy powder had a predominantly crystalline structure. The SHS7574 and SHS7574–WC coatings were fabricated by detonation spraying using the C_2H_2 + 0.3 C_3H_6 + 1.4 O_2 gas mixture. The effects of WC addition on the microstructure, phase composition, mechanical and corrosion properties of SHS7574 detonation coatings were investigated by an optical microscope, X-ray diffraction (XRD), scanning electron microscopy (SEM) coupled with energy-dispersive spectroscopy (EDS), Vickers hardness tester, sliding wear tester, and salt spray chamber. The results show that the addition of WC powder (more than 20 vol.%) to the SHS7574-WC powder mixture can not only improve microhardness and wear resistance of the composition coatings but also reduce porosity. An increase of the WC concentration in the powder mixtures causes a simultaneous rise of tungsten carbide content in the coatings. Composite coatings fabricated by spraying of the SHS7574–40vol.%WC powder mixture demonstrated the highest hardness and wear resistance under dry sliding conditions. Furthermore, it was found that the wear resistance of this coating was twice that of coatings without WC addition. Detonation coatings obtained in the present work showed high resistance to neutral salt fog.

The effect of Al Content on Structure and Properties AlCoCrFeNi HEA Coatings Produced by Non-Vacuum Electron Beam Cladding

Tatiana Ogneva

Novosibirsk State Technical University, Russia

The structure and properties of AlCoCrFeNi high-entropy coatings produced on low-carbon steel substrates by non-vacuum electron beam cladding were studied. Powder mixtures containing 0.5, 1, and 1.5 molar ratios of Al were used for cladding. The structure of the coatings was investigated by optical microscopy, scanning electron microscopy, electron backscatter diffraction (EBSD), and energy dispersive X-ray (EDX) analysis.

The phase transformations during heating of the samples above the solidus temperature were assessed using in-situ synchrotron X-ray diffraction (SXRD). Microhardness was measured, and dry sliding wear tests of the coatings were performed. The structure of the coatings with a higher Al content predominantly consisted of a bcc phase with nanosized A2+B2 precipitates. Coatings with an equal ratio of initial components consisted of a mixture of bcc and fcc phases. In coatings with lower Al content, the main phase was fcc. It was found that the amount of Al in the initial powder mixtures significantly affected the concentration of Fe in the coating: as the Al molar ratio decreased from 0.5 to 1.5, the Fe content increased from 9.9 to 48.1. at. %.

Coatings with a high Al content showed the highest hardness and wear resistance, which was associated with the high hardness of the cc phase. Fcc coatings with increased Fe content were more prone to plastic flow because of their low hardness. However, these coatings demonstrated wear resistance comparable to that of a two-phase bcc+fcc sample, which was related to the work hardening of the fcc phase during friction.

Al-based Quasicrystalline Alloys and Composites with Improved Wear Resistance

Witor Wolf

Department of Metallurgical and Materials Engineering, Federal University of Minas Gerais, Brazil

Quasicrystals are solid phases with an atomic organization significantly different from that observed in conventional crystalline materials. In addition to the scientific community's interest in their particular structure, the methods used to manufacture these materials, as well as their mechanical and functional properties, have been subject of extensive study since their discovery. Among the main properties of these materials are their high hardness and elastic modulus and a low coefficient of friction when in contact with other metallic and ceramic solids, very desirable characteristics for wear-resistant materials. With regard to their mechanical properties, quasicrystals, when embedded in a tough matrix, can be highly resistant to plastic deformation at high temperatures. However, applications involving these interesting materials are still incipient. One of the main reasons for this lies in the difficulties and costs associated with their fabrication. These phases generally form in narrow compositional regions and are formed through complex reactions which, in general, occur in conjunction with the formation of other intermetallics and which, in the absence of a tough matrix, result in a highly fragile material with little possibility of application. The solution to these issues usually involves the use of rapid solidification methods and/or powder metallurgy, which makes these materials more expensive and restricts their applications. In this presentation we will show recent advances in our studies regarding Al-based quasicrystalline alloys, focusing on the improvement of their wear resistance while, at same time, aiming at simplifying their fabrication methods. We will show how different manufacturing methods can be used to produce different microstructures containing quasicrystals and complex intermetallic phases, including conventional casting, spray-forming, high-velocity oxygen fuel and high-pressure torsion. We will show that the Al-Cu-Fe-Cr system is one of the most promising quasicrystal-forming systems to be used as protective coatings against wear. Decagonal and icosahedral quasicrystals have been reported to form in this system, depending on chemical composition and solidification rates. Additionally, it has been shown that they can be embedded in an Al-FCC matrix by applying both rapid and slow solidification routes, making this a very flexible system in terms of fabrication methods.

Short-Range Ordering in High Entropy Alloys

Francisco Gil Coury, Guilherme Stumpf, Vinícius Bacurau, Angelo Andeolli, Piter Gargarella, Eric Mazzer

Federal University of São Carlos, Brazil

Understanding Chemical Short-Range Order (CSRO) in High and Medium Entropy Alloys (HEAs/MEAs) such as CrFeNi, CoCrNi, and CoCrFeNi is essential for grasping their impact on material properties. This research investigates the potential effects of CSRO on physical properties, as indicated by distinct behaviors in thermal expansion and specific heat capacity with varying temperatures. By focusing on different ordered states, the study employs microstructural analysis techniques including synchrotron X-Ray diffraction, absorption spectroscopy, and transmission electron microscopy to mitigate influences such as texture, recrystallization, and secondary phase formation. A significant pseudo-gap in the Density of States suggests specific Ni-Cr atomic interactions, corroborated by Hybrid Monte Carlo/Molecular Dynamics (MC/MD) simulations. Integrating calorimetric data with simulations confirms the presence of CSRO, initiating discussions on its quantification. The findings suggest that while heat treatments can influence CSRO levels, their impact on the mechanical behavior of alloys may be limited, at least for these compositions. These results underscore the necessity for quantitatively identifying CSRO to accurately assess its effects on material properties.

Design, Structure/Microstructure Evolution, Mechanical and Corrosion Properties of Newly-Developed Pseudo-High Entropy Amorphous Alloys

Weverson C Batalha[1], Virginie Roche[1], Claudio S. Kiminami[2], Alberto M. J. Junior[1,2 *]

[1]University Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, France

[2]Federal University of São Carlos, DEMa, Brazil

This work reports on the influence of devitrification on the structure/microstructure, corrosion, and mechanical properties of two new Fe61Cr11Mo8Nb4B16 and Fe61Cr11Mo8Ni4B16 pseudo-high entropy (PHE) amorphous alloys that may be used as coatings. So far, only two PHE alloys (only two systems) have been studied.

Calphad simulation assisted the alloys' design. Amorphous ribbons produced by melt spinning were heat-treated to simulate crystallization. Thick physically simulated coatings of commercial-grade precursors using spray forming (cooling rate after deposition ranges from 0.1 to 10 K/s) in the air were produced to infer their viability and glass-forming ability and confirm the crystallization path and mechanical properties.

After heat treatment, amorphous phases were kept at high temperatures and crystallized in multi-principal element bcc or fcc phases, with few borides. The simulated coating of the Nb-PHE alloy was nearly amorphous, and the Ni-PHE one crystallized in a bcc phase + few borides. Nanoindentation evaluated the ribbons' mechanical behavior and coatings by Vickers microhardness. Ribbons' hardness and elastic modulus depended on annealing temperatures and were very high, indicating high wear resistance. The simulated coatings confirmed hardness values. Corrosion properties in seawater at different pHs showed outstanding corrosion resistance in amorphous conditions, much better than any other Fe-based conventional amorphous alloys. After devitrification, both compositions preserved excellent corrosion behavior up to ~700 °C, but the Nb-PHE alloy presented better properties. Pitting corrosion, usual in most Fe-based amorphous alloys, was not present in any condition.

After crystallization, their resistance to corrosion and wear indicates that they are promising for coating applications through different techniques.

Wear-Resistant Ultrafine-Grained Stainless Steel Composite Produced by Additive Manufacturing

Brenda Juliet Martins Freitas[1,2,*], Guilherme Yuuki Koga[3,4], Sergio de Traglia Amancio-Filho[2], Claudemiro Bolfarini[3]

[1]Federal University of São Carlos, Graduate Program in Materials Science and Engineering, São Carlos, 13.565-905, Brazil

[2]Graz University of Technology, Institute of Materials Science, Joining and Forming, Graz, 8010, Austria

[3]Federal University of São Carlos, Department of Materials Engineering, São Carlos, 13.565-905, Brazil

[4]Federal University of São Carlos, Center for Characterization and Development of Materials (CCDM), Rod. Washington Luis, São Carlos, SP, CEP 13565-905, Brazil

*Corresponding author: brenda@ppgcem.ufscar.br

Boron-modified stainless steel composites exhibit a great combination of corrosion resistance and toughness of the metallic matrix with wear resistance conferred by hard reinforcing nanoparticles. Given its near-net-shape manufacturing characteristics, laser powder bed fusion (LPBF) is attractive to produce these hard and wear-resistant classes of materials with low machinability. The microstructure, hardness, and wear behavior of a boron-containing stainless steel composite (SAF 2205 composition with 0.6 wt.% of B) produced by LPBF was evaluated and benchmarked against its boron-free hot rolling- and LPBF-produced counterpart. Ultrafine-grained (~1 μm), dense (~99.9%), and crack-free ferritic-induced matrix composite with Cr2B-nanoborides reinforcing the grain boundaries (GBs) was obtained. Moreover, the boron-modified stainless steel composite exhibited noteworthy higher hardness (up to 456 HV0.5) and wear resistance (4.4 x 10-5 mm3 N-1m-1) in sliding condition compared to a hot-rolled (225 HV0.5 and 2.9 x 10-3 mm3 N-1m-1) and a LPBF-produced SAF 2205 (314 HV0.5 and 3.3 x 10-4 mm3 N-1m-1), being ascribed to its ultrafine-grain structure, and hard and rigid boride-skeleton armoring the steel matrix. Therefore, replacing SAF 2205 components used in environments subject to severe wear and corrosion with LPBF-produced boron-containing stainless steels composites may be beneficial in increasing the component service life.

Wear-Resistant Fe-Cr-Mo-Nb-B Coating by Plasma Transferred Arc

Luana Cristina Miguel Rodrigues[1,2], Guilherme Yuuki Koga[2,3], Ana Sofia Clímaco Monteiro de Oliveira[4], Claudemiro Bolfarini[2], Cláudio Shyinti Kiminami[2], Walter José Botta[2]

[1] Federal University of São Carlos, Graduate Program in Materials Science and Engineering, São Carlos, 13.565-905, Brazil

[2] Federal University of São Carlos, Department of Materials Engineering, São Carlos, 13.565-905, Brazil

[3] Federal University of São Carlos, Center for Characterization and Development of Materials (CCDM), Rod. Washington Luis, São Carlos, SP, CEP 13565-905, Brazil

[4] Federal University of Paraná, Department of Mechanical Engineering, Curitiba, Paraná, Brazil

Corresponding author: luanarodrigues@estudante.ufscar.br

$Fe_{68}Cr_8Mo_4Nb_4B_{16}$ gas-atomized powders were employed to coat carbon steel substrates through the Plasma Transferred Arc (PTA) process. Four processing conditions were considered: A, B, C e D. For condition A and condition B the powder feed rate was 10 g/min and current were 120 A, varying only the particle size range: 106 - 180 μm and 53 - 106 μm, respectively. For condition C and condition D, the powder feed rate was 6 g/min, using powders with a granulometric range of 53 - 180 μm, being 50% powders with a particle size of 53 - 106 μm and 50% powders with particle size 106 - 180 μm, changing only the current: 120 A and 180 A respectively. The coatings were evaluated by X-ray diffraction (XRD), scanning electron microscopy (SEM), optical microscopy (OM), differential scanning calorimetry (DSC), transmission electron microscopy (TEM) and confocal microscopy (CM). The Vickers microhardness was analyzed in the top and cross section of the polished coatings. Tribological tests were performed based on the standard (ASTM G133-05) on polished surfaces (Al_2O_3 1-μm), in pin-on-plate reciprocal configuration. Preliminary results indicated: i) coatings with refined microstructures, composed of M_2B - tetragonal hard borides; ii) Fe dilution of the coating on the substrate ~ 23%; iii) Vickers Microhardness ~ 370 $HV_{0.5}$; iv) and abrasive wear resistance ~ 1.7 x 10^{-4} $mm^3N^{-1}m^{-1}$. Such results demonstrate that the $Fe_{68}Cr_8Mo_4Nb_4B_{16}$ alloy is viable to be used in steel coating processes by PTA.

Influence of Chemical Composition on the Hot Cracking Susceptibility in AA2017-Based Alloys

N. Rojas-Arias [a, b*], F.G. Coury [a, b], P. Gargarella [a, b, c]

[a] Graduate Program in Materials Science and Engineering, Federal University of São Carlos, Rod. Washington Luis Km 235, São Carlos, 13565-905, Brazil

[b] Department of Materials Engineering, Federal University of São Carlos, Rod. Washington Luis Km 235, São Carlos, 13565-905, Brazil

[c] Center for Characterization and Development of Materials, Federal University of São Carlos, Rod. Washington Luiz, km 235, São Carlos, 13565-905, Brazil

*Corresponding author: nicolas.rojas@estudante.ufscar.br

Aluminum alloys are widely applied in several industrial fields, with wrought aluminum alloys being particularly noteworthy for their exceptional mechanical properties, which can be enhanced through heat treatments. Nevertheless, wrought aluminum alloys, e.g. Al-Cu-based compositions, exhibit a wide solidification interval that promotes a high hot cracking susceptibility (HCS). This limits their application in processes with rapid cooling rates, such as welding and additive manufacturing processes. Considering the above, we propose a methodology for designing and modifying alloys with a high HCS, focusing on the AA2017 wrought aluminum alloy as a case of study. Candidate compositions were developed by thermodynamic calculations using the Pandat Software. Parts of these compositions were produced at different cooling rates and characterized by optical microscopy, scanning and transmission electron microscopy, X-ray diffraction, differential scanning calorimetry, and microhardness techniques. The study revealed that Cu and Si concentrations significantly influence the HCS of AA2017. Optimizing the concentrations of these elements, along with the incorporation of Ce, resulted in a reduced solidification interval and the formation of eutectic regions rich in Al + Al_3CeCu. This led to a substantial decrease in the HCS index by approximately 2500 °C, enabling the production of crack-free parts irrespective of the cooling rate applied. Furthermore, the modified composition of AA2017 contributed to increased hardness values through microstructure refinement and the formation of eutectic regions and secondary phases facilitated by the addition of Ce.

Production of a New Al-Cu-Ce-Based Composition for its Processing by Additive Manufacturing Processes

N. Rojas-Arias[1,2,3,*], F.G. Coury[1,2,4], ST Amancio-Filho[3], P. Gargarella[1,2,4]

[1] Federal University of São Carlos, Graduate Program in Materials Science and Engineering, 13565-905 - São Carlos, SP, Brazil

[2] Department of Materials Engineering, Federal University of São Carlos, 13565-905 - São Carlos, SP, Brazil

[3] Graz University of Technology, TU Graz, Institute of Materials Science, Joining and Forming, BMK Endowed Professorship for Aviation, Kopernikusgasse 24/1, 8010 Graz, Austria

[4] Center of Characterization and Development of Materials (CCDM), Federal University of São Carlos, 13565-905 - São Carlos, SP, Brazil

*Corresponding author: nicolas.rojas@estudante.ufscar.br

The metal additive manufacturing (AM) of aluminum alloys is mainly focused on eutectic compositions with an Al-Si-(Mg)-based composition. These compositions, known as cast aluminum alloys, present an optimal fluidity and a short solidification interval enhancing their processability in AM but the as-built parts exhibit diminished mechanical strength. In contrast, wrought aluminum alloys offer superior mechanical properties and widespread industrial use. Nevertheless, their wide solidification range results in a heightened hot cracking susceptibility (HCS), constraining their applicability in AM processes. Considering the above, here we explore the potential of incorporating wrought alloys in AM by modifying the composition to reduce the solidification interval. We investigate a novel Al-Cu-Ce-based aluminum alloy for AM parts produced through the Laser Powder Bed Fusion (LPBF) technique. Optimal printing parameters were selected via design of experiments (DoE), considering the mechanical properties and microstructural characteristics as response variables. The proposed composition demonstrates excellent printability, facilitating the production of crack-free parts irrespective of the processing parameter combination. It maintains a highly refined columnar microstructure, and the addition of Ce significantly mitigates HCS while fostering the formation of eutectic regions rich in Al + Al_3CeCu. This not only prevents crack formation but also enhances the mechanical resistance of the as-built parts.

Correlating the Solidification Kinetics, Microstructure, and Physicochemical Properties of Gas-Atomized Powders

N. Rojas-Arias[a, b*], F.G. Coury[a, b], P. Gargarella[a]

University of São Carlos, Rod. Washington Luiz, km 235, 9 São Carlos, 13565-[, b, c]

[a] Graduate Program in Materials Science and Engineering, Federal University of São Carlos, Rod. Washington Luis Km 235, São Carlos, 13565-905, Brazil

[b] Department of Materials Engineering, Federal University of São Carlos, Rod. Washington Luis Km 235, São Carlos, 13565-7 905, Brazil

[c] Center for Characterization and Development of Materials, Federal 905, Brazil

*Corresponding author: nicolas.rojas@estudante.ufscar.br

The atomization of metal powders has gained significant attention in recent years due to its role as a raw material in processes like metal injection molding (MIM), hot isostatic pressing (HIP), and additive manufacturing (AM). Gas atomization stands out as one of the predominantly used techniques for producing metal powders, featuring a broad particle size distribution that significantly impacts physicochemical properties such as density and free-flowing, being both critical aspects in AM processes. Moreover, the extensive range of cooling rates experienced during atomization, ranging from 10^2 to 10^7 $°C \cdot s^{-1}$, allows particles not only to serve their conventional role as raw materials but also as indicators of how high cooling rates can influence the microstructural characteristics of an alloy. Considering this, we conduct an in-depth analysis of the physicochemical properties and microstructural characteristics of gas-atomized powder samples for two compositions based on Al-Cu-(Ce). By scanning electron microscopy and dynamic image analysis, we establish correlations between particle size, morphology, and formation of defects like satellites, splashes, and agglomerates. Analyses of density, fluidity, and angle of repose enable an assessment of the applicability of the samples in additive manufacturing processes. Finally, employing empirical relationships and mathematical models previously reported in the literature, we establish correlations linking the influence of the cooling rate on the microstructural characteristics of the metal powders.

Hard and corrosion-resistant pig iron-based steel glass

C.L.G.P. Martins[a,b,], G.Y. Koga[a,c], C.A.C. de Souza[d], D.D. Coimbrão[a], C.S. Kiminami[a], C. Bolfarini[a], W.J. Botta[a]*

[a] Federal University of São Carlos, Department of Materials Engineering, Rodovia Washington Luís, km 235 SP-310, 13565-905, São Carlos, SP, Brazil

[b] Federal University of São Carlos, Graduate Program in Materials Science and Engineering, Rodovia Washington Luís, km 235 SP-310, 13565-905, São Carlos, SP, Brazil

[c] Federal University of São Carlos, Center for Characterization and Development of Materials (CCDM), Rod. Washington Luís, São Carlos, SP, CEP 13565-905, Brazil-310, 13565-905, São Carlos, SP, Brazil

[d] Department of Materials Science and Technology, Federal University of Bahia, Rua Aristides Novis, 02 Federação, 40210-630 Salvador, BA, Brazil

*Corresponding author: caiolgpm@estudante.ufscar.br

The $Fe_{62}Cr_8Nb_4Mo_4(C,B)_{22}$ steel glass was produced using inexpensive pig iron as the main master alloy, with minor addition of commercially available ferrous alloys. The fully vitreous nature of the steel produced by melt-spinning was confirmed through X-ray diffraction, from conventional and synchrotron radiation sources, and transmission electron microscopy. Differential scanning calorimetry confirmed the glass transition temperature of approximately 553 °C, and the onset of the crystallization at 574 °C, with supercooled liquid temperature interval of 21 °C. The $Fe_{62}Cr_8Nb_4Mo_4(C,B)_{22}$ steel glass proved to be harder than the pig iron (1070 *vs* 666 $HV_{0.1}$, respectively) and more stable in chloride-rich medium than the 444 stainless steel, as assessed by the passivation window prior to pit corrosion (1253 *vs* 738 mV, respectively) and the ease reprotection upon the reverse scan. The results contribute to the strategies for production of affordable hard and corrosion-resistant steel glasses for demanding applications.

Keywords: Metallic glass; Stainless Steel; Cast Iron; Corrosion, Hard Materials.

Novel High Nitrogen Austenitic Stainless Steels: From High-Throughput Screening to Experimental Validation and Properties Relationship

Victor Hugo Mafra Monfredo Ferreira[1,2,*], Francisco Gil Coury[1,2], Diego Araújo Santana[1,2], Guilherme Yuuki Koga[1,2,3].

[1]Federal University of São Carlos, Graduate Program in Materials Science and Engineering, São Carlos, 13.565-905, Brazil

[2]Federal University of São Carlos, Department of Materials Engineering, São Carlos, 13.565-905, Brazil

[3] Federal University of São Carlos, Center for Characterization and Development of Materials (CCDM), Rod. Washington Luis, São Carlos, SP, CEP 13565–905, Brazil Washington Luis, São Carlos, SP, CEP 13565–905, Brazil.

*Corresponding author: victormonfredo@estudante.ufscar.br, phone +55 9198900-4152

The quest for affordable and price-stable alternatives for nickel as the main austenitizing alloying element is pushing the stainless steel industries to develop new types of Ni-lean austenitic stainless steels. This work focuses on the challenges of designing austenitic stainless steels with appreciable nitrogen content using computational methods, which can still be produced at 1 atm N_2 pressure and thermomechanically processed without excessive cracking or N_2 degassing. CALPHAD-based computational tools enabled the identification of promising alloys by high-throughput screening from more than 2000 candidates based on predefined criteria considering composition (Ni-poor, N-rich), phase stability (austenite), degassing (far from N_2 loss from liquid or solid phase), cost (Ni-lean), and pitting resistance equivalent number (PREN > AISI 201 stainless steel). The resulting alloys exhibited an austenitic microstructure with dispersed micrometric and nanometric aluminum nitrides (AlN) precipitates. Even with the occurrence of appreciable AIN precipitates, hot rolling was performed without cracking, resulting in equiaxed austenitic grains. The mechanical properties of the developed alloys exceeded those of AISI 201 stainless steel in terms of hardness, yield strength, and ultimate tensile strength, with values of 304 HV, 534 MPa, and 953 MPa, respectively, yet with considerable ductility (~40% elongation). Even in the presence of AlN that pick up some of the nitrogen from solid solution, the corrosion resistance of the developed alloy was superior to the AISI 201 stainless steel. This research provides valuable insights for developing and processing high-nitrogen austenitic stainless steels to compete with 201 and 304 stainless steels in terms of mechanical properties and corrosion resistance.

Keywords: Alloy design; CALPHAD; Manganese; Nitrogen; Mechanical properties; Corrosion.

Short-Range Ordering Assessment in CrCoNi Alloy Through Thermal Analysis: A New Detection Method and Its Influence on Mechanical Properties

Vinícius Pereira Bacurau[1,2*], Pedro A. Moreira[3], Gustavo Bertoli[1,2], Angelo Fernandes Andreoli[2], Eric Marchezini Mazzer[1,2], Flávio Fávaro de Assis[1,2], Guilherme Cardeal Stumpf[1,2], Piter Gargarella[1,2], Santiago J.A. Figueroa[4], Michael Widom[5], Michael J. Kaufman[6], Andrea Fantin[7], Yifan Cao[8], Rodrigo Freitas[8], Daniel Miracle[9], Francisco Gil Coury[1,2]

[1]Federal University of São Carlos, Graduate Program in Materials Science and Engineering, São Carlos, 13.565-905, Brazil

[2]Federal University of São Carlos, Department of Materials Engineering, São Carlos, 13.565-905, Brazil

[3] Federal University of São Carlos, Department of Physics

[4]Brazilian Center for Research in Energy and Materials

[5]Carnegie Mellon University (Department of Physics)

[6]Colorado School of Mines

[7]Federal Institute for Materials Research and Testing (Department of Materials Engineering)

[8]Massachusetts Institute of Technology (Department of Materials Science and Engineering)

[9]Materials and Manufacturing Directorate (AF Research Laboratory)

e-mail: vinicius.bacurau@estudante.ufscar.br, phone +55 (88) 9923-33162

Multi-principal element alloys (MPEAs) are a new class of materials that are characterized by the absence of a primary element in their composition. The $Cr_{33}Co_{33}Ni_{33}$ (at.%) alloy, derived from the Cantor alloy ($Cr_{20}Co_{20}Ni_{20}Mn_{20}Fe_{20}$ (at.%)), stands out in the literature due to its excellent mechanical properties at room and cryogenic temperatures. However, there are contributions to the mechanical properties of the Cr33Co33Ni33 alloy that have not been fully elucidated. One of the possible contributions is Short-range ordering (SRO). This phenomenon can be defined as the coordination preference of a certain constituent element in the alloy by another, affecting up to 2 atoms relative to the central atom. Due to the small scale of SRO formation, which is in the nanometer range, this phenomenon presents difficulties in detection, generating ambiguities in the literature. Therefore, the present work aims to assess the formation of SRO in 2 compositions $Cr_{33}Co_{(33-x)}Ni_{(33+x)}$ (x=0, 33) through isothermal treatments at low temperatures (475 °C) for different times. The goal is to verify, through indirect detection techniques (thermal capacity analysis, microhardness, and synchrotron DRX), whether the SRO phenomenon occurs, complementing the literature with more information about the SRO for the CrCoNi system.

Keywords: $Cr_{33}Co_{33}Ni_{33}$, Short Range Order, Thermal Analysis

Mechanical Alloying and Accumulative Roll Bonding (ARB)

Erika Biral Baptistella[1], Bruno Diego de Oliveira[1], Leonardo Henrique Fazan[1], Katia Regina Cardoso[1], Dilermando Nagle Travessa[1], Andre Martins Neves[2], Daniel Rodrigo Leiva[2], Alberto Moreira Jorge Jr[2], Gisele Ferreira de Lima-Andreani[1]

[1]Science and Technology Institute, Federal University of São Paulo, São José dos Campos - SP, Brazil

[2]Department of Materials Engineering, Federal University of São Carlos, São Carlos - SP, Brazil

*Corresponding author: gisele.lima@unifesp.br

In this study, pure magnesium with Ti as catalyst (2 wt.%) was processed by mechanical alloying (MA) under argon and accumulative roll bonding (ARB) under ambient air with 20 passes (MA+ARB). Our primary focus was to analyze the impact of ambient air exposure while also evaluating the processing route. Some powder samples were exposed to air for one year (stored in a glass desiccator with an average yearly temperature and relative humidity of ~27 °C and 50.5%) before undergoing ARB processing (MA(y)+ARB). After ARB processing, samples exhibited a (002)-type texture for Mg. Our results demonstrate that all samples, including those air-exposed for one year and processed via ARB, could rapidly absorb hydrogen within a matter of minutes despite considerable differences in surface area between powders and rolled samples. Grain size reduction to nanoscale level produced by MA and ARB processing and texturing may have influenced this behavior. The most interesting is that absorption and desorption kinetics remained fast, even after prolonged exposure to air, despite the reduced capacities. The MA(y)+ARB sample reached approximately ~4.3 wt.% or 57% of the maximum capacity of MgH_2. The desorption temperature was the lowest for MA(y)+ARB sample (381°C), and lower than those of commercial MgH2 (~ 432°C). The oxidation during rolling passes in air of the air-exposed sample probably contributed reducing grains and particles sizes, and with the better distribution of catalyst.

Tailored solidification microstructures
for innovative use of high-density materials in lightweight products

Abdoul-Aziz Bogno
Department of Chemical and Materials Engineering, University of Alberta
Edmonton, Alberta, Canada T6G 1H9
e-mail: ablaziz@gmail.br

As more industries move to capitalize on the technological benefits of additive manufacturing, researchers are exploring ways to design new alloys with properties that cannot be achieved through traditional manufacturing methods. One approach is to tailor the solidification microstructures of lightweight components using dense materials. This study examines the microstructures and mechanical properties of near eutectic Al-Cu alloys under different thermal histories, covering both high and low solidification rates found in various additive manufacturing techniques. Slow cooled lattice structures of diamond type unit cell were produced at a relatively low cooling rate by a hybrid investment casting process involving 3D printing of the lattice patterns, and rapid solidified powders of various sizes were generated by Impulse Atomization. Microstructural analysis revealed different eutectic morphologies and spacing depending on the cooling rate and location. The alloys strength was increased by spheroidization of their eutectic phases. The alloys eutectic structures were spheroidized using two spheroidization mechanisms, including (i) Thermo-mechanically by plastic deformation of as solidified samples, followed by heat treatment, and (ii) Chemically by addition of Mg and Si to the near eutectic Al-Cu alloy. Both the thermo-mechanical and the chemical spheroidization mechanism are found to improve the mechanical properties of the alloys. This study demonstrates a potential cost-effective use of heavy alloys in high-performance applications through additive manufacturing (e.g. using lattice structures) by optimizing microstructures and enhancing mechanical properties.