EUROPM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

ABSTRACTS BOOK

GROUP 1 - MATERIALS

EPMA
european powder metallurgy association

EURO PM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

MATERIALS

HARD METALS AND CERMETS

EPMA
european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M01
ID : 6278470

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Kok Yin Nan (Powderloop Technology Ltd., United Kingdom)

Co-author(s) :

Title : Resource Efficient Hardmetal Powder For Additive Manufacturing (AM)

Keyword(s) :
Hardmetal Powder, Additive Manufacturing, DED, Hardfacing, Coating, Powder Manufacturing,Tungsten Carbide, Resource Efficient

Abstract :
Hardmetal powders used in today's AM were originally formulated for thermal spraying over six decades ago. The conventional hardmetal powder manufacturing process involved multiple high-energy stages i.e. pre-manufacturing of carbide and grinding. During AM process, a melt pool is created by laser beam. Chemical reactions occur within the melt pool in a fraction of a second. When pre-manufactured carbide is used, the carbide is re-melted, this can lead to decomposition and formation of unfavourable brittle eta-carbide phase which is detrimental to the coating performance. This paper presents a novel powder for AM using a resource-efficient powder manufacturing method. The powder was produced by employing elemental materials compared to the conventional methods that used pre-manufactured carbide powder. This novel powder is expected to promote in-situ formation of carbide during laser fusion processes and provide a chemically more stable coating and cleaner interface with better adhesion between the carbide and the matrix.

Innovative Aspect(s) :
This paper has not been submitted elsewhere. This work is based on our internal research and developments and findings from our subject matter expertise in the field. As explained in the abstract, as far as we are aware, there is no commercially available powder as such for AM to promote in-situ formation of hard carbides using the resource-efficient methods of spray drying.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M02
ID : 6278433

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Ing Biedma Ángel (Universidad Carlos III de Madrid, Spain)

Co-author(s) : Mr García Marcos (Universidad Carlos III de Madrid, Spain); Dr de Nicolás María (IMDEA Materiales, Spain); Prof Dr Gordo Elena (Universidad Carlos III de Madrid, Spain)

Title : Influence Of Sintering Pressure Cycle And Composition On The Processing Of Ti(C,N)-based Cermets

Keyword(s) :
Ti(C,N)-based Cermets, Sintering Cycle, Sintering Vacuum Pressure, Microstructure Formation, Densification

Abstract :
Ti(C,N) cermets with Fe-based binders have shown great potential as alternatives to hardmetals, as they can reduce the dependence on critical raw materials while maintaining similar properties. Although Ti(C,N)-FeNiCr has been extensively researched, there are certain aspects that warrant further investigation in order to enhance its properties. This study focuses on the development of sintering combined cycles, which involve controlling the levels of vacuum and gas partial pressures. These cycles aim to address various challenges, such as the degassing of N2 from ceramic particles, the volatilization of metallic binder, grain growth, and densification. The formation of gradients and oxides on the surface of cermets has also been examined. Furthermore, adjustments to the levels of Cr and C have been made to prevent the precipitation of M7C3-type carbides. The CALPHAD methodology and EBSD have been utilized within the framework of this study to analyze and understand the cermet's behavior.

Innovative Aspect(s) :
This project enhances the comprehension and knoledge of the sintering conditions of cermets, thereby making a valuable contribution. Its primary objective is to tackle existing challenges in vacuum sintering process and provide explanations for the occurrence of such issues in this particular Ti(C,N)-based cermets.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M03
ID : 6278565

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr De Gaudenzi Gian Pietro (F.I.L.M.S. S.p.A., Italy)

Co-author(s) : Mrs Tedeschi Sandra (F.I.L.M.S. S.p.A., Italy); Mrs Pirone Fransisca (F.I.L.M.S. S.p.A., Italy); Ing Garabelli Mattia (F.I.L.M.S. S.p.A., Italy); Mr Ruggiero Domenico (F.I.L.M.S. S.p.A., Italy)

Title : Functionally Graded Hardmetal Systems For Applications Requiring Corrosion And Abrasion Resistance

Keyword(s) :
Functionally Graded Hardmetal, Functionally Graded Metallic Binder, Corrosion Behavior, Mechanical Properties

Abstract :
The application of the Functionally Graded Materials concept to cubic carbide-free hardmetals is commonly associated with achieving optimized mechanical properties in different regions of an article. In this work, special attention is given to maximize the corrosion and wear resistance of an outer layer while keeping the toughness values of the bulk material. This involves a detailed examination of gradients in the alloying of the metallic binder. A Ni-based outer layer, featuring a composition known for corrosion resistance, is sintered over a Co-based bulk with a medium WC grain size distribution. The concentration gradients of Ni and Co, along with the influence on mechanical properties and corrosion resistance, are thoroughly assessed. This analysis extends to the effects of additives such as chromium, molybdenum, with copper considered as an additional additive. The results reveal a promising path for the development of innovative hardmetal solutions in demanding applications.

Innovative Aspect(s) :
The application of the Functionally Graded Materials (FGM) concept to the hardmetal Metallic Binder (MB). Investigation on the impact of MB compositional gradient on mechanical properties and corrosion behavior in FGM systems. Exploring additive diffusion and the effect of additive content gradient on mechanical properties and corrosion behavior. The role of copper in the MB alloy on the corrosion behavior of hardmetal in simulated sea water.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M05
ID : 6278304

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Ing Mégret Alexandre (University of Mons, Belgium)

Co-author(s) : Prof Dr Vitry Véronique (University of Mons, Belgium); Prof Dr Delaunois Fabienne (University of Mons, Belgium)

Title : Corrosion And Tribological Characterizations Of A Recycled Tungsten Carbide Powder

Keyword(s) :
Cemented Carbide, Recycled Powder, Corrosion Properties, Tribology

Abstract :
Recycling end-of-life tungsten carbide tools is important to encounter the issues linked to critical raw materials (CRM). Indeed, cobalt and tungsten have been listed as critical by the European Commission since 2011. Previous studies have characterized a recycled powder in terms of densification, microstructure, and mechanical properties, leading to interesting properties compared to conventional powders. The study of corrosion and tribological properties was not characterized although they are essential to understand the interactions between the cemented carbide tool and other materials. In this study, parts made from recycled tungsten carbide powder containing 7.5 wt.% cobalt have been sintered to evaluate their corrosion properties (open-circuit potential, polarizations…) and their tribological properties (friction coefficient, wear mechanisms…).

Innovative Aspect(s) :
The study of corrosion and tribology of cemented carbide parts is not numerous but is of great importance for their traditional applications. Correlations with microstructures and mechanical properties are drawn. Moreover, only few papers mention the characterization of recycled powder.

Reviewer's name : ……..

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ……

Notes to author : ……

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M07
ID : 6277229

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Sandoval Ravotti Daniela (Hyperion Materials & Technologies, Spain)

Co-author(s) : Dr Girman Valdimír (Institute of Materials Research, Slovak Academy of Sciences, Slovakia); Dr Sedlak Richard (Institute of Materials Research, Slovak Academy of Sciences, Slovakia); Ing Serra Marc (Universitat Politècnica de Catalunya, Spain); Dr Larrimbe Laura (Hyperion Materials & Technologies, Spain); Ing Mendez Marco (Hyperion Materials & Technologies, Spain)

Title : Influence Of Processing Route In The Fracture Toughness Of Cemented Carbides With Different Grain Size And Binder Content

Keyword(s) :
WC-Co, Fracture Toughness, WC Plasticity, TEM, Dislocations

Abstract :
Samples with 12 and 20 wt.% of binder content and fine, medium, and coarse WC grain size were manufactured by three different processing routes. It was noticed that for one route, fracture toughness was improved without a decrease in hardness, contrary to the other routes in which the typical hardness and toughness inverse relation was followed. As expected for cemented carbides, different mechanisms compete to affect fracture toughness. On one end, for fine grain size, the toughness is influenced mainly by the binder content; on the other end of the scale, for coarse grain size, binder content has a minimum influence, regardless of the processing route. Unexpectedly, deeper characterization by EBSD, XRD and TEM showed that there is a region of binder and grain size in which the processing route leads to an improved intrinsic plasticity of WC and ultimately, the fracture toughness of the composite.

Innovative Aspect(s) :
By changing the processing route, and for a range of binder content and WC grain size, the plasticity of the WC is afected, resulting in a improved fracture toughness of the composite

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M08
ID : 6280791

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Ms Mohammadpour Kasehgari Saba (KTH Royal Institute of Technology, Sweden)

Co-author(s) : Ms Toller-Nordström Lisa (KTH Royal Institute of Technology, Sweden); Ms Borgenstam Annika (KTH Royal Institute of Technology, Sweden)

Title : Martensitic Phase Transformation In Cemented Carbides With Steel-Based Binder

Keyword(s) :
Cemented Carbides, Alternative Binders, Advanced High-Strength Steel, Martensitic Transformation, Thermodynamic Modeling, Electron Backscatter Diffraction

Abstract :
Cemented carbides, important composites produced by powder metallurgy, exhibit an excellent performance within metal cutting tools and mining equipment when their hard phase, tungsten carbide, is bound by cobalt. However, in recent years, due to health and ethical concerns related to cobalt, there has been a significant focus on designing alternative binders. The martensitic transformation in high-strength steel and its subsequent transformation-induced plasticity effect propose a solution to substitute cobalt and improve the overall properties of cemented carbides. However, numerous factors including carbon and tungsten content, residual stresses induced by tungsten carbide grains, and the confined dislocation mean free path in the binder significantly affect the nature of the martensitic transformation in these composites. Thus, in this study, thermodynamic and kinetic-based models coupled with dilatometry and electron backscatter diffraction characterization were utilized to predict the martensitic start temperature and fraction and morphology of martensite in steel-based binders of cemented carbides.

Innovative Aspect(s) :
Over time, we have gained extensive knowledge and valuable insights about the third generation of steel. Despite numerous previous studies on alternative binders in cemented carbides, there has been no attempt before to apply the latest achievements in advanced high-strength steel to these relatively new metal composites. The current work has aimed to build a multi-length scale computational framework for designing new sustainable composites with minimum trial and error experiments. Thermodynamic and kinetic-based models coupled with experimental data were utilized for a thorough understanding of phase transformations and microstructural evolution in cemented carbides with the aim of translating the martensitic phase transformation and the TRIP effect to the binders in these composites. The models will further be used to explore different processing conditions and sets of compositions for tailoring phase transformations in steel-based binders in cemented carbides which would lead to improved strength and ductility and reduced usage of cobalt.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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Withdraw ☐ Reason : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M10
ID : 6280715

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Mrs Fooladimahani Saghar (Universitat Politècnica de Catalunya - BarcelonaTech, Spain)

Co-author(s) : Dr Liu Chao (Xiamen Tungsten Co., Ltd., China); Dr Liu Bolu (Xiamen Tungsten Co., Ltd., China); Dr Lin Le (Xiamen Tungsten Co., Ltd., China); Prof Llanes Luis (Universitat Politècnica de Catalunya - BarcelonaTech, Spain)

Title : Optimization Of Short-pulse Laser Shaping Of Micro-features In Cemented Carbides: Assessment Of Dimensional Accuracy, Surface Integrity And Microstructural Effects

Keyword(s) :
Laser Ablation Method, Controlled Damage, Hardmetals, Mechanical Properties

Abstract :
Laser ablation is a proven method for post-processing fabrication, surface texturing, and micromachining hardmetal tools. In this regard, dimensional accuracy and surface integrity of shaped features are expected to depend on both processing parameters and microstructural assemblage. However, detailed information about such correlations is limited, especially concerning practical and cost-effective methods like short-pulse laser ablation. This study addresses this gap by shaping microfeatures on the surfaces of fine-grained cemented carbides with different Co content. In doing so, distinct laser processing parameters are optimized to shape microdimples, micronotches, and through-thickness microgrooves accurately. Advanced characterization techniques, including scanning electron microscopy, focused-ion beam milling, and digital image correlation, are employed to investigate the surface integrity of these features. Results show that laser parameter alterations significantly influence surface integrity (concerning induced damage or residual stresses). Feasible application of this knowledge is applied to evaluate the fracture toughness and damage tolerance behavior of cemented carbides.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M12
ID : 6281484

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Toller-Nordström Lisa (KTH Royal Institute of Technology, Sweden)

Co-author(s) : Dr Borgh Ida (Sandvik Mining and Rock Technology, Sweden); Ms Sten Stella (Sandvik Mining and Rock Technology, Sweden); Prof Norgren Susanne (Sandvik Mining and Rock Technology, Sweden); Prof Borgenstam Annika (KTH Royal Institute of Technology, Sweden)

Title : Hardmetals With Novel Binder Phase Systems

Keyword(s) :
Hardmetal, Cemented Carbide, Alternative Binder, Characterisation

Abstract :
Due to the increased demand of cobalt and its negative health aspects, as well as it being listed as a critical raw material, the metallic cobalt binder of hardmetals, or cemented carbides, need to be replaced or substituted with an alternative.Over a decade of intensive research into alternative binders has significantly increased our knowledge on how metals other than cobalt affect the production and performance of hardmetal tools. Still, many challenges remain for complete substitution of cobalt across applications.Current efforts are focused on exploring more complex alloy systems that in turn may lead to formation of new phases and microstructures whose effect on the performance are yet unknown. This work presents recent advances in alternative binder research using steel based binder phases and what benefits these systems can bring. Thermodynamic calculations, electron microscopy and x-ray diffraction are used to characterise and analyse the material.

Innovative Aspect(s) :
Much of existing research on alternative binders for hardmetals have focused on pure elements or alloys of two or three elements, or the proposed binder phase has been an existing advanced alloy but without full consideration of the complex situation of stress state, grain size, mean free path and dissolution of hard phases that will ultimately lead to much different properties of the binder phase compared to a bulk alloy of the same target composition.This work considers previous research and combines that knowledge with thermodynamic calculations to design complex alloys to be used specifically as a binder phase in a hardmetal. Advanced characterisation techniques are used to evaluate the resulting material to further our knowledge on alternative binder hardmetals.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M13
ID : 6281545

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Ing Guillen Pineda Rene Miguel (Hyperion, Spain)

Co-author(s) : Dr Ther Oliver (Hyperion, Spain)

Title : Design Of Cermet Materials: Influence Of Ti Hard Phases Raw Material

Keyword(s) :

Abstract :
Cermet materials are a good alternative to cemented carbide for cutting applications due to their higher hot hardness, nevertheless this family of materials is more complex to use due to their relatively lower toughness in comparison to cemented carbides.This study is focused on the influence of Ti raw materials used for the composition of cermet and their influence on the final mechanical properties. A comparison between the materials TiC, TiN and TiCNs, showed that the use of Ti (C, N) s brings a strong improvement of the final properties over the usage of TiC and TiN. A deeper look at the effect of the C and N ratio (30-70, 50-50, and 70-30) initially present in the TiCN raw material highlighted a surprising behavior. In these materials hardness is decreasing with the increase of N content, even though N is a well-known grain growth inhibitor for Ti hard phase.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M15
ID : 6281340

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dipl-Ing Berger Christian (Fraunhofer IKTS, Germany)

Co-author(s) : Dr Ing Scheithauer Uwe (Fraunhofer IKTS, Germany); Dr Ing Pötschke Johannes (Fraunhofer IKTS, Germany)

Title : Comparison Of Different Binder-Jetting Printers For Additive Manufacturing Of Hardmetals

Keyword(s) :
Cemented Carbide, Powder, Additive Manufacturing, FESEM, Hardness, Hardmetal, Binder Jetting

Abstract :
Binder-jetting (BJT), a sinter and powder-based additive manufacturing technology, is becoming more and more established on the market due to its high productivity and the wide variety of materials it can process. The production of WC-Co based hardmetals is being promoted by well-known hardmetal and powder manufacturers using the BJT technology. Within this study, five different binder jetting printers from four different manufacturers were tested and compared for their suitability for the production of hardmetals. In addition to hardmetal properties, printing performance and green part handling are compared and the investigated differences discussed. The studies shows, that all tested BJT printers show the principle feasibility of producing hardmetal green parts which can after sintering yield dense samples.

Innovative Aspect(s) :
For the first time investigations about the production of hardmetal green parts on five different binder jetting printers were done. Previously, only ExOne binder jetting manufacturers were used, with a few exceptions. The study proves that dense hardmetals can be produced with binder jetting printers from different manufacturers using different binder fluids and process approaches.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M16
ID : 6281346

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Mr Spalden Mathias von (Fraunhofer IKTS, Germany)

Co-author(s) : Dipl-Ing Vornberger Anne (Fraunhofer IKTS, Germany); Dr Ing Pötschke Johannes (Fraunhofer IKTS, Germany)

Title : Influence Of Various Alloying Elements On WC-Ni Hardmetals

Keyword(s) :
Hardmetal, WC, FAST, SPS, Co Free, Alternative Binder Systems

Abstract :
The substitution of cobalt in hardmetals has a crucial economic role, since increasing costs driven by the demand for Li-ion batteries can lead to higher prices for the majority of hardmetal grades which depend on cobalt as binder metal. Nickel has already proven to be a possible substitute. However, so far it cannot compete with cobalt in terms of mechanical properties. Therefore, in this work a systematic investigation on various alloying elements in nickel-based binder systems for hardmetals was done. A further goal of this study was the reduction of needed sintering temperatures which can lead to less energy consumption for the sintering process. The trials were carried out using field assisted sintering. Subsequent SinterHIP treatment was done to investigate quasi thermodynamicall state. The chosen alloying elements are iron, manganese, copper, silicon, and germanium. For some combinations, hardmetals with a novel nickel-based binder alloy could be successfully prepared.

Innovative Aspect(s) :
To the authors' knowledge there have not been any systematic studies on alloying nickel in situ with various elements as binder systems for hardmetals in combination with the preparation by a field assisted sintering technique.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M18
ID : 6281388

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Ing Müller-Köhn Axel (Fraunhofer IKTS, Germany)

Co-author(s) : Dipl-Ing Hering Michael (Konrad Friedrichs GmbH & Co KG, Germany); Dipl-Ing Abel Johannes (Fraunhofer IKTS, Germany); Ing Jucan Ovidiu (Gühring SRL, Romania); Dipl-Ing Jegust Stephan (Inmatec Technologies, Germany); Dr Ing Pötschke Johannes (Fraunhofer IKTS, Germany); Dr Ing Moritz Tassilo (Fraunhofer IKTS, Germany)

Title : Testing Of Hardmetal Cutting Inserts Additive Manufactured By Fused Filament Fabrication

Keyword(s) :
Fused Filament Fabrication, Additive Manufacturing, Indexable Inserts, Hardmetal, Machining, Cemented Carbide

Abstract :
Additive manufacturing allows machining tools to be specifically adapted to the machining task. However, currently the question remains whether additive manufactured hardmetal tools can achieve comparable performance to conventional produced hardmetal tools. In this study, hardmetal inserts manufactured using fused filament fabrication were tested in industrial machining trials on samples of AISI 304 (X5CrNi18-10). Due to their high degree of standardization and simple geometry, indexable inserts are well suited for such feasibility tests, although they do not have a geometry that requires or is advantageous for additive manufacturing. Within the presentation the whole process chain from powder up to the grinded tool will be shown. Specific issues for ensuring high material and component quality are discussed and an outlook into the use of ultrafine hardmetal powders more complex tools will be given. The promising results show great potential for complex special hardmetal tools, weight savings and conformal cooling.

Innovative Aspect(s) :
Application of ultrafine hardmetal powders in thermoplastic shaping; Complete processing off FFF-manufactured indexable inserts until ready to use tools- Assessment of FFF-manufactured hardmetal inserts in comparison to conventional produced hardmetal tools for machining of AISI304.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M143
ID : 6281827

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Besharatloo Hossein (CIEFMA-UPC|Colfeed4Print, Spain)

Co-author(s) : Mr Zegai Ahmed (University of Sciences and Technology Houari Boumediene, Algeria); Prof Dr Llanes Luis (CIEFMA-UPC, Spain); Dr Chirico Caterina (ICV-CSIC, Spain); Dr Ferrari Begoña (ICV-CSIC, Spain); Dr Sanchez-Herencia Antonio Javier (ICV-CSIC, Spain)

Title : Effects Of Nickel Content And Sintering Methods On Microstructure And Micromechanical Properties Of WC|Ni Composites

Keyword(s) :

Abstract :
Powder composition and sintering process significantly influence the microstructure, phase composition, and mechanical properties of WC-based composites. The precise control of both chemical composition and sintering conditions is crucial for tailoring these materials to meet specific requirements across diverse applications, such as cutting tools, wear-resistant components, and various industrial uses.The study comprehensively assesses: I) the impact of varying nickel content, and II) the influence of sintering methods, including conventional and Spark Plasma Sintering (SPS), on the final microstructures and mechanical properties of the WC|Ni composites.In doing so, two sets of WC|Ni composites (containing 5 and 10 vol% Ni) were sintered using SPS and conventional methods. Microstructural analysis included FESEM and XRD, while micromechanical properties were evaluated with nanoindentation mapping in conjunction with statistical analysis for evaluating hardness and elastic modulus of each phase. This detailed examination contributes valuable insights for enhancing the microstructural design of WC|Ni composites.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M319
ID : 6286628

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Dr Ing Cinca Núria (Hyperion Materials and Technologies, Spain)

Co-author(s) : Prof Dr Isalgué Antoni (Universitat Politècnica de Catalunya, Spain); Dipl-Ing Riu Guiomar Steros GPA Innovative S.L., Spain); Prof Dr Llanes Luis (Universitat Politècnica de Catalunya, Spain); Dr Ing Roa Joan Josep (Steros GPA Innovative S.L, Spain)

Title : In-situ Surface Integrity Study Focused On Cobalt Phase Transformation Induced During The Grinding And Polishing Process In Cemented Carbides WC-Co Surfaces

Keyword(s) :
Cemented Carbides, Surface Integrity, Dry Electropolishing, Compressive Stresses, Phase Transformation, Synchrotron Radiation

Abstract :
The surface integrity in terms of phase transformation and compressive residual stresses (scomp) on ground WC-10wt.%Co specimens and sequentially dry-electropolised was studied by means of synchrotron radiation and, in-situ heating up to 900°C helped in monitoring the h.c.p-Co to f.c.c-Co reverse transformation. It was revealed that as the dry-electropolishing process time increased, the full width at half maximum of XRD peaks decrease, associated with a reduction of the scomp near the surface of the specimens. In addition, both ground and polished specimens exhibited a release in scomp as result of the thermal treatment. Deeper study on the Co phase revealed that the h.c.p. peak intensity decreased while the f.c.c. one increased, together with a peak shift to low angles confirming the h.c.p to f.c.c phase reversion reaction for the metallic Co binder.

Innovative Aspect(s) :
The present paper evaluates the compressive stresses in the novel dry electropolishing method applied to cemented carbides by means of synchrotron radiation.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-M19
ID : 6278247

Requested presentation type : Poster Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Mr Leclef Arnaud (UMONS, Belgium)

Co-author(s) : Dr Ing Mégret Alexandre (UMONS, Belgium); Prof Dr Tricoteaux Arnaud (UPHF, France); Prof Dr Vitry Véronique (UMONS, Belgium)

Title : Carbon-doped FeMn-based Binders For Tungsten Carbide

Keyword(s) :
Tungsten Carbide, Ball Milling, Vacuum Sintering, Hardness, Binders, Phase Diagrams

Abstract :
The use of cobalt as binder for tungsten carbide raises more and more questions of environmental, health and societal ethics. The aim of this study is to find alternatives to cobalt as a binder for tungsten carbide. Tested binders were FeMn-based binders. The latter were carbon-doped to prevent the presence of eta-phase. Expected results required HV30 > 1600, fracture toughness > 10 MPa.m1|2, and a corrosion resistance equivalent to WC-Co composites. The first aspect is to model the phases that were generated by the replacement of cobalt. Pseudo-binary phase diagrams have been performed. The second aspect was to process the alternative "WC – promising alternative binder" composites. The powder metallurgy method was chosen for this purpose. Vacuum sintering technology was used. The samples were then mechanically and morphologically characterized. Corrosion resistance was also analyzed.

Innovative Aspect(s) :
The use of FeMn alloys as substitutes for cobalt as binders for tungsten carbide is rare in the literature. Furthermore, the study of carbon-doping the FeMn binder to inhibit the presence of eta-phase in the WC-FeMn composite has not been pursued in the past.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-M20
ID : 6281335

Requested presentation type : Poster Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Prof Senos Ana (Department of Materials and Ceramics Engineering CICECO, Portugal)

Co-author(s) : Dr Fernandes Cristina (Palbit, Portugal); Dr Ferrari Begoña (Institute of Ceramic and Glass (ICV-CSIC), Spain); Dr Sanchez-Herencia A.J. (Institute of Ceramic and Glass (ICV-CSIC), Spain); Dr Chirico Caterina (Institute of Ceramic and Glass (ICV-CSIC), Spain)

Title : Debinding And Sintering Of WC-Ni Samples Obtained By Material Extrusion Of A Thermoplastic Composite

Keyword(s) :
Material Extrusion, Hardmetal, Debinding, Colloidal Processing

Abstract :
Material Extrusion (MEX) is a promising technique for AM of high-performance hardmetal components, allowing to obtain complex shapes, including internal cavities, which are necessary in cooling systems of cutting tools.In this work, the effect of different atmospheres (Air, Ar, and N2-H2) during debinding was studied. Filaments contain 45 vol.% of hardmetal powders (WC-Ni) with 10 and 15 vol.% Ni and PLA-based thermoplastic matrix. Debinding was performed using a tube furnace up to 800 °C. Samples were sintered up to 1450 °C in Ar atmosphere at 30 bar, using a sinter-HIP furnace. This thermal cycle also includes a debinding at 600 °C in H2 atmosphere.The microstructure is similar to that obtained in conventional processed hardmetal, achieving a relative density between 92 and 97%. Most of the defects observed are related to the printing process. Sintered samples were microstructural characterized using SEM, carbon content was evaluated by direct combustion technique.

Innovative Aspect(s) :
This work studies the effect of different atmospheres during the debinding of hardmetal parts produced by MEX in order to enhance the polymer removal, maintaining the structural integrity, and reducing the amount of residual carbon that could allow the precipitation of secondary phases, usually associated with the detriment of mechanical properties. Furthermore, this work proposes a "low-cost" and efficient approach that reduces the consumption of inert gas employed during the thermal cycle. To do this, it is performed a cycle using air in much of the debinding process and subsequently changing to an N2-H2 atmosphere. In this way, the polymer combustion is favored, and the sample remains without oxidation.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-M120
ID : 6281747

Requested presentation type : Poster Presentation

Topic : Materials **Subtopic :** Hard Metals & Cermets

Author : Mr Figueiredo Daniel (University of Aveiro, Portugal)

Co-author(s) : Dr Guimarães Bruno (Palbit SA, Portugal); Dr Fernandes Cristina (Palbit SA, Portugal); Prof Dr Davim J. Paulo (Aveiro University, Portugal)

Title : Control Of Ductile Mode Machining During Micro-milling Of Cemented Carbide

Keyword(s) :
Hardmetal, Micro Milling, Diamond-coated Carbide Tools, Size Effect, Surface Quality

Abstract :
Machining in ductile mode is usually applied for finishing precision parts of hard materials e.g. cemented carbide parts, medical ceramic components or glass material applications. Thus the study of ductile mode cutting of brittle materials has been attracting more and more efforts. Bifano et al. presented a model, demonstrating the possibility to apply this mechanism while machining hard and brittle materials by the use of ultra-precision machines presented a formula for the transition from brittle to ductile cutting mechanism, also known as the critical depth of cut, relating the material specific properties Young's-Modulus E, material hardness H and fracture toughness K1C and is widely used controlling grinding processes. In the present work hardmetal micro-milling of a WC-15wt.%Co part was performed with diamond coated end mills, confirming the influence of cutting parameters on the cutting regime. Critical scale effects structure-related behaviour was confirmed. Positive impact on machined surface quality was observed when ductile mode is applied.

Innovative Aspect(s) :
Advanced caracterization of machining regimes of cemented carbide; Ductile regime evaluation during micro-milling of cemented carbide; Process optimization of micro-milling of cemented carbide using diamond coated end mills; Micro miling scale effect correlation with cemented carbide micro-struture

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

MATERIALS

ULTRA HARD MATERIALS

EPMA
european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M22
ID : 6281649

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ultrahard Materials

Author : Miss Navarrete Cuadrado Jazmina (CEIT-BRTA, Spain)

Co-author(s) : Dr Soria Biurrun Tomas (CEIT-BRTA, Spain); Dr Lozada Cabezas Lorena (CEIT-BRTA, Spain); Dr Alveen Patricia (Formerly at HILTI Co., now at EURICE, Germany); Dr Moseley Steven (Hilti Corporation, Liechtenstein); Prof Dr Sanchez-Moreno Jose M. (CEIT-BRTA, Spain)

Title : New Ultrahard Ceramics And Ceramic-metal Composites Based On Tungsten Tetraboride

Keyword(s) :
Tungsten Tetraboride, HIP, Ceramics, Reactivity With Ni Powders

Abstract :
WB4-B and WB4-TaB2 based materials with hardness values over 43 GPa have been obtained by glass encapsulated HIPing. Sintering of WB4-B-TaB2 powders is significantly activated by Ni additions. Porosity removal is achieved at 1100°C-150 MPa- 1hour, that is, 250°C below the temperature needed without nickel. However, there is strong chemical reactivity between Ni and WB4-B-TaB2 powders leading to the formation of W2B5, NiB, Ni4B3 and M2B5 phases. Since no metallic nickel remains after sintering, these ceramic composites are very brittle. Strength and toughness of WB4-B-TaB2-Ni alloys are notably improved by TiAl3 and Zr additions. Although Ni containing borides are still present in these materials, there are also Ni-rich regions free of boron after sintering, which provide a significant strengthening effect, reaching TRS values near 1 GPa. However, when Zr is added to the mixtures, WB4 grains are fully decomposed into a combination of mixed borides.

Innovative Aspect(s) :
Production of new ultrahard WB4-B ceramics by HIP at temperatures 300°C below those reported so far for these materials achieving nanohardness values over 43 GPa; Analysis of the reactivity between WB4-B powders and Ni additions. Identification of phases formed after sintering; Control of chemical reactions between WB4-B and Ni by additions of TiAl3 and Zr with the aim of producing tougher ceramic metal composites

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M151
ID : 6283253

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ultrahard Materials

Author : Dipl-Ing Thomas Thomas (Fraunhofer IFAM Dresden, Germany)

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Title : Copper-Diamond Composite With Complex Shape By Gel Casting Plus Spark Plasma Sintering

Keyword(s) :
Powder Metallurgy, Copper Diamond Composite, Additive Manufacturing, Spark Plasma Sintering

Abstract :
The trend toward miniaturization in electronic packaging poses challenges in cooling and temperature control, limiting design and efficiency. To address this, interest is growing in complex-shaped packaging with enhanced thermal conductivity. Additive technologies actual work for metallic materials but face compatibility issues with complex composites like copper-diamond, known for its high thermal conductivity (up to 700 W|mK). This report details efforts to introduce copper-diamond composites to additive manufacturing through gel casting. Mixtures of copper and diamond powder (up to 60% diamond volume) underwent optimization for binder systems. Post-sintering using a modified spark plasma sintering process resulted in structures with thermal conductivities measuring 688 W|mK, 1.7 times that of pure copper. Copper-diamond composites offer a new class of 3D cooling structures, crucial for heat dissipation in microelectronics, power modules, charging infrastructure, and e-mobility.

Innovative Aspect(s) :
At present, the shaping of composite materials with high thermal conductivity such as copper-diamond composites is mainly limited to dense, simple shapes such as discs or plates. Complex shapes are essential for heat dissipation. Special pin and rib structures increase the cooling capacity. Due to the high particle load of the composite materials, conventional machining poses a major challenge. The solution of shaping complex moulds using additive manufacturing and sintering them accordingly will further increase the performance of the cooling elements. At the same time, miniaturisation and weight reduction can be tackled.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : M104
ID : 6277058

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ultrahard Materials

Author : Dr Nilen Roger (Element Six (UK) Ltd., Global Innovation Centre, United Kingdom)

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Title : Polycrystalline Diamond Cutters With Cobalt-Rhenium Binder For Enhanced Thermal Stability In Rock Drilling

Keyword(s) :
Cobalt Rhenium Carbide Polycrystalline Diamond Rock Drilling

Abstract :
The excellent abrasion resistance and impact resistance of polycrystalline diamond (PCD) make it the material of choice for rock cutting applications. For example, a PCD table bonded to a WC|Co substrate forms a cutter suitable for oil and gas drilling. However, the presence of binder in the PCD – infiltrated from the substrate during high pressure high temperature (HPHT) sintering – severely shortens tool life through thermal degradation mechanisms. Acid leaching this binder from the cutting surface significantly improves its thermal stability, but the use of alternative, more thermally stable binders is also an option. In this work, a novel Co-Re binder was evaluated for thermally stable PCD. Hot-stage XRD confirmed a 200°C delay to the onset of graphitisation in the PCD compared to standard Co binder-based PCD, and high-resolution TEM confirmed Re-enrichment at the binder-diamond interface. Finally, crack analysis demonstrated the material's suitability for thermally demanding drilling applications.

Innovative Aspect(s) :
The sintering of a Co-Re based carbide grade, and its application in polycrystalline diamond (PCD) cutting tool manufacture for oil & gas drilling applicationsDemonstrated gain in thermally stability of Co-Re binder-based PCD as measured by hot-stage XRD via the delayed onset (at least 200°C) of diamond graphitisation compared to standard Co binder-based PCDThermal stability gain also demonstrated in crack inspection comparison between Co-Re and Co-based PCD polished cross-sections after thermal treatments up to 10000C (for 1 hour) under vacuumHigh-resolution TEM & EDX evidence for the build-up of several Re-rich atomic monolayers at the diamond – binder interface, to which the thermal stability improvement is partly attributedCredible performance of the resulting novel PCD in granite cutting tests using a vertical turret lathe (pin-on-disc type abrasion test).

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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