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Research Projects Offer 2021
2021 年可申请研究项目和方向

1. Mechanical and biological characterization of materials based in Zn manufactured by SML for its use as biomedical implant
用作生物医学植入物-锌基材料的机械和生物学特性研究
Supervisors: **Prof. Javier LLorca and Dr. Monica Echeverry-Rendón**

2. High-throughput discovery of High Entropy Alloys (HEA)
高熵合金的高通量研究
Supervisor: **Dr. Srdjan Milenkovic**

3. Development of ductile and creep resistant Fe-Al-X alloys
具有韧性和抗蠕变性能 **Fe-Al-X** 合金的研究
Supervisor: **Dr. Srdjan Milenkovic**

4. Nanomechanics of high-performance composites
高性能复合材料的微观力学研究
Supervisor: **Dr. Juan José Vilatela**

5. Synthesis of multifunctional nanocarbon fibres
多功能碳纳米纤维的合成
Supervisor: **Dr. Juan José Vilatela**

6. Nanofibrous hydrogels for tissue engineering
用于组织工程的纳米纤维水凝胶研究
Supervisor: **Dr. Jennifer Patterson**

7. Development of new Co base superalloys for high temperature applications using advanced powder route technologies (Field Assisted Sintering and Selective Laser Melting)
先进粉末路径技术（辅助烧结和选择性激光熔化）用于高温应用的新型 **Co** 基高温合金的研究
Supervisor: **Prof. Jose Manuel Torralba**

1. Mechanical and biological characterization of materials based in Zn manufactured by SML for its use as biomedical implant
用作生物医学植入物-锌基材料的机械和生物学特性研究

Duration of project and time-length for hosting CSC student/scholar

4 years

Name of the project leader/supervisor, and contact info including webpage link

Prof. Javier LLorca, Scientific Director
Dr. Monica Echeverry-Rendón, Senior Post-doctoral Research Associate
Mechanics of Materials Group

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Project description

Biodegradable materials offer a revolutionary therapeutic option that provides mechanical support for and a turnover process including progressive degradation and synchronous with growth tissue. Zinc is one material in the group of degradable metals that can be used as platform for tissue regeneration. This application requires both good mechanical properties and high biocompatibility. New strategies for manufacturing as Selective Laser Melting (SLM) can be implemented to improve the general performance of the material in a biological environment. In this project, Zn alloys based with the required mechanical and corrosion properties will be designed and manufactured by SLM. Posteriorly this material will be evaluated under biological conditions with different cell types to validate its possible use *in vivo*.

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA

The student working in this project will participate in the development and experimental validation of state-of-the-art Zn alloys from the material and biological perspective as a possible application of this material in a biomedical application. This topic is at the forefront of the development of Zn alloys and is expected to lead to scientific advances with a large industrial impact.

Skills required for CSC students/scholars

A solid background in physical metallurgy and/or in biology is required. Experience in 3D printing and/or cell culture will be valued.

Remarks

This project can host 1 student

2. High-throughput discovery of High Entropy Alloys (HEA)
高熵合金的高通量研究

Duration of project and time-length for hosting CSC student/scholar

4 years

Name of the project leader/supervisor, and contact info including webpage link

Dr. Srdjan Milenkovic, Senior Researcher
Head of Solidification Processing and Engineering Group

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Project description

High entropy alloys constitute a new class of materials, quite different from the traditional alloys, consisting of several principal elements intermixed in the crystal lattice. Although showing some attractive properties, an extensive work, both theoretical and experimental, is urgently needed to fully understand the microstructure-properties relationship of this novel family of metallic materials.

The aim of the proposal is to use systematic design approach for rapid screening and discovery of single and two-phase HEA alloys for structural applications at intermediate temperatures (600-800ºC). The vast composition space of HEA offers great potential for useful discoveries, but at the same time is also the biggest barrier to alloy discovery and development. Therefore, high-throughput methods will be used in several stages. High-throughput method for creating macroscopic materials libraries with controlled composition gradients will be used in the second stage, and in the stage 3 high-throughput experiments will be performed on materials libraries with controlled microstructure gradients.

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA

During the project the student will be introduced to and trained to master several experimental techniques: high-throughput melting and casting methods, directional solidification, metallographic techniques, microstructure analysis using, optical, scanning and transmission electron microscopy, EBSD and nanomechanical testing (compression, tension and nanoindentation). The results of the investigation will be published in high impact international peer-reviewed journals.

Skills required for CSC student/scholar

Basic knowledge of thermodynamics, phase diagrams, metallography and casting.

Remarks

This project can host 1 PhD student.

3. Development of novel ultrafine eutectic alloys by additive manufacturing
具有韧性和抗蠕变性能 Fe-Al-X 合金的研究

Duration of project and time-length for hosting CSC student/scholar

4 years

Name of the project leader/supervisor, and contact info including webpage link

Dr. Srdjan Milenkovic, Senior Researcher
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Project description

Metal Additive Manufacturing (AM) is a growing field and the variety of materials available for metal AM systems is continuously expanding. However, there are many alloys yet to be developed or optimized for AM. Ultrafine eutectics and hierarchically structured near-eutectic alloys have been the subject of academic research for decades and remarkable mechanical properties have been reported. However, thus far, none of these alloys is used in industrial applications. One of the main reasons for this is that conventional casting does not provide the required cooling rates through component thickness.

The main objective of this PhD is to develop and optimize novel pre-defined composition, either eutectic or near-eutectic, for the further development of the ultrafine eutectic alloys with high strength and high ductility by additive manufacturing.

- Production of pre-alloys by conventional casting methods
- Powder production by gas atomization
- Additive manufacturing by selective laser melting (SLM)
- Characterization of microstructure-properties relationship
- Analysis of deformation mechanisms

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA

By implementing the project the student will be introduced to and trained to master several experimental techniques: vacuum induction melting and casting, gas atomization, selective layer melting, metallographic techniques, microstructure analysis using, optical, scanning and transmission electron microscopy, EBSD and mechanical testing. The results of the investigation will be published in high impact international peer-reviewed journals.

Skills required for CSC student/scholar

Basic knowledge of phase diagrams, metallography, casting and mechanical behaviour of metallic materials

Remarks

This project can host 1 PhD student.

4. Nanomechanics of high-performance composites
高性能复合材料的微观力学研究

Duration of project and time-length for hosting CSC student/scholar

4 years

Name of the project leader/supervisor, and contact info including webpage link

Dr Juan J. Vilatela, Senior Researcher
Head of the Multifunctional Nanocomposites Group

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Project description

Macroscopic fibres and fabrics of carbon nanotubes are considered the next generation high-performance material for structural composites, with particular application in transport. Key areas of development to materialize this potential are in improving understanding of factors governing stress transfer at different length scales, ranging from individual layers in CNTs, up to laminated composites.

This experimental project focuses on using advanced methods of characterization to study structural deformation and stress transfer in CNT fibre systems at different lengthscales. Envisaged techniques include in-situ mechanical tests in electron microscopes (HRTEM and FIB-SEM) to inspect mechanics at bundle level, coupled with spectroscopic (e.g Raman) to monitor stress transfer at the molecular level, as well as synchrotron X-ray methods (WAXS/SAXS) used to monitor structural deformation at the crystal and pore level.

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA

Development of a multiscale mechanical model to describe mechanical properties of CNT fibres, with possible extension to other properties (thermal, electrical) and use of advanced characterization techniques coupled with in-situ testing methods. The student is expected to interact strongly with industrial collaborators in the manufacturing and transport sectors and have internships at other leading laboratories of collaborators in Europe and the US.

Skills required for CSC students/scholars

A solid background in materials science and mechanics is required as well as fluent English (oral and written). Experience in writing scientific papers and conducting experimental work, particularly spectroscopy and/or X-ray, are desired.

Remarks

The project may host 1 PhD student. Strong collaboration with our academic partners in Europe and the US, and with industrial suppliers of CNT fibres is expected.

5. Synthesis of multifunctional nanocarbon fibres
多功能碳纳米纤维的合成

Duration of project and time-length for hosting CSC student/scholar

4 years

Name of the project leader/supervisor, and contact info including webpage link

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Project description

Macroscopic fibres and fabrics of carbon nanotubes are considered the next generation high-performance material for multifunctional applications, exploiting their extraordinary combination of electrical conductivity, high surface area, and toughness. Particular areas of interest are structural electrodes for energy storage and tough conductors. Key areas of development to materialize this potential are in controlling the structure of these CNT fibres at the molecular level and developing methods to combine them with semiconductors, polymers and other materials to form hybrids.

This experimental project focuses on establishing methods to control the molecular structure of CNT fibres, for example with respect to the presence of semiconducting and metallic CNTs, and the extent to which these are effective strategies to maximize surface area and or longitudinal transport properties. A particular aim is to translate synthesis and assembly control to bulk properties of energy storage and energy transfer electrodes. Additionally, chemical methods will be used to form hybrids of CNT fibres with a range of materials: including nanostructued dichalcogenides, transition metals, semiconductors and active polymers.

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA

The student will produce leading edge knowledge on synthesis and hybridization methods for the use of CNT fibres in energy storage and energy transfer applications. He/she will gain experience on gas-phase CVD processes, advanced characterization by electron microscopy spectroscopic and synchrotron X-ray methods, and will be directly exposed to work in the group on multifunctional battery and conductor development. Strong interaction with industrial collaborators in the manufacturing and transport sectors and internships at other leading laboratories of collaborators in Europe and the US are expected.

Skills required for CSC students/scholars

A solid background in materials science, physics, chemistry or chemical engineering is required, as well as fluent English (oral and written). Experience in writing scientific papers and conducting experimental work, particularly synthesis and characterization of inorganic nanomaterials.

Remarks

The project may host 1 PhD student. Strong collaboration with our academic partners in Europe and the US, and with industrial suppliers of CNT fibres is expected.

6. Nanofibrous hydrogels for tissue engineering
用于组织工程的纳米纤维水凝胶研究

Duration of project and time-length for hosting CSC student/scholar
4 years

Name of the project leader/supervisor, and contact info including webpage link
Dr Jennifer Patterson, Researcher
Head of the Biomaterials and Regenerative Medicine Group

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Project description
Tissue engineering, an approach combining materials, cells, and biological factors to promote tissue regeneration, has been a promising concept for the treatment of injury and disease since first proposed over 30 years ago. In spite of this, very few tissue engineering therapies have reached clinical practice. This is due in part to the challenges associated with the design of a combination of materials and biological signals to direct the desired cellular response. In this project, novel synthetic nanofibrous hydrogels will be developed to support cell growth and differentiation. In particular, the student/scholar will work on the development of novel hydrogels based on self-assembling peptides and/or other supramolecular gelators, focused on three main aspects: (1) the synthesis and chemical characterization of compounds to form the hydrogels, (2) the characterization of the nanoscale morphology and mechanical properties of the hydrogels using advanced materials characterization techniques (SEM, TEM, AFM, rheology, in situ characterization), and (3) the evaluation of the novel hydrogels in cell culture experiments first following standardized assays to demonstrate cytocompatibility and second using relevant cell types and biochemical assays for a tissue of interest.

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA
The candidate will learn new interdisciplinary experimental skills and will have access to the state of the art equipment at IMDEA Materials Institute, including a new cell culture lab with confocal microscope. It is also expected that the results will be disseminated by the student/scholar through scientific journal publications and presentations at international conferences. The Institute is also committed to training in “soft” or transversal skills.

Skills required for CSC students/scholars
The candidate should have a Master of Science in Materials Science/Materials Engineering, Biomedical Engineering, Mechanical Engineering, Chemistry, or a related field, with strong academic credentials. A high level of English (both oral and written) is mandatory. The candidate should have hands-on experience with some of the following techniques: chemical synthesis, materials characterization (electron microscopy, rheology, mechanical testing), cell culture, or biochemical assays.

Remarks
The project may host 1 PhD student.

7. Development of new Co base superalloys for high temperature applications using advanced powder route technologies (Field Assisted Sintering and Selective Laser Melting)
先进粉末路径技术（辅助烧结和选择性激光熔化）用于高温应用的新型 Co 基高温合金的研究

Duration of project and time-length for hosting CSC student/scholar

4 years

Name of the project leader/supervisor, and contact info including webpage link

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Project description

The new Co based superalloys developed based on Co-9W-Al (at.%) have based their good behaviour at high temperature, thanks to their ability to develop, at microstructural level, a γ-γ' structure, with a stable γ' precipitates at higher temperature than many Ni base superalloys. These alloys were gas atomized with some additions previously analysed with the aim of maintaining this stabilization at higher temperatures and make these alloys more competitive. These powders will be process through advance manufacturing techniques, such as field assisted sintering (allowing full density materials) and selective laser melting (allowing full density and complex shapes). All developed materials will be further heat treated in order to optimize the shape, distribution and amount of γ' precipitates. Obtained materials will be fully microstructural characterized and the mechanical behaviour at high temperature will be investigated.

Project outcomes that CSC student/scholar could expected to achieve via working in IMDEA

By implementing the project the student will be introduced to and trained to advanced manufacturing process for superalloys (field assisted sintering and selective laser melting) and also advance microstructural characterization techniques (TEM, FEG-SEM, EBSD) and mechanical characterization (at nano and macro scale). The results of the investigation will be published in high impact international peer-reviewed journals and conferences. The development of this family of Co base alloys is expected to lead to scientific advances in the development of engines for the aeronautical industry.

Skills required for CSC students/scholars

A solid background in physical metallurgy is required. Experience in computational thermodynamics will be valued. Basic knowledge of phase diagrams, metallography, powder metallurgy and mechanical behaviour of metallic materials. Fluent English (oral and written) is mandatory. Experience in writing scientific papers will be valued.

Remarks
The project can host 1 PhD student.