UNNC-NIMTE, CAS Doctoral Training Partnership

It's essential that you have contacted the UNNC and/or NIMTE supervisors and agreed on a suitable collaborative PhD topic before submitting an application.

Formal applications should follow the instructions in 'How to apply' section.

Research areas

- New Material Science
- Advanced Manufacturing
- Electrical Machines and Drives
- Composite Materials
- Computer Science

Potential PhD topics

PhD topic	Design of novel material for functional enrichment of complex microbial communities
NIMTE Supervisor	Kaiyang Yin
UNNC Supervisor(s)	Enrico Marsili
Short introduction & description of the PhD project	Microbial communities, comprising hundreds of different species, are the key in many environmental and health processes, such as corrosion, bioremediation, and infections. However, most microbiological methods study only single species in idealized laboratory conditions, which does not represent the complexity of natural environments. One of the key issues in studying mixed microbial consortia is how to enrich microbial communities in bacteria with specific functions (e.g., metal reduction, acetate oxidation, etc.). This enrichment is currently carried out through cumbersome media formulation and time-consuming enriching cycles. This project will follow a radically different approach of using novel materials for microbial enrichment. This project will (i) develop polymeric materials with custom-designable molecular and micro-/meso-scale structures, (ii) investigate the interaction between the materials and microbial groups, (iii) establish the approach of rapid functional enrichment of specific microbial groups from environmental and clinical consortia with materials.
Contact points	Informal inquiries may be addressed to Assoc Prof Enrico Marsili (enrico.marsili@nottingham.edu.cn) and Prof. YIN Kaiyang (yinkaiyang@nimte.ac.cn)

PhD topic	**Protective coatings in harsh environments**
NIMTE Supervisor	Prof. Yongxin WANG
UNNC Supervisor(s)	Prof. Hao Chen
Short introduction & description of the PhD project	Expanding human activity space and better utilizing natural resources are always being the continuous driving forces for the development of human society. With the great development of engineering technologies for last two centuries, we human are able to set foot on the moon and reach to areas (deep space, deep sea and polar region etc.) where might have not been touched by intelligence life. Such areas generally, have extreme harsh service conditions for components which keep challenging the engineering technologies. Usually, a single material can not meet all the service requirements. Therefore, a reasonable and practical solution is to apply a protective coating on the surface of mechanical components to increase the performances. Coating technologies play a more and more important role on meeting the service requirements in harsh environments.
Contact points	Informal inquiries may be addressed to Prof. Hao Chen (Hao.Chen@nottingham.edu.cn) and Prof. Yongxin WANG (yxwang@nimte.ac.cn).
PhD topic	**Research on Magneto-Elastic Composite Materials and Devices for Three-Dimensional Force-Tactile Sensors in Embodied Intelligent Robots**
NIMTE Supervisor	Prof. Jie SHANG
UNNC Supervisor(s)	Prof. Xiaoling LIU
Short introduction & description of the PhD project	As a cutting-edge achievement of the deep integration between artificial intelligence and robotics, embodied intelligent robots are rapidly emerging as a core engine driving social progress and industrial transformation. Meanwhile, digital and intelligent mechanical research on three-dimensional force-tactile sensors is fundamentally reshaping the paradigm of interaction between machines and the physical world, serving as a critical breakthrough for embodied intelligence to overcome the constraints of the "perception-action" closed loop, and holds significant scientific value in advancing the fusion and innovation of AI and robotics. Based on this, this project will focus on a novel magneto-electric tactile sensor—capable of high-density integration with dexterous hands of embodied intelligent robots and offering unique advantages in high-resolution 3D force perception. By investigating low-hysteresis, low-modulus resin materials, we aim to enhance the sensor's robustness and sensitivity. Through studying the 3D topological design of photoresin-based magneto-elastic materials, along with digital-intelligent modeling and optimization strategies for force-magnetic response, we will uncover the underlying relationships among the composition, spatial structure, magnetic pole arrangement, mechanical properties, and force-to-magnetic conversion efficiency of magnetic elastomers. By exploring signal inversion methods for magneto-electric tactile sensors and the physical-data fusion approach for 3D force decoupling, we will reveal the deeper mechanisms enabling precise 3D force separation. Furthermore, by establishing a digital-intelligent mechanical model for tactile information "perception-recognition" tailored to embodied intelligence, we will develop a systematic framework for digital-intelligent mechanical methods in signal inversion and 3D force decoupling. The ultimate goal is to develop a 3D force-tactile sensor compatible with the dexterous hands of embodied intelligent robots, enabling accurate identification of complex contact states and real-time perception and cognitive reasoning under multi-modal sensory fusion. This will

	provide a generalizable digital-intelligent mechanical support system for the intelligent upgrade of tactile systems in embodied intelligent robots.
Contact points	Informal inquiries may be addressed to Prof. Xiaoling LIU (Xiaoling.liu@nottingham.edu.cn) and Prof. Jie SHANG (shangjie@nimte.ac.cn).
PhD topic	**Development of High-Performance Redox Flow Batteries**
NIMTE Supervisor	Prof. Gang Wang
UNNC Supervisor(s)	Dr Richard Adjei
Short introduction & description of the PhD project	Redox flow batteries (RFBs) are regarded as one of the most promising large-scale energy storage technologies to address the intermittency of renewable energy sources, owing to their unique advantages of flexible capacity design, high safety and long cycle life. The flow field is a core structural component of RFBs, which governs electrolyte transport, reactant renewal and electrochemical reaction kinetics inside the cell, and ultimately determines the battery's energy efficiency, power performance and operating cost. Traditionally, RFB flow fields are classified merely by macroscopic geometric features, while the intrinsic correlation between flow field structure, internal mass transport behaviour and actual cell performance is often overlooked, restricting the breakthrough of high-performance, low-energy-consumption RFB design. This PhD project focuses on solving the core bottleneck of empirical, geometry-oriented flow field design in current RFB research. It aims to establish a transport-driven flow field design theory and systematic evaluation framework, breaking the limitation of fixed-performance cognition of mainstream and emerging flow field architectures. The research outcomes will provide universal, reproducible design guidelines for high-efficiency, low-pumping-loss RFB flow fields, and support the scalable industrial application of vanadium, zinc-based and other novel flow battery systems. This research project will systematically investigate the multi-physical coupling mechanism between hydraulic driving force, electrolyte transport behaviour and electrochemical performance in RFB porous electrodes. Vanadium systems are adopted as the benchmark to explore universal mass transport rules, while zinc-based hybrid batteries serve as a contrasting case to reveal the coupling effect of local flow characteristics and metal deposition behaviour, covering diverse mainstream RFB systems. This project will integrate computational fluid dynamics (CFD) simulation, topology optimisation, experimental validation, and machine learning-assisted high-throughput screening to expand the flow field design space comprehensively. This research will lay a solid theoretical and technical foundation for the industrialisation and large-scale promotion of high-efficiency, low-cost redox flow batteries.
Contact points	Informal inquiries may be addressed to Dr Richard Adjei (Richard-Amankwa.Adjei@nottingham.edu.cn) and Prof Gang Wang (gang.wang@nimte.ac.cn)
PhD topic	**Materials and devices, performance optimization, and optoelectronic mechanism research of perovskite solar cells**
NIMTE Supervisor	Prof. Ziyi GE
UNNC Supervisor(s)	Prof. Tao WU
Short introduction & description of the PhD project	Flexible perovskite solar cells (f-PSCs) have become an important technology for promoting China's green and low-carbon goals due to their lightweight, simple preparation process, low production cost, and excellent flexibility. However, its industrialization is still limited by the bottleneck of materials and preparation.

	This project will focus on developing electrode materials with high conductivity and excellent flexibility, as well as hole transport layer materials that match them. We will conduct in-depth research on the film formation mechanism of large-area flexible perovskite films, explore perovskite crystallization control strategies, design high-performance self-healing materials, enhance the mechanical durability of flexible perovskite films, optimize module processes, and promote the development of high-performance flexible photovoltaic module integration technology.
Contact points	Informal inquiries may be addressed to Prof. Ziyi GE (geziyi@nimte.ac.cn) and Prof. Ruixiang PENG (pengrx@nimte.ac.cn).
PhD topic	**Development of Smart, Biodegradable Bone Implants Using Engineered Cellular Metallic Structures**
NIMTE Supervisor	Prof. Lijing Yang
UNNC Supervisor(s)	Dr. Amin Farrokh Abadi
Short introduction & description of the PhD project	This research project addresses a critical challenge in orthopedic surgery: the need for bone implants that provide temporary mechanical support and then safely dissolve, eliminating the necessity for secondary removal surgery and mitigating issues like stress-shielding. Current permanent implants, while strong, can hinder long-term bone health and require additional interventions. The proposed solution is the development of a new generation of **smart, biodegradable implants** made from advanced metallic alloys. The core innovation lies in a **triple-integrated approach** that synergizes **material science**, **architectural design**, and **predictive intelligence**. Instead of a solid metal piece, the implant will feature an optimized **cellular or lattice structure**. This engineered architecture serves multiple purposes: it reduces the implant's overall stiffness to better match natural bone and prevent stress-shielding, creates interconnected pores for blood vessel ingrowth and new bone formation (osseointegration), and provides a high surface area to actively control the degradation rate of the metal. The project will employ a comprehensive **computational-experimental methodology**. It begins with computer-aided design and multi-physics simulation to model the implant's mechanical performance and degradation behavior in the physiological environment. Advanced manufacturing techniques, such as metal 3D printing, will be used to fabricate these complex porous structures with precision. The implants will then undergo rigorous laboratory testing, including mechanical strength assessment, degradation analysis in simulated body fluid, and biological evaluation with bone cells to ensure safety and effectiveness. The collected data will feed into a machine learning model to create a predictive digital twin, enabling the intelligent design of future patient-specific implants. The ultimate goal is to create a **dynamic, multifunctional implant** that seamlessly interacts with the body: it carries load initially, guides tissue regeneration, and gracefully dissolves at a rate synchronized with the natural bone healing process. This research aims to establish a new paradigm for intelligent orthopedic solutions, paving the way for personalized, more efficient, and patient-friendly treatments.
Contact points	Informal inquiries may be addressed to Dr. Amin Farrokhabadi (amin-farrokh.abadi@nottingham.edu.cn) and Prof. Lijing Yang (yanglj@nimte.ac.cn).
PhD topic	**Laser Additive Manufacturing of 3D Micro-Architectures for Advanced Gas Sensors**

NIMTE Supervisor	Prof. Yuchuan CHENG
UNNC Supervisor(s)	Dr. Reza Shoja Razavi
Short introduction & description of the PhD project	This project establishes a collaborative platform to explore novel gas sensor designs by combining laser additive manufacturing with functional materials science. The research will focus on using Laser Powder Bed Fusion (LPBF) to design and fabricate three-dimensional metallic micro-architectures. These structures aim to provide an optimized porous scaffold or platform with high surface area and tailored geometry. The PhD candidate will work on optimizing the LPBF process parameters to achieve these designed structures with good fidelity and stability. This 3D-printed platform will then serve as a substrate for advanced functionalization conducted at NIMTE, targeting enhanced performance in gas sensing applications. This collaborative approach provides a flexible foundation to develop a new generation of sensors, with the specific sensing materials and mechanisms to be refined based on the student's progress and the combined expertise of both research groups.
Contact points	Informal inquiries may be addressed to Dr. Reza Shoja Razavi (Sayed-Reza.Shoja-Razavi@nottingham.edu.cn) and Prof. CHENG Yuchuan (yccheng@nimte.ac.cn).
PhD topic	**Topology Optimization of Ultrasonic Horns for Modal Decoupling and Robust Support**
NIMTE Supervisor	Prof. Silu CHEN
UNNC Supervisor(s)	Prof. Jian YANG
Short introduction & description of the PhD project	Ultrasonic horns constitute the core energy-transmission components in high-precision applications such as advanced machining and robotic surgery. The performance and reliability of these systems critically depend on the effective suppression of parasitic vibration modes and the accurate localization of displacement nodes. Under high-power excitation, however, pronounced thermo-mechanical coupling induces modal interaction and nodal drift, resulting in energy leakage and excessive dissipation at clamping interfaces. To overcome these challenges, the coming research would like to propose a topology-optimization-based design framework for ultrasonic horns with intrinsically enhanced modal decoupling and thermo-mechanical robustness. By revealing the dynamic redistribution of strain energy under coupled thermal and mechanical perturbations, a robust sensitivity analysis will be integrated to guide the topological evolution toward multiple synergistic objectives. This design paradigm is expected to effectively mitigate impedance mismatch in high-power ultrasonic systems and establishes a fundamental methodology for the development of next-generation high-Q, ultra-low-loss acoustic resonators.
Contact points	Informal inquiries may be addressed to Prof. Silu Chen (chensilu@nimte.ac.cn) and Prof Jian YANG (Jian.Yang@nottingham.edu.cn).
PhD topic	**Study on Low-Temperature Densification and Reliability of SiC_f/SiC Composites Using Low Neutron Toxicity Sintering Aids**
NIMTE Supervisor	Prof. Yinsheng Li
UNNC Supervisor(s)	Prof. Hao Chen

Short introduction & description of the PhD project	Silicon carbide fiber-reinforced silicon carbide matrix composites (SiC_f/SiC) are highly valued for their exceptional high-temperature creep resistance, corrosion resistance, and radiation tolerance, making them crucial materials for high-safety cladding in harsh environments within the nuclear energy sector. The Nano Infiltration and Transient Eutectic (NITE) process is a significant method for fabricating SiC_f/SiC composites. However, key challenges hindering its application in nuclear energy include the introduction of sintering aids with high neutron absorption cross-sections and the detrimental effects of high densification temperatures on fiber integrity and mechanical performance. In this research subject, we propose the use of metal oxides with low neutron absorption cross-sections (such as Al_2O_3 and ZrO_2) as efficient sintering aids. By employing electric field-assisted rapid sintering techniques at lower temperatures, we aim to achieve densification of SiC_f/SiC while protecting the fibers and obtaining excellent mechanical properties. This study will investigate the physicochemical processes involved in the formation of liquid phases by the metal oxide aids, revealing the factors influencing the densification of SiC_f/SiC composites and clarifying the mechanisms of liquid-phase sintering. Furthermore, by examining the composition-microstructure-mechanical property relationships of SiC_f/SiC composites, we will elucidate the interaction principles between fibers, interfaces, and matrices under stress conditions, uncovering the failure mechanisms of the composites. This understanding will guide the optimization of microstructural design to enhance the mechanical performance of the composites. Finally, by studying the interactions between energetic particles and SiC_f/SiC composites at the atomic scale, we aim to clarify the irradiation damage mechanisms of materials in extreme environments. This research subject will provide theoretical support for the design and preparation of NITE-SiC_f/SiC composites.
Contact points	Informal inquiries may be addressed to Prof. Yinsheng Li (liyinsheng@nimte.ac.cn) and Dr. Hao Chen (Hao.Chen@nottingham.edu.cn).
PhD topic	**Radiative cooling based upon the optical modulation of optical materials and the dual-band spectral manipulation of thin film system.**
NIMTE Supervisor	Prof. Hongtao Cao
UNNC Supervisor(s)	Prof. Hao Chen
Short introduction & description of the PhD project	The application of radiative cooling can be traced back to ancient time as the ancestors made ice in the nocturnal time even the ambient temperature is above 0 ℃. This approach can passively decrease the ambient temperature through heat radiation without energy consumption, providing a solution to compensate problems raised by global warming. The scientific concept of radiative cooling first came up in 1826, whose critical point is to enhance the heat exchange between the Earth and the outer space within the atmospheric window (AW, 3-5, 8-13, 16-28 μm), while prevent the systemic solar irradiance absorption (0.2-2.5 μm). Therefore, the project mainly focuses on the spectral manipulation of thin film system. Besides, considering the performance optimization and integration of the designed film system, the project also involves the optical modulation of the relative materials, including the broadening of the absorption band and the enlargement of the resonance dielectric refractive index. This project will focus on two major optical dimensions on (i) high reflection in solar irradiance range and (ii) selective absorption in infrared regime.

Contact points	Informal inquiries may be addressed to Prof. Hongtao Cao (h_cao@nimte.ac.cn) and Prof. Hao Chen (Hao.Chen@nottingham.edu.cn).
PhD topic	**Research on thermal-sprayed functional ceramic coatings with photothermal property**
NIMTE Supervisor	Prof. Hua Li
UNNC Supervisor(s)	Prof. Hao Chen
Short introduction & description of the PhD project	Photothermal materials hold immense potential in many applications ranging from energy conversion to thermal management systems. The ability to harness and manipulate photothermal effect in ceramic coatings can contribute to groundbreaking advancements in renewable energy, environmental engineering, smart material design, and other fields. Thermal spraying presents a versatile and effective method for fabricating these functional ceramic coatings. It allows for the deposition of coatings on a wide range of substrates, regardless of their melting points, providing a significant advantage in terms of material compatibility. Meanwhile, it offers the advantage of engineering coatings with specific microstructures and tailored properties. The main objective of this project is to develop and optimise ceramic coatings that demonstrate superior photothermal efficiency and durability via thermal spraying. By harnessing the advantages of thermal spraying, this project aims to deliver transformative solutions that are economically viable and technologically advanced, setting new benchmarks in the field of photothermal ceramic coatings.
Contact points	Informal inquiries may be addressed to Prof. Hua Li (lihua@nimte.ac.cn) and Prof. Hao Chen (Hao.Chen@nottingham.edu.cn).
PhD topic	**Green, low - carbon and circular recycling project for spent power lithium battery resources**
NIMTE Supervisor	Prof. Gao JIE
UNNC Supervisor(s)	Prof. Philip Hall and Dr Zheng Wang
Short introduction & description of the PhD project	With the rapid development of the global new-energy vehicle industry, the quantity of spent power lithium batteries has surged exponentially. If not properly handled, this will not only lead to the waste of scarce resources such as lithium and cobalt, but also the heavy metals and chemical substances contained within them will cause serious environmental pollution. Against this backdrop, our project was initiated. It aims to achieve the circular reuse of spent power lithium battery resources in a green and low-carbon manner, designed to address the dual challenges of resource conservation and environmental protection.
Contact points	Informal inquiries may be addressed to Dr Zheng Wang (Zheng.Wang@nottingham.edu.cn), Prof. Philip Hall (Philip.HALL@nottingham.edu.cn) and Prof. Gao JIE (gaojie@nimte.ac.cn).
PhD topic	**Enhancing Polycrystalline Diamond Performance through Precision Engineering of Diamond-Diamond Bonding**
NIMTE Supervisor	Prof. Lifen Deng
UNNC Supervisor(s)	Dr. Hainam Do

Short introduction & description of the PhD project	This PhD research aims to fundamentally enhance the properties of polycrystalline diamond (PCD) by shifting from traditional empirical methods to the precision engineering of the diamond-diamond bonding process. The central hypothesis is that the macroscopic performance of PCD is directly governed by the quality of the intergranular bonds between diamond crystals. The project is supposed to answer the following three questions: 1)Mechanistic Deciphering: To unravel the atomic-scale mechanisms and interface evolution during diamond-diamond bonding under high-pressure high-temperature (HPHT) conditions;2)Process-Property Correlation: To establish quantitative links between dynamic sintering parameters, the characteristics of the bonded interfaces (e.g., strength, thickness), and the final mechanical/thermal properties of PCD;3)Alternative Pathway Exploration: To explore and validate novel catalyst alternatives or sintering aids (e.g., non-metallic media) that promote densification and strong diamond-diamond bonding while minimizing detrimental residual phases.
Contact points	Informal inquiries may be addressed to Prof. Lifen Deng (denglifen@nimte.ac.cn) and Dr. Hainam Do (Hainam.Do@nottingham.edu.cn).
PhD topic	**Microstructure evolution and high temperature mechanical/chemical behaviour of novel Ni/Co-based alloys**
NIMTE Supervisor	Prof. Xuezhi Qin
UNNC Supervisor(s)	Prof. Hao Chen
Short introduction & description of the PhD project	This project aims to design and develop novel Ni/Co-based alloys for enhanced microstructure control and high temperature mechanical/chemical characteristics. Thermodynamic calculation is employed to evaluate the Al/Cr/Ti ratios and Nb/Mo/W additions on the phase equilibria. High temperature precision casting will be used and microstructure evolution of the novel Ni/Co-based alloys will be investigated to understand the microstructure and phase distributions. Heat treatments will be conducted to further control the microstructure and γ' distribution. High temperature mechanical properties will be studied to reveal the effects of γ', Laves phase and carbide precipitates on the failure characteristics of the Ni/Co-based alloys. In addition, the high temperature oxidation behaviour will also be examined to study the oxide formation mechanisms and corresponding phase changes. This project will bring scientific advancements in the design and development of novel Ni/Co-based alloys for high temperature applications.
Contact points	Informal inquiries may be addressed to Prof. Hao Chen (Hao.Chen@nottingham.edu.cn) and Prof. Xuezhi Qin (xzqin@nimte.ac.cn).