List of IC@N Research Projects and Supervisors

School of Materials Science & Engineering (MSE)	
Name of Supervisor	**Research Project Description**
Associate Professor Huang Yizhong yzhuang@ntu.edu.sg	**Synthesis of hydrogels for clean water** Hydrogels are three-dimensional crosslink polymer networks that have the ability to absorb large volume of water without dissolving. They can be prepared starting from monomers, prepolymers or existing hydrophilic polymers. Applications of hydrogel include in areas sun as drug-delivery systems, sensor systems, oil-water separations and tissue engineering. In this project, hydrogels are to be synthesized from which hydrogel beads are manufactured. These hydrogel beads should present a possible way to provide pathogen-free water to disaster regions, where the distribution of potable water are always an issue due to the lack of easy access, technical support and electrical power. Along with shelter, medicine and food, safe drinking water is crucial for both short term survival and long term stability of immune system.
Professor Lam Yeng Ming ymlam@ntu.edu.sg	**Nanostructured films for solar cells application** Nanostructured films provide nice pathways for charge to be collected at the electrodes. In this work, the student will work towards the development of a solution processible photovoltaic system that is flexible, low-cost and light-weight. Photoexcited excitons will be generated once light is absorbed and will dissociate at the heterojunction interface and therefore create free charge carriers at this interface, resulting in a photocurrent. The student will make use of nano structuring approach to promote charge transport.
	Understanding effect semiconducting nanoparticles on the optical properties of order film This work explores the effect of semiconducting nanoparticles on the optical properties optical properties of self-assembled PS arrays. The student will have a chance to learn about the synthesis of semiconducting nanoparticles. They will also learn about how the absorption/luminescence properties changes with different nanostructures.
Professor Lee Pooi See pslee@ntu.edu.sg	**Electrical circuit management for robotics** The project requires knowledge on robotics related programming like ROS. The experimental realization will be done with electrical circuit management to control robot movements. These robots

	were made of novel materials that have difference properties and characteristics in actuating and sensing.
Associate Professor Ng Kee Woei kwng@ntu.edu.sg	**Fabrication of Mechanically Robust Blood Vessels from 3D Keratin-Based Hydrogels** **<u>The project is open to IIT Hyderabad students only.</u>** Blood vessels will help in the rapid delivery of oxygen and nutrients to the tissues. The tube-like vascular structure consists of the inner lumen which is populated with endothelial cells (EC), and the underlying stroma layer made up of fibroblasts and smooth muscle cells (SMC). The thickness of blood vessel walls will vary between the artery to vein. Clinical problems associated with the vascular system are common and serious, typically caused by inflammation or deposition of fat in the blood vessels. Vascular Diseases include any condition that affects the circulatory system, ranging from Peripheral arterial disease (PAD) and Abdominal Aortic Aneurysm (AAA). If not treated early, these conditions advance to a stage where graft replacements like autograft and allograft will be required. However, there are limitations such as underlying pathologies including varicose vein disease and immunological reactions between the host and donor. Tissue engineering provides an alternative approach to overcome these difficulties, by replacing defect sites using biomaterials or biomaterials with combinations of specific cells. For vascular graft replacements, 3D printed hydrogels could be used to recapitulate the function of blood vessels. The fabrication process to mimic the natural blood vessel can be possible through the 3D bio-printing technology. 3D printing technology represents the bottom-up process in which biological materials and cells are patterned and assembled into three-dimensional (3D) organisations with controlled architecture. The technique could evoke the regeneration process with high cell population throughout the printed structure. In this project, suitable Bio-inks consisting of hydrogels and cells will be prepared and fabricated. Hydrogels may be derived from natural or synthetic raw materials. For biomedical applications, natural material based hydrogels (gelatin, alginate, chitosan, GelMA, etc.) are commonly used [1], which may require external stimuli to crosslink or gel. To develop a mechanically robust vasculature channel, it is proposed that keratin-based hydrogel composites can be used to fabricate the 3D scaffolds [2]. These scaffolds will enhance cell proliferation, cell differentiation and cell alignment with the help of the stimulation system. We predict that these vascular channels will facilitate the mass transport requirements of a metabolically active and highly populated tissue. The functionality of the 3D printed scaffolds will be accessed based on cell proliferation test, scanning electron microscopy (SEM) to analyse the morphology, DNA quantification, tensile and

	compressive strength study, gene expression studies and immunohistochemistry (IHC). 3D bio-printing of patient-specific defects is also possible with the help of CAD modelling and DICOM images. 3D printed vascular channels can be used effectively to improve vascularization, and together with the matured cells in the construct, these could function as fully developed blood vessels.
	3D Printing of Keratin Derived Hydrogel for Skin Tissue Engineering **<u>The project is open to IIT Hyderabad students only.</u>** 3D bio-printing technique is an appealing biofabrication platform due to its ability to precisely pattern living cells in pre-defined architecture with functionally active scaffolds. The demand of skin substitute in the world due to large skin defects resulting from burns, trauma, and other diseases that can lead to skin necrosis and ultimately needs the skin graft from the same patient or allograft which rises in cross immunological reactions. A major challenge of skin tissue engineering is to seek a suitable source of bio-ink capable of supporting and stimulating printed cells for Active tissue development. However, current bio-inks for skin tissue printing rely on homogeneous biomaterials which have several shortcomings such as insufficient mechanical properties and recapitulation of microenvironment or necrosis of cells due to inadequate nutrient supply. A number of approaches have been employed to enhance cellular survival and physiological functioning of damaged tissue during regeneration such as cellular substitutes (seeding keratinocytes, fibroblasts, and stem cells), non-cellular skin substitutes such as synthetic and natural biomaterials and also commercially available skin substitute's example Alloderm, Integra, SureDerm, Recell etc. each of the replacement method will have the limitations. Skin is made up of two main layers, epidermis which is an outer most layer and protects physiological attack and dermis is the fibrous inner layer containing mainly extracellular matrix and blood vessels. Recapitulating skin tissue is difficult due to the intricate structure. 3D bio-printing has proven its capacity to produce 3D scaffolds composed of living cells which can potentially produce highly organised tissues such as full thickness skin that includes both the dermis and epidermis layers [1]. A wide range of biomaterials (hydrogels) have been used for printing but most do not attain the functionally active tissue due to poor mechanical strength and in vivo microenvironment. Hair keratin has emerged as a new alternative that could complement current materials in fulfilling the purpose [2]. Our own studies have reported that keratin based templates are cell compatible and can enhance neovascularisation in vivo [3, 4]. An account of this suitable biomaterial and cells with keratin will improve the functionality of the scaffolds. Keratins have emerged as potential materials to address some of these challenges that can support

	high-density cell culture over the long term due to the cell binding motifs such as an arginine-glycine-aspartic acid (RGD), and the establishment of neovascularisation will mimic the dermis layer of the skin tissue. We aim to recapitulate the skin tissue by 3D bio-printing of two different layers with keratin based hydrogels in combination with other biomaterials such as gelatin, to recapitulate the bilayered structure of skin. The functionality of the 3D printed scaffolds will be accessed by cell proliferation test, scanning electron microscopy (SEM) to analyse the morphology, DNA quantification, tensile and compressive strength study, gene expression studies and immunohistochemistry (IHC).
Associate Professor Nripan Mathews nripan@ntu.edu.sg	**Perovskite solar cells and light emitting diodes** Halide perovskite semiconductors have gained attention due to their exceptional semiconducting properties despite the fact that the materials are processed at low temperatures from solutions. This project explores the fabrication of electronic devices such as solar cells, light emitting diodes and tackling the fundamental factors limiting perovskite research.
	Transparent electronics This project would focus on the development of novel material systems and devices to enable easily integrable transparent electronics. The applications targeted include thin film transistors, sensors and integrated systems.
Assoc Prof Terry W.J. Steele wjsteele@ntu.edu.sg	**Shape-selective nanoparticles for biomedical application** (Undergraduate/ Postgraduate) This project will focus on the development of shape-selective anisotropic magnetic particles for biomedical applications. Project Duration: 6 months
	Development of biofriendly antimicrobial surface coating reagent (Undergraduate/ Postgraduate) The objective of the current work is to synthesize nanocoating as antiviral and antimicrobial surface coating reagent. Project Duration: 6 months
Professor Raju V. Ramanujan ramanujan@ntu.edu.sg	**Advanced Magnetic Nanomaterials** We will examine the development, i.e., synthesis, characterization and property evaluation of magnetic nanomaterials for energy

	and transducer applications. These nanomaterials are of great current interest due to the urgent global need for energy efficiency and energy conservation. The synthesis of these materials will be followed by characterization using electron microscopy techniques and property evaluation by magnetometry. It is expected that this work will provide new insights into the cutting-edge technology needed for future development of magnetic nanomaterials.
Assoc Prof Andrew Clive Grimsdale acgrimsdale@ntu.edu.sg	**Singlet fission materials** (Postgraduate Level) New organic materials to be made and tested to see if they show singlet fission. Successful materials will be tested in solar cells to see if they improve performance. Project Duration: 6 months