List of Projects offered in MSE, NTU (for 2016)

1. Flame Retardancy Of Polymer Nanocomposites

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The objective of the proposed work is to develop flame retardant textiles with particular emphasis on ignition and heat transfer to the substrate. In the past, many different coatings based on intumescent compounds and sol-gel based silica have been used, but very few studies have focused on polymer nanocomposite coatings as flame retardant compositions on fabrics. This is the basis of the proposed work. Two coating methodologies will be used for this purpose: electrostatic self-assembly and spray coating processes. Along the way, some fundamental questions of prime importance will also be addressed. These include factors influencing physiological comfort as well.

A. SEM micrograph of a polyester fabric and B. Specific heat release rate of neat fabric and coated fabrics as observed from pyrolysis combustion flow calorimeter.
2. Catalytic Activity Of Metal-Semiconductor Hybrid Nano-Structure Arrays

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**Abstract:**
ZnO and TiO$_2$ are two excellent optoelectronic materials due to their wide direct band gap, low cost and facile fabrication. The larger exciton binding energy (60 meV vs 4 meV), higher electron mobility (200 cm$^2$·V$^{-1}$·s$^{-1}$ vs 30 cm$^2$·V$^{-1}$·s$^{-1}$) and, more importantly, better conductivity of ZnO than TiO$_2$ render it an ideal candidate of photoelectrode in the photoelectrochemical (PEC) system. However, the poor stability of ZnO in both acidic and alkaline electrolytes$^1$ and the low efficiency in the visible light region have restrained it from the practical applications so far$^2$. To overcome these problems, ZnO nano-heterostructures are designed and synthesized through the incorporation of photocatalytic and anti-corrosive components$^3$.

It is expected that the ZnO nano-heterostructures are tailored to not only improve the chemical stability of ZnO but also significantly enhance the photocatalytic activity by increasing both light absorption and charge separation. Furthermore, three-dimensional nano-heterostructured arrays with desirable surface morphology provide a large surface area for the surface redox reaction, so as to increase gas evolution on the large surface curvature$^6$ and augment the higher absorption of the solar light.

In the project, an approach is introduced to fabricate highly ordered metal-sulfide-coated ZnO/Si heterostructure arrays which are expected to demonstrate as a photoelectrode suitable for the application in the PEC system.

3. Numerical Simulations About Surface Plasmon Resonance Of Metallic Nanoparticles (Asst Prof Li Shuzhou)

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**Abstract:**
The noble metal nanostructures can show unique optical properties in visible region because of their surface plasmon resonance. These unique optical properties have broad applications on biosensing and metamaterials.

This project will introduce the basic knowledge about optical properties of metallic nanostructure first. Then study the optical properties of metallic spheres by numerical simulations. After this project, students should have the basic knowledge about electromagnetics and clear understanding about the principles of surface plasmon resonances. Students should also be able to calculate optical properties of metallic nanostructures by softwares.
4. Developing Human Hair Keratin Templates for Biomedical Applications

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**Abstract:**  
Human hair keratin has been explored as a raw material for various biomedical applications in recent years. This material brings exciting new possibilities because it is abundant, easily accessible and a cheap biomaterial that is of human origin. The amino acid sequence of hair keratins contains a cell adhesion motif, LDV (leucine - aspartic acid - valine). This motif is also found in extracellular matrix proteins such as fibronectin and is recognized by the cell adhesion molecule α4β1 integrin, which is expressed by leucocytes, fibroblasts and endothelial cells. These characteristics suggest that hair keratins could function as an extracellular scaffold to encourage cell adhesion, migration and proliferation, which are important in various biomedical applications.

In this project, the objective is to explore novel ways of manipulating keratins extracted from human hair, in order to produce templates of new and improved properties. This project will train the candidate on methods to extract and characterize human hair keratins, template processing and characterization techniques such as electrospinning, chemical crosslinking, freeze-drying, electron microscopy, FTIR and mechanical testing.

5. Electron Microscopy and X-Ray Diffraction of Olivine Nanoparticles for Li-ion Battery (Assoc Prof Dong Zhili)

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**Abstract:**  
The objectives of the project are to gain scientific knowledge on battery materials through x-ray diffraction technique with electron microscopy analysis. This research effort could provide additional battery characterization knowledge that promotes the development of new cathode, anode, electrolyte and separator materials for batteries.

The project scope includes:
1. X-ray diffraction characterization on the crystal structure, residual stress, and defects.
2. Electron microscopy characterization for the morphologies, defects and compositions of battery materials.

This project will train student with both advanced materials science and engineering knowledge, as well as x-ray and e-beam characterization techniques.