Tentative List of Ph.D. Topics, Year 2010-11

Department of Energy Science and Engineering, IIT Bombay

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Tentative list of Ph.D. topics to be offered by faculty members of Department of Energy Science and Engineering, IIT Bombay. Kindly consider the topics as indicative area of research.		
Name of Faculty	**Tentative topic for PhD**	**Description of topic**
Prof. Santantu Bandyopadhyay	Integration of Solar thermal system in process industries	Objective is to develop methodologies for integrating solar thermal system with various industrial processes. Uncertainties associated with solar radiation should also be considered while designing the system
Prof. Manoj Neergat	Unsupported Alloys and Core-Shells as Cathode catalysts for Low Temperature Fuel Cells	Conventionally carbon-supported precious metal catalysts are used as catalysts in fuel cells operating at low temperature. Fuel cells based on pure hydrogen works well with such catalysts. But, due to difficulties associated with production, storage, and transportation of hydrogen, there is an increasing interest to develop fuel cells based on alcohols. High crossover of the fuel from anode to cathode demands alternative unsupported alloys clusters or core-shells. This will significantly reduce the precious content and improve the activity resulting in reduced cost and better performance. This project focuses on development of alloy clusters and core-shell catalysts.
	Non precious catalysts for oxygen reduction reaction	Pt, the most commonly used catalyst in fuel cells, is also one of the most expensive elements. Several alternatives are reported in the literature – both non- Pt, and non - precious metal catalysts. The non-precious catalysts are not active enough to replace Pt and their stability in electrochemical environment is highly questionable. This project aims at developing novel alternative non- Pt architectures capable of delivering comparable stability and activity as that of Pt.
Prof. Prakash Ghosh	Development of Polymer Electrolyte Fuel Cell stack	In the proposed work, polymer electrolyte fuel cell will be designed and demonstrate in kW ranges.The work includes the theoretical modelling for the fuel cell design and fabrication of the fuel cell and characterisation of performances.
Prof. Pratibha Sharma	Investigation of Phase change memory materials	The materials which undergo a change in phase subject to fast electrical current pulses exhibit remarkable application in data storage. The storage mechanism

		consists in the structural reversible phase change and the two logical states are represented by the crystalline phase (low resistivity) and the amorphous phase (high resistivity).Materials which show such characteristics will be investigated and modifying their composition the storage properties will be enhanced.
	Thin Film Solar Cells	Semiconducting layer of PV materials will be grown on lost cost substrate and also using the cost effective techniques. Further modifications to achieve improved efficiency will be worked out. Further the concentration will be tried using LSCs.
Prof. Manaswita Bose	Kinetics and hydrodynamics of a fluidized bed gasifier	This project aims to develop a comprehensive model for the fluidized bed gasifier for coal and solid biomass gasification. The project involves both experiment and simulation. Kinetics data need to be obtained from lab scale experiment. This data will be used to design the gasifier. We will also fabricate a bench-top gasifier and study the hydrodynamics. The project also involves extensive CFD modelling.
	Attrition of particles in fluidized bed gasifier	The project involves both experiment and numerical simulation. We plan to study the attrition and fragmentation of coal and other solid biomass particles in the fluidized bed gasifier at the pressure and temperature they are usually operated in the commercial scale. This involves visualization experiments and extensive CFD simulation.
Prof. Rajesh Gupta	Electrical Approach for Active Infrared Thermography	Active infrared thermography is a non destructive material testing technique. This technique is used to find sub-surface defects in material. In this technique, object under investigation is stimulated by heat radiations and it surface temperature evolution is recorded by infrared camera. As the heat propagates inside the material, it get perturbed by the presence of sub-surface defects causing a temperature contrast on the surface. In this work, heat propagation inside the material will be modeled by electrical circuits and simulated/analyzed by circuit simulator or network analysis techniques.
	Electrical Simulation and performance evaluation of	Solar module electrical performance decreases with time due to degradation effects. In this work, these effects will be simulated by circuit simulator and its performance

	degraded solar module	will be studied under different environment conditions.
Prof. Sagar Mitra	Nano-architectured Copper current collectors - Metal Phosphides as Anode for Next generation Lithium-ion Battery Applications	To benefit from the large capacity gain advantages offered by transition metal phosphide based electrodes, we propose here to improve the kinetics of reactions of metal phosphides vs Li together with enhancement of their capacity retention by designing new nanoarchitectured electrodes. The process is based on the electrochemical template synthesis of copper nanorods. The as-obtained metallic Cu nanopillars are then chemically treated with different metal cations and phosphide precursors for metal phosphide formation and loading. The total nano architectured electrode assembly will be tested as negative electrode for lithium-ion battery applications
	Synthesis and electrochemical characterization of nano-sized coated $LiMPO_4$ as cathode material for lithium ion battery applications	Safety is of utmost concern especially in applications that use large-capacity lithium-ion power packs. Conventional cathode materials tend to explode in contact with the electrolyte at temperatures above 220˚C. $LiFePO_4$ is thermally safe and exhibits higher reversible capacities over many cycles. Moreover, it is non-toxic and has very little capacity fade. The main problem with this material is its poor electronic conductivity, which necessitates a conductive coating over its particles for electrochemical applications. Impurities, especially Fe^{3+} can be particularly damaging in its performance. Strategies in its development must, therefore, address purity, conductivity and particle size. Specific targets for $LiFePO_4$ are a specific capacity of more than 140 mAh/g and cyclability of at least 1000 cycles. The task of producing coated-$LiFePO_4$ and new method of nano $LiFePO_4$ production is another interest of the project.
Prof. Suneet Singh	Nodal Integral method for neutron diffusion equation in cylindrical coordinates.	Nodal Integral method is an advanced numerical scheme for solving differential equations. These schemes are well developed in Cartesian coordinates. For various applications, the method needs to be extended to cylindrical coordinates.
	Inverse Heat Conduction Problem for material characterization.	Conductivity and diffusivity distribution in an object can be obtained if temperature and heat flux is known at the object boundaries, by solving inverse heat conduction problem. These distributions can be used for material characterisation. Numerical

		and analytical methods need to be developed for solving this problem and these methods need to be validated against experimental data.
Prof. Rangan Banerjee	Sustainability Analysis of Renewables	Many new renewables are emerging – difficult to estimate viability, costs. In order to screen necessary to assess sustainability. Existing techniques include life cycle analysis, net energy analysis. This topic will involve assessing/ proposing new methods for sustainability analysis – materials, water, land, cost, emissions . Methods to be applied to dye sensitized solar, algae from biomass, new solar thermal etc. (applications may be chosen based on student interest).
	Spatial Energy models	GIS integrated energy models to be developed for urban-rural planning. This could be integrated with smart grid concept . Spatial interpolation and diffusion models to be included. A case study for IIT and another area could involve interfacing with smart meters for different end-uses.
	Large scale energy scenarios	Development of an end use based scenario for renewables and efficiency for India/ Maharashtra. Several methodological issues related to coupling with sectoral growth, technology choices etc.
Prof. C. S. Solanki	High efficiency Crystalline Si solar cells	Silicon has been the dominant material in solar PV technologies. More than 80% of solar cells are made in Si. Despite the growth of last 40 years, there is gap between the best laboratory solar cell and efficiency of commercial PV modules. This research will focus on developing solar cell process for improving the efficiencies of cell beyond 20%. These processes (selective emitter, point contact, laser fired diffusion) should be commercially viable in large area high throughput scenario. This development can significantly bring down the cost of solar cells.
	Si nanoparticles for 'All Si' multi-junction solar cells	Si solar cell efficiency is restricted to 31% by Shockley-Queisser limit. One of the viable ways to overcome this limit is by using Si nano-materials in a multi-junction solar cell. Si nano-particle of dimension less than 10 nm exhibits quantum confinement effect attributing to high effective band-gap well above c-Si (1.12 eV). Si-QDs show a variation in the bandgap from 1.7 to 2.5 eV with a reduction in Si-QDs diameter from 5 to 1 nm. The band-gap of Si-QD can be tuned by controlling the size

		of the quantum dots. Si exhibits quantum confinement effects when it is surrounded by high bandgap insulating materials like SiO_2 (9 eV), Si_3N_4 (5.4 eV) and SiC (2.5 eV). Here, SiN_x dielectric is chosen for embedding Si-QDs. This work will focuse on the fabrication of Si-QD/SiN_x ML films for fabricating all-Si multi-junction solar cells.
Prof. A. Ganesh	Study of Influence of Fuel Additive on Engine Performance	There are various fuel additives which are now being introduced in the market for improving the performance of the engine for eg. Emission characteristics, fuel consumption etc. the problem aims to understand the influence on the combustion characteristics of the fuel when additives are added. The combustion chemistry, atomisation, the Pi-Theta curve etc. will be studied. Both experimental investigation and mathematical modelling of the engine will be made use of. The above will be studied for both diesel and alternate fuels.
	Co-gasification of Biomass and Indian Coal	Experimental investigation and mathematical modelling will be done to understand the influence of biomass on high ash/high moisture coal gasification. Development of a Gasifier for the same is proposed.
	Study of electrochemical oxidation of Methane for application in a fuel cell	Experimental studies for development of catalyst and performance evaluation of fuel cell for electrochemical oxidation of methane will be done. This will also involve theoretical studies.
	Development of the process of pyrolysis for transport fuel	Experimental investigation with support from theoretical studies will be carried out to develop transport fuels from biomass. Catalyst development will be a part of it.
	Capture of CO_2 from the engine exhaust for growth of micro-algae	Identification of specific micro-algae for maximum capture of CO2 will be made. This study would include experimental as well as characterisation will be extensive.
Prof. Suryanarayna Doolla	Control of DG in a micro grid for PQ improvement.	This project involves in developing control strategies for improvement of voltage and frequency profile in a Micro-Grid environment (both grid connected and islanding condition). Study involves modeling, simulation and testing on a prototype at

		laboratory scale.
	Communication protocols for IED in smart grid environment	This project involves in developing protocols for intelligent electronic devices (IED) for monitoring of performance parameters (power electronics/power system) and effective communication with neighboring IEDs'. Study involves development and testing of the protocols.
	Direct Current Micro-grid	This project involves in design and analysis of direct use of DC supply (from PV) for daily use. Stability of the system is to be analyzed when power is injected from multiple sources into this DC grid. Study involves, modeling, simulation and testing at a laboratory scale.
Prof. Shaibal Sarkar	Interface modification of semiconductor Sensitized Solar Cells for faster charge separation.	The student will be engaged in optimizing the interface of the Semiconductor materials for faster charge separation. Surface passivation, bandgap engineering are the possible key words defining this project. Atomic Layer Deposition techniques will be used as thin film deposition technique along with solution route ones. Interest in instrumentation is must with good knowledge in English, Physics and Chemistry.
	Atomic Layer Deposition of low Eg Materials for Sensitized Solar Cell Application	The student will be working on developing newer chemistry to deposit films of low bandgap semiconductors which will be tested under sensitized solar cell configuration. This project includes development chemistry and device physics. Interest in instrumentation is must with good knowledge in English, Physics and Chemistry.