Research Fellows and Research Project Abstracts 2001/2002
(AMM&NS programme)

Dr Heng Chenglin
Expertise: Optoelectronic & microelectronic properties of Si-based nanoscale semiconductor materials & devices.

Optoelectronic Properties of some Si-based System comprised Semiconductor Nanocrystals
Project Advisors (Singapore): Assoc Prof Choi Wee Kiong, Assoc Prof Chim Wai Kin
Project Advisor (MIT): Prof Dimitri A. Antoniadis
Duration: September 2000 to August 2002

Project Abstract:

In this project, we studied the electrical memory effects of Ge nanocrystals embedded in SiO_2 matrix. The devices used for this work was a metal-insulator-Si structure. The insulator layer consisted of a SiO_2/Ge nanocrystals + SiO_2/rapid thermal oxide structure. The Ge nanocrystals were synthesized by rapid thermal annealing the co-sputtered Ge + SiO_2 films or the electron beam evaporated Ge films. We have demonstrated that such a device exhibited interesting characteristics that have potentials in memory devices. We are currently examining the roles of each layer, the Ge concentration, the distribution of Ge nanocrystals on the memory characteristics.

Dr Lei Yong
Expertise: Highly ordered nanowire and nanotube arrays embedded in anodic porous alumina membranes & highly ordered nanoparticle arrays used in two dimensional nanodevices and their characterization by SCM, EFM and AFM.

Growth of Germanium Nanocrystals and Application In Memory Devices
Project Advisors (Singapore): Assoc Prof Chim Wai Kin, Assoc Prof Choi Wee Kiong
Duration: October 2001 to October 2003

Project Abstract:

The increasing use of portable electronics and embedded systems has resulted in the need for low-power high-density nonvolatile memory devices. Nanocrystal memories, utilizing dimensional scaling of the floating gate to attain observable room temperature threshold voltage shifts upon charge injection and storage, can satisfy such a need. Over the last three years, we have carried out research on the formation of germanium (Ge) nanocrystals embedded in silicon oxide synthesized by sputtering and rapid thermal annealing. We are currently investigating the possibility of using such nanocrystal devices for flash memory application. To achieve controllable device characteristics, we are looking at ways to manipulate the arrangement or spatial order of the Ge nanocrystals. We have achieved moderate success in the vertical ordering of the nanocrystals by controlling the thickness of the sputtered Ge layer in a trilayer structure of rapid thermal oxide/Ge mid layer/sputtered capping oxide. We are currently investigating the use of a highly ordered alumina membrane mask, fabricated on a silicon wafer through anodization of an aluminum film, during Ge sputtering to achieve lateral spatial ordering of the Ge nanoparticles.

Dr Yao Linquan
Expertise: Computational mechanics of smart and (or) composite structures.

Finite Element Method for Piezoelectric Structures
Project Advisor (Singapore): Assoc Prof Lu Li
Duration: March 2001 to February 2003

Project Abstract:

The modelling, estimation and control of laminated composite plate/shell structures with segmented piezoelectric sensors and actuators will be presented. Numerical models of the finite element methods, especially the hybrid-stress solid-shell elements formulations, will be developed. The displacement field and electric field of the couple smart structure will be calculated by the developed numerical models. The vibration, shape and stability control will be researched using sensors and actuators. A number of popular examples will be considered by the new numerical models to illustrate their accuracy and efficacy in smart structure modelling.

Dr Zhang Yong
Expertise: Formation & properties of bulk metallic glasses, and bulk metallic glass-based composite.

Formation of La and Zr-based Bulk Metallic Glass and Bulk Metallic Glass Matrix Composite by Bridgman Solidification
Project Advisor (Singapore): Assoc Prof Li Yi
Duration: November 2000 to November 2002

Project Abstract:

Bulk metallic glass is a new kind of material which was discovered in 1990's, its discovery opened a new research area for both fundamental science and engineering applications. Our works focus on the discovery new bulk metallic glasses and in-situ crystalline phase reinforced bulk glass matrix composite. We have found that the best glass forming ability can be obtained either at eutectic composition or at off-eutectic composition. The detailed study shows that this is related to the type of the eutectic coupled zone, alloys with a symmetric eutectic coupled zone will have their best glass forming composition at eutectic or very near; and alloys with an asymmetric eutectic coupled zone will have their best glass forming composition at off-eutectic composition. From this we have obtained a hcp-La dendrite reinforced bulk metallic glass matrix composite at the eutectic composition, namely $La_{60}[Cu_{0.5}Ni_{0.5}]_{20}Al_{14}$, with critical diameter of 12 mm. The critical cooling rate to form the composite is 15 K/s measured by Bridgman solidification. The off-eutectic alloy shows better glass forming ability was also verified in Zr-Cu-Al ternary eutectic alloys.

Dr Zhu Tiejun
Expertise: Pulsed laser deposition of ferroelectric thin films & thin micro-batteries.

Pulsed Laser Deposition of Oxide Thin Films of Si substrates
Project Advisor (Singapore): Assoc Prof Lu Li
Project Advisor (MIT): Prof Carl V. Thompson
Duration: January 2002 to January 2004

Project Abstract:

Perovsike oxide thin films has attracted much attention for their applications in microelectronic and optoelectronic devices. Pulsed laser deposition (PLD) is an extremely versatile technique to obtain epitaxial thin films and multilayers of multi-component oxides. This reserach focuses on fabrication of piezoelectric lead zirconate titanate (PZT) thin films with various underlayers on Si substrates by PLD technique. The objective of the present project is to grow thin films with preferred orientation by varying different operating parameters, such as, back ground pressure, laser power and temperature.

Research Fellows and Research Project Abstracts 2001/2002
(HCPES programme)

Dr Chen Shuo
Expertise: Biomolecular suspension flow in microchannel using dissipative particle dynamics method.

Biomolecular Suspension Flow in Microchannel Using Dissipative Particle Dynamics Method
Project Advisors (Singapore): Assoc Prof Khoo Boo Cheong, Prof Nhan Phan-Thien
Project Advisor (MIT): Prof Robert A. Brown
Duration: January 2002 to January 2004

Project Abstract:

Dissipative Particle Dynamics (DPD) is a mesoscopic simulation technique that is intended to simulate hydrodynamic behaviour as well as the rheological properties of complex fluids such as multiphase systems, polymer and biomolecular suspensions (for example, DNA molecules carried out by the flow of bio-molecular suspensions through micro channels). The fluid particles are acted upon by three two-particle forces, these forces are: dissipative force, random force and conservative Force.

Features of DPD:
- Conserve not only the number of particles but also the total momentum of the system.
- Simulate the motion of fluid particles (momentum carriers) instead of molecules (or atoms).
- Momentum carriers move in continuous space and discrete time-steps.
- The conservative pairwise forces between DPD particles are soft-repulsive, which makes it possible to extend the simulations to longer time scales.

Dr Chen Xiongda
Expertise: Smoothing Newton method and nonlinear network programming.

Semidefinite Programming, Theory, and Applications
Project Advisor (Singapore): Prof Sun Jie
Duration: April 2001 to August 2002

Project Abstract:

Semidefinite programming is currently one of the most active areas of research in optimisation. It has attracted researchers from a wide variety of areas because of its theoretical and numerical elegance and also its wide applications. Semidefinite can be regarded as a parallel of linear programming, though the latter is a proper subfamily of semidefinite programming. Thus the parallel theory and algorithms of linear programming are expected to be found for semidefinite programming. We study these kinds algorithms of semidefinite programming and its related topics as second order cone programming.

Dr Hu Xiangyu
Expertise: Numerical simulation of shock waves in bio-MEMS & biological systems.

Numerical Simulation on Shock Wave in Bio-MEMS and Biological Systems
Project Advisor (Singapore): Assoc Prof Khoo Boo Cheong
Duration: January 2002 to January 2004

Project Abstract: Not available at this time

Dr Li Jianying
Expertise: Analysis of electromagnetic scattering, radiation by using the fast multipole method (FMM) and multilevel fast multipole algorithm (MLFMA).

Electromagnetic Scattering by Conducting or Dielectric Objects: An Analysis Using the Fast Multipole Method (FMM) and Multilevel Fast Multipole Algorithm (MLFMA)
Project Advisor (Singapore): Assoc Prof Li Le-Wei
Duration: December 2001 to December 2003

Project Abstract:

Electromagnetic scattering from 3-D arbitrarily shaped conducting or homogeneous dielectric objects is an important and challenging problem in the field of computational electromagnetic. The method of moments (MoM) is usually employed to study this problem. But this method results in, however, a matrix of very large scale when applied to analyzing electrically large objects. For the resultant matrix equation of N unknowns, the $O(N^3)$ floating-point operations are required in the Gaussian elimination; and the $O(N^2)$ operations are required in the conjugate gradients method. Moreover, the memory requirements for a MoM solution are also to $O(N^2)$. To over come this, the fast multipole method (FMM), a well-known and popular technique, is used to speed up the MoM solution of large-scale electromagnetic scattering and radiation problems. It reduces both complexity of the matrix-vector multiplications and memory requirements to $O(N^{1.5})$. Multilevel fast multipole algorithm (MLFMA) is an extension of FMM and can further reduce the computational complexity to $O(N \bullet logN)$. We explore the application of both the fast multipole method and multilevel fast multipole algorithm (MLFMA) to 3-D conducting or dielectric objects of arbitrary shape.

Dr Li Rongheng
Expertise: Complexity analysis for combinatorial problems & heuristic algorithms design and analysis for scheduling & network problems.

Complexity Analysis & Heuristic Algorithms Design and Analysis Combinatorial Problems
Project Advisor (Singapore): Assoc Prof Huang Huei Chuen
Duration: September 2000 to September 2002

Project Abstract:

Heuristic algorithm design and analysis for facility location problem. In the last few years, a number of constant factor approximation algorithms have been proposed for the classical facility location problem in the metric space. We study the more general cases, k-product facility location problems: Each client needs to be supplied with k kinds of products by k different facilities, respectively. Each facility can be set up to supply with only one kind of product. k-level facility location problems: Each client needs to be serviced by a chain of k different facilities and each facility can be set up only for a distinct level of the supply chain with a non-negative fixed cost determined by the level it is designated. Based on LP rounding technique, we have proposed heuristic algorithms with constant performance guarantees. Some complexity analysis is done for the problems, too.

Dr Liu Xin
Expertise: Computational mechanics, especially the research and application on meshless methods.

Research and Application of Meshless (Meshfree) Methods
Project Advisor (Singapore): Assoc Prof Liu Guirong
Duration: May 2002 to May 2004

Project Abstract:

In recent year, various kind of meshless (meshfree) methods have made a great progress in science and enginneering, especially in the area of computational mechanics. Meshless methods based on Radial basis function has a good advantage over other meshless method due to its simplicity and efficiency. However, traditional radial basis function method has non band width characteristics which its algebraic matrix is full. The drawback limit its application in practical engineerings. Here, we will try to improve this method so that it will possess band width property and be able to be applied to settle more complicated problems. In this research, two efficient schemes based radial basis point interpolation method, namely Galerkin-based and collocation approach, will been adopted.

Dr Liu Xinwei
Expertise: Algorithms and theory for constrained optimization and their applications.

Nonlinear Optimization
Project Advisors (Singapore): Assoc Prof Khoo Boo Cheong, Prof Sun Jie
Duration: January 2002 to June 2002

Project Abstract:

Based on a regularization scheme, we study a primal-dual interior point method for the mathematical programs with equilibrium constraints (MPEC), which solve a set of barrier-regularized logarithmic-barrier problems sequentially and approximately. The global convergence results are derived without assuming strict complementarity and full regularity in advance. Under suitable conditions, it is proved that the algorithm will converge to the piecewise stationary point of the MPEC (which is also the B-stationary point if the full regularity holds at the point) provided the penalty parameter is bounded, even if the penalty parameter is unbounded the algorithm still converge to some points with stationarity. The preliminary numerical results show the algorithm is effective.

Stochastic Optimization
Project Advisors (Singapore): Assoc Prof Khoo Boo Cheong, Prof Sun Jie
Duration: January 2002 to June 2002

Project Abstract:

We consider a homogeneous self-dual interior point approach for solving multistage stochastic linear programs. The problem is reformulated as a large-scale linear program with sparse and structured nonanticipativity constraints. The sparsity and the structure are exploited through a three-step decomposition scheme. In addition to its efficiency, the method can detect infeasibility of the original problem. Numerical results are reported.

Traffic Problems
Project Advisors (Singapore): Assoc Prof Khoo Boo Cheong, Prof Sun Jie
Project Advisor (MIT): Assoc Prof Georgia Perakis
Duration: January 2002 to June 2002

Project Abstract:

We consider various traffic models that lead to a variational inequality formulation of the traffic problems. Some algorithms are proposed and tested for solving the problems. We also seek to deeper understand and to better control the traffic in metropolitan areas.

Dr Nie Xiaochun
Expertise: Analysis & design of EM scattering, radiation & MMIC by using the hybrid method & fast algorithm.

Electromagnetic Scattering by Open-ended Cavities: An Analysis using Precorrected-FFT Approach
Project Advisor (Singapore): Assoc Prof Li Le-Wei
Project Advisor (MIT): Prof Jacob K. White
Duration: September 2000 to August 2002

Project Abstract:

In this paper, the precorrected-FFT method is used to solve the electromagnetic scattering from two-dimensional cavities of arbitrary shape. The integral equation is discretised by the method of moments and the resultant matrix equation is solved iteratively by the generalised conjugate residual method. Instead of directly computing the matrix-vector multiplication, which requires N2 operations, this approach reduces the computation complexity to $O(N \log N)$ as well as avoids the storage of large matrices. Some examples are considered and excellent agreements of radar cross sections between these computed using the present method and those from the direct solution are observed, demonstrating the feasibility and efficiency of the present method.

Fast Solutions to Electromagnetic Scattering Problems using Precorrected–FFT Method
Project Advisor (Singapore): Assoc Prof Li Le-Wei
Project Advisor (MIT): Prof Jacob K. White
Duration: September 2000 to August 2002

Project Abstract:

A precorrected-FFT method is utilised in this paper to fast manipulate the matrix-vector multiplication that occurs in the internal loop of iterative algorithms for solving the integral equation of electromagnetic scattering problems in two dimensions. The integral equation is discretised by the method of moments and the resulted matrix equation is then solved iteratively by the generalised conjugate residual method. Some examples are considered in the numerical computations and radar cross section of a circular cylinder, an L shaped object, a rectangular cylinder with a small protrusion and a 20-wavelength long NACA2415 airfoil are obtained using both the direct iterative method and the precorrected-FFT. Comparisons of these radar cross sections are made, and an excellent agreement is found between each set of results. However, the precorrected- FFT reduces the memory requirements and computation complexity from $O(N2)$ for direct computation to at best $O(N)$ and $O(N \log N)$, respectively.

Mr Qian Liwen
Expertise: Sampling theory and its application to computation & discrete optimization.

Linear Programming and Stable Admission
Project Advisor (Singapore): Assoc Prof Teo Chung Piaw
Duration: September 2001 to September 2002

Project Abstract:

The research project is on the stable matching theory which has wide link to Ecomomics, Computer science and game theory. Recently Baiou and Balinski study the polyhedral structure of the solution to the stable admission problem. We extend the result by demonstrating a nice geometric structure to the fractional solution in the stable admission polytope. Several structural results for the stable admission problem

follows naturally from this geometric property. Therefore we obtain deeper understanding of the structure properties and wider application of the stable admissions polytope. (See the attached paper for details.) Another project we just begin to study is about the Partial Digest Problem (PDP) which arises in computatioal biology.

Mr Wang Shengyin
Expertise: GA-based topology optimization, morphological representation global optimization methods, compliant mechanism.

Topology and Shape Optimization of Structures by Evolutionary Algorithms
Project Advisor (Singapore): Asst Prof Tai Kang
Duration: March 2002 to March 2004

Project Abstract:

The ability to optimize the structural geometry of design artifacts is recognized as the next big step in design automation and will have a big impact in the CAD/CAE industry. Current design optimization software are mainly add-ons to existing CAE software, and as such do not represent a smooth integration between optimization and simulation. They also do not resolve the fundamental differences between the geometric data used in CAD and that used in CAE, and these differences are the main stumbling blocks that prevent design optimization from being applied routinely in engineering design and being developed into successful commercial software for industry. In this research, a fundamentally different approach towards the underlying geometry representation is being developed as an enabling technology to allow engineers to apply both optimization and simulation together in an intuitive and designer-friendly way. The capabilities and robustness of the techniques are to be established and demonstrated for engineering structures and components.

Dr Xing Xiuqing
Expertise: Aerodynamic design, flow field simulation and numerical optimization's application in turbomachinery.

Optimization and Simulation of Aerodynamics Shapes Using Simultaneous Perturbation Stochastic Approximation and CFD
Project Advisor (Singapore): Assoc Prof Murali Damodaran
Duration: April 2001 to April 2003

Project Abstract:

The Simultaneous Perturbation Stochastic Approximation (SPSA) method has been demonstrated in literature to deal with difficult multivariate optimisation problems, and has recently attracted considerable international attention in many different areas such as statistical parameter estimation, feedback control, simulation-based optimisation, signal & image processing so on. The primary virtues of this method are ease of implementation, lack of need for loss function gradient, theoretical and experimental support for relative efficiency. It is robust to noise in the loss measurements and has the ability to find a global minimum when multiple minima exist. The SPSA is being tested on several standard functions for comparative studies with other optimisation methods. It will be implemented for constrained and unconstrained design of optimal aerodynamics shapes of the leading edges of turbo-machinery blades, airfoil sections, nozzle profiles so on which couple CFD solvers and optimisation methods. The effectiveness of this method over other optimisation methods will also be assessed.

Dr Xu Yigui
Expertise: 1) Atomistic computer modeling of mechanical properties and failure behaviors of nanostructured materials and structures; 2) Neural networks techniques & generic algorithms with application to inverse problems – optimization, identification and detection; 3) Damage detection of composite materials & structures using techniques of modal analysis, elastic-wave scattering and PZT actuators/sensors; 4) Numerical modeling for structural & mechanical vibration and dynamics, fatigue and failure.

Atomistic Computer Simulation of Mechanical Properties and Failure Behaviors of Nanostructured Materials and Structures
Project Advisor (Singapore): Assoc Prof Liu Guirong
Duration: November 2001 to November 2002

Project Abstract:

With the development of computational nanotechnology, atomistic computer simulation provides us with an opportunity for probing the mechanical properties and failure behaviors of nanostructured materials and structures at atomistic-scale level. Our researches in this field are focused on: (1) molecular dynamics simulation of mechanical properties for single crystal of metals, (2) molecular dynamics simulation of fracture process and failure behavior at atomistic-scale level, (3) effective simulation techniques for large-scale atomic systems, such as the quasicontinuum method, etc. (4) interatomic potential fitting using molecular dynamics models and evolutionary algorithms. We have developed an adaptive neural network model which is suitable for modeling the complex force field, proposed a hybrid evolutionary algorithm which can be used to parameterize the potential functions from experimental data, and developed a user-friendly atomistic simulation program in Fortran 90. We are presently doing the work on fitting the interatomic potentials and investigating the fracture toughness of typical crystals.

Dr Xuan Zhaocheng
Expertise: Numerical methods for partial difference equations.

Output Bounds for Partial Differential Equations
Project Advisor (Singapore): Assoc Prof Lee Kwok Hong
Project Advisor (MIT): Prof Jaime Peraire
Duration: December 2000 to December 2002

Project Abstract:

This project focuses on the development of methods for the efficient calculation of lower and upper bounds to outputs which are functionals of the solutions to partial differential equations. Such methods are extremely useful in engineering design where outputs, such as temperatures, displacements and stresses are needed at critical locations, provided of course that the methods are accurate, efficient and inexpensive. Obviously, coarse element discretizations are inexpensive but rather inaccurate, while fine element discretizations are accurate but expensive. The aim is to find methods which possess both accurate and inexpensive characteristics, and which can also be implemented with little difficulty in multiprocessor environments. In particular, the primary objective of this project is to extend the recent work of Patera and Peraire to fracture mechanics problems, where lower and output bounds to stress intensity factors and J-integrals will be of importance to fracture-resistant design.

Dr Zhou Guanglu
Expertise: Computational methods in computational optimization and non-linear complementary & variational inequality problems.

Second Order Cone Programming
Project Advisor (Singapore): Asst Prof Toh Kim Chuan
Project Advisor (MIT): Prof Robert M. Freund
Duration: March 2001 to March 2003

Project Abstract:

Second order cone programs (SOCP) are linear optimization problems over a second order convex cone. This class includes several important classes of optimisation problems such as linear and convex quadratic programming problems. Interiorpoint methods (IPM) are currently the most popular methods used to solve SOCP. However, there are numerous theoretical and numerical issues that need to be resolved in order for IPM to solve an SOCP robustly and efficiently. Among these issues are (a) stable and efficient computation of search direction; (b) application of Krylov subspace iterative methods for computing the search direction; (c) establishing the polynomial complexity of IPM when inexact search direction is used. Our research project aims to resolve problems in the three areas just mentioned.

Dr Chen Xing
Expertise: Computer aided design & engineering in plastic injection molding, and numerical simulation in powder injection molding.

Simulation of Particle Migration of Powder-Resin in Injection Molding
Project Advisor (Singapore): Prof Lam Yee Cheong
Duration: July 2000 to May 2001

Project Abstract:

Powder injection moulding is an important processing method for producing precision metallic or ceramic parts. Experience, intuition and trial-and-error have been the practice for the design and process optimisation of such moulding operations. However, this practice is becoming increasingly inefficient and impractical for the moulding of larger, more complicated and more costly parts. In this investigation, a numerical method for simulating the mould-filling phase of powder injection moulding was developed. The flow was modelled using the Hele-Shaw approach coupled with particle diffusion transport equation for the calculation of powder concentration distribution. The variation of powder density distribution can be predicted, which is ignored by the existing simulation packages. Simulation results indicated that powder concentration variation could be significant in practical PIM. Using a capillary rheometer with a specially design split die, experimental validations were obtained.

Dr Fu Yongqi
Expertise: Micro-optics, photonics, MOEMS, optical design, and microfabrication.

One Step Transfer of Diffractive Structure from Designed Pattern to Replica with Hybrid Sol-Gel Film
Project Advisor (Singapore): Assoc Prof Ngoi Kok Ann, Bryan
Duration: January 2002 to June 2003

Project Abstract:

A novel one-step method of microfabrication of diffractive lens mold with continuous relief and six annulus, combining sol-gel process for corresponding replication is investigated. The mold is fabricated by use of focused ion beam milling (FIBM) on substrate material of bulk Silicon, and then being used directly for replication of the diffractive structure by aid of hybrid sol-gel glass stamping process. The hybrid sol-gel material is different from conventional sol-gel material with pure SiO_2. It consists of SiO_2 and TiO_2. With this hybrid sol-gel material, shrinkage during the replication process of gel and densification can be reduced greatly compared with the normal sol-gel material. Surface roughness of the replica, *Ra*, is 3nm in the area of 1um × 1um. Measured diffraction efficiency is 86% under the influence of accumulated mold geometry error and sol-gel process error. The demonstrated process of direct stamping using the masterpiece fabricated by FIBM is potential for mass production use at very low cost. Further study will be performed in aims of improving uniformity of relief depth and lateral width of replica.

Dr Krishnan Padmanabhan
Expertise: Fracture & failure analysis of polymer matrix composites, advanced fibres & composites, micromechanics & interface, and dental composites & wear.

Macrostructural Properties of Fibre/Polymer Composites through the Mesomechanical Route; Micro-Injection Molding
Project Advisor (Singapore): Prof Yue Chee Yoon
Duration: October 2000 to October 2002

Project Abstract:

The goal of this project is to predict and validate the acrostructural (laminate and subcomponent level) properties of fibre/polymer composites based on the interfacial properties and obtained from micro and mesomechanical tests like single and multiple fibre pullout tests and interlaminar shear tests. Interesting correlations are expected from this study that aim to understand the composite performance with the minimum possible parameters. Work in microinjection moulding is also being explored.

Dr Muthu Mathirajan
Expertise: Applied operations research, heuristic optimization, modeling and scheduling in manufacturing, logistics & distributions management, and decision support systems.

Scheduling of Batch Processing Machines in Semiconductor Manufacturing
Project Advisor (Singapore): Assoc Prof Appa Iyer Sivakumar
Project Advisors (MIT): Dr Stanley B. Gershwin, Prof Stephen Graves
Duration: May 2002 to December 2003

Project Abstract:

Scheduling of batch processes in semiconductor manufacturing has a significant impact on the overall flow time and WIP inventory. In addition batch processors are often the constraints in the entire semiconductor manufacturing. There are many batch processing machines in the semiconductor manufacturing process. For examples Etching Process for creating circuitry in wafer fabrication is a batch process. During the etching process, chemical tanks are used to etch (or strip) away any portion of the deposited layer that is not protected by photo resist during the photolithography operation. Each chemical tank is a BPM that handles a batch of wafers simultaneously

The main expected contributions of the research would be in designing practical methods for solving the scheduling of batch-processing machines in the semiconductor manufacturing. In order to achieve this the following research activities will be carried out:
1. Reviewing the literature particularly on "deterministic scheduling of Batch Processing Machines in Semiconductor Manufacturing.
2. Developing and identifying a number of heuristic algorithms appropriate to various BPMs, considered as independent processors. Further, a series of computational experiments will be developed for evaluating the proposed algorithms.
3. Studying the effect of proposed algorithms in the multi machine-flow shop with and without reentrant situation and to develop or refine further.

Dr Saddikuti Venkataramanaiah
Expertise: 1) Design and analysis of cellular manufacturing systems; 2) Manpower planning and allocation models; 3) Performance analysis of logistics systems; 4) Models for integrated lotsizing and scheduling in the semiconductor industry and; 5) Inventory control models cellular manufacturing

Project Advisor (Singapore): Assoc Prof Rohit Bhatnagar
Duration: July 2002 to July 2004

Project Abstract:

In this research project we focus on developing mathematical models for improving the productivity of Cellular Manufacturing Systems (CMS). CMS implementation requires (a) cell formation, (b) cell layout

and (3) scheduling of jobs in cells. Previous research has addressed these problems by proposing direct and indirect algorithms and heuristic approaches. However, very few papers have focused on minimizing non-value added activities e.g., setups. We consider the set-up data in terms of sequence requirements of parts that visit each resource/machine. We propose to develop suitable models and performance measure to form cells considering sequence dependent set-up time of parts and machine capacities. We also propose to develop models for cell formation with dual resources (capacitated cell formation problem). This requires allocation of operators who are multi skilled, to appropriate cells. This is an important future trend of research in the area (Min and Shin, IJPR 1993, Suresh and Slomp, IJPR 2001, Askin and Huang, IJPR 2001, Norman et al., IJPR, 2002, Askin and Vakharia IIE Trans, 1999).

Dr Wang Shanzhong
Expertise: MBE & CVD growth of semiconductor materials & its microstructures; characterization of semiconductor materials with different kinds of tools such as microscope, SEM, XRD, TEM, SEM, AFM, Raman, PL PLE, PR, MPR, transmittance, I-V, C-V, Hall & so on; and standard semiconductor processing for electronic and optical devices.

Development of Compound Semiconductor Device Fabrication and Growth Technology
Project Advisor (Singapore): Assoc Prof Yoon Soon Fatt
Project Advisor (MIT): Prof Clifton G. Fonstad
Duration: March 2001 to March 2003

Project Abstract:

The proposed project focuses on the development of novel compound semiconductor growth technology using the molecular beam epitaxy technique. Particular emphasis will be placed on investigations, which involve the introduction of gas sources such as hydrogen and nitrogen into a solid source molecular beam epitaxy system for the development of low temperature epitaxy involving novel nitrides. The target applications for such mixed nitride compounds are in the areas of high frequency microelectronic devices such as high electron mobility transistors and heterojunction bipolar transistors with a view for these devices to be integrated into microwave monolithic integrated circuits. The project also involves a concurrent effort to develop novel mixed nitride materials for optoelectronic devices with a view for optoelectronic-VLSI integration. Extensive material and device/circuit characterisation will be carried out as part of this work.

Dr Xiong Mohua
Expertise: Complicated information systems analysis & modeling web-based supply chain management, and Decision Support Systems.

Customer Demand Fulfilment Approaches under Limited Capacity
Project Advisors (Singapore): Assoc Prof Tor Shu Beng, Asst Prof Rohit Bhatnagar
Duration: October 2001 to October 2003

Project Abstract:

Customer demand fulfillment is the business process within a company that determines how the customer demand is fulfilled. It strongly influences the order lead-time and the on time delivery, and hence plays a very important role in retaining and increasing the market shares. In the project, a new methodology for customer demand fulfillment is investigated and the corresponding approach is developed based on the fulfillment constraints of the material availability and the production capacity. In this research, based on an Integrated BOM Model, an Extended Dynamic BOM Approach is developed for effectively handling multilevel BOM of the product. For assessing the approach, a prototype will be developed on the up-to-date

J2EE framework and Internet technologies. This new approach and its application would be very helpful to support companies to make reliable and informed decisions when facing customer requirements, especially in today's globalization progress.

Dr Yuan Miaolong
Expertise: Visual inspection, image matching, 3D reconstruction, CAD, and spatial layout.

Development and Testing of the Advanced SQC and Vision Inspection Techniques
Project Advisor (Singapore): Assoc Prof Xie Ming
Duration: September 2000 to September 2003

Project Abstract:

The goal of this project is to develop an automated vision system for inspection that bridges the gap from CAD models to machine vision algorithms. The project allows the user to select an object and its features to be inspected. It then performs the specified dimensional inspection on a given image of the selected object. There are three main steps in the projects: (a) 3D data acquisition of inspected products, (b) CAD-model based data fitting; and (c) Process monitoring.

(a)   3D data acquisition of inspected products: This step is to develop algorithms for 3D data reconstruction. The main task is the matching procedure that finds feature correspondences between images.
(b)   CAD-model based data fitting: This process will compare inspection points to CAD model and provide with provide inspection results. The inspection points are obtained from the first step.
(c)   Process monitoring: This process will use a movable camera, an annunciator and several light sources. Then, design control charts to monitor the variation of product's geometry.

Mr Zhang Wenyu
Expertise: All in progressive die design automation.

Progressive Die Design Automation
Project Advisor (Singapore): Assoc Prof Tor Shu Beng
Duration: March 2002 to March 2004

Project Abstract:

Though AI technologies have achieved a lot of success in the design of progressive dies, because of complexity of the die design process, most of the "intelligent" die design automation prototypes are rather restrictive in their applications. There is still a substantial distance to cover before these works can be put into practical use. It is found from the literature that feature-based scheme has been widely used to speed up progressive die design, but the computer representation and processing of feature relations needs more attention. The main purpose of this project is to develop a more scientific and efficient feature model embedded in a knowledge based design environment to automate the progressive die design process.

Dr Chen Weixiang
Expertise: Nanostructured materials for Li-ion batteries and fuel cell.

Inorganic Nanocomposites
Project Advisor (Singapore): Assoc Prof Lee Jim Yang
Duration: July 2001 to July 2003

Project Abstract:

This project focuses on the use of chemical templating techniques to produce inorganic nanoparticles and nanocomposites useful for electrochemical energy conversions (battery electrodes and fuel cell electrocatalysts). For instance, carbon nanotubes have been used to obtain nanoscale tin and antimony alloys with good lithium ion storage capacity and improved fade characteristics. On-going work includes the use of microwave and ultrasound excitations to promote the formation of nanostructures. A major goal of this work of particular importance from the application perspective is the stabilization of the nanostructures against agglomeration without the use of chemical agents for surface passivation.

Dr Deng Rensheng
Expertise: Hydrodynamics and mixing behavior of fluidized beds; cracking and pyrolysis of heavy hydrocarbons; and instability analysis of flow in granular materials.

Instabilities in Flow of Granular Materials
Project Advisor (Singapore): Asst Prof Wang Chi-Hwa
Duration: October 2001 to June 2002

Project Abstract:

The influence of periodic vibrations on the granular flow of materials is of great interest to scientists and engineers due to both theoretical and practical reasons. In this work, the equations of continuity, momentum and energy, as well as the corresponding boundary conditions, are applied to study the instability of the granular materials under vertical vibrations. Topics to be investigated include flow regimes, structures and temporal evolution, together with the kinetic mechanisms that cause the instability. The methods mainly include (1) calculating the base state; (2) finding out the instability profile after introducing small perturbations; and (3) predicting the new patterns that will form. The linear instability is studied by solving the eigenvalue problem resulting from the linearized equations, while the non-linear instability is examined by transient integration so as to figure out the long-term behavior. The simulation results are to be compared with the experiments.

Dr Palaniswamy Ravi
Expertise: Synthesis and characterization of novel stimuli responsive amphiphilic block copolymers for biomedical applications.

Synthesis and Characterization of Stimuli Responsive Amphiphilic Block Copolymers for Targeted Drug Delivery
Project Advisor (Singapore): Assoc Prof Tam Kam Chiu, Michael
Duration: August 2001 to August 2003

Project Abstract:

This project focuses on developing novel stimuli-sensitive polymers for drug and gene delivery applications. Two major classes of polymer systems will be considered; namely polyethylene-oxide/polypropylene-oxide tri-block copolymers (FDA approved) and methacrylic acid (MAA) block and random copolymers. The self-assembly of these materials produces a complex hierarchical structure that can be harnessed for potential applications described in this proposal. The atom transfer radical polymerisation (ATRP) will be adopted to synthesize a range of mono-dispersed block copolymers (e.g. PEO-b-MAA, MMA-b-MAA). Other stimuli-sensitive functional groups such as methacrylic acid can be used to impart pH sensitivity to the polymers. Interesting novel systems, such as the fullerene based block copolymers will be synthesized. Through the ATRP technique, we hope to synthesize mono-dispersed and well-defined block-copolymers that exhibit interesting microstructure for potential drug delivery applications.

Mr Parayil Kumaran Ajikumar
Expertise: Design, synthesis, and structure activity study of biologically interesting molecules such as peptides and peptido mimetic compounds, solid phase peptide synthesis, solid phase organic synthesis, and combinatorial chemistry.

Design of Novel Peptides as Building Blocks for Functional Materials
Project Advisor (Singapore): Asst Prof Suresh Valiyaveettil
Duration: December 2001 to December 2003

Project Abstract: Not available at this time.

Dr Ren Lei
Expertise: Surface modification of nano colloids with drug adsorption; hybrid nanocomposite interaction with cancer cells.

Nanomaterials for Drug Delivery
Project Advisor (Singapore): Assoc Prof Chow Gan-Moog
Duration: July 2001 to June 2003

Project Abstract:

Nanostructured materials have been attained much importance in drug delivery system due to: 1) a reduction of the particle size to nano scale may enable an intravenous injection; 2) a reduction in particle size may minimize possible irritant reactions at the injection site; 3) a reduction in particle size may allow the carriers to penetrate the membranes of the diseased cells, and thus to provide a way to deliver drugs to cancerous tumors, but not on healthy cells. The objective of this project is to synthesize nano Au-based carriers with near IR (NIR) sensitivity for delivery of anti-tumor drugs. Gold is essentially a bio-inert material with applications ranging from dental surgery to arthritis treatments, the current Au-based nanostructured materials may thus also take advantage of the inherent biocompatibility of gold. The NIR sensitivity of the carrier is designed so as to allow for targeted drug release at cancer cells as a response to the irradiation by NIR laser. To accomplish these goals simultaneously, the interface interaction between drug and carrier and the effects of laser irradiation on drug release will be also clarified.

Dr Theivanayagam Chairman Deivaraj
Expertise: Carbon mono oxide resistant eletrocatalysts for direct methanol fuel cells, and biomolecule guided nanoparticle synthesis.

Chemical and Biochemical Synthesis of Multi-Metallic Nanoclusters
Project Advisor (Singapore): Assoc Prof Lee Jim Yang
Duration: April 2002 to April 2004

Project Abstract:

Multi-metallic nanoclusters with potential application values in catalysis and electrocatalysis are prepared via various molecular and biomolecular templating methods. Work has been initiated to exploit the hybridization of complementary DNA strands as a means of self-assembling nanostructures from ions in the solutions and from appropriately surface functionalized nanoparticles. Optimization of the synthesis conditions; the effects of synthesis conditions on the properties and the final morphology of the nano-assemblies; and the examination of the mechanistic details of the assembly process, form the three major objectives of this project.

Dr Victor Wong Vai Tak
Expertise: Plant & mammalian cell cultivation for production of biotherapeutics.

Understanding the Effects of Media Supplements in Serum Free Media on Hybridoma Cells via Transcriptional Analysis
Project Advisor (Singapore): Prof Miranda Yap G. S.
Project Advisor (MIT): Prof Daniel Wang I. C.
Duration: May 2001 to April 2003

Project Abstract:

An increasing number of biopharmaceutical products approved for human therapeutic use are produced through mammalian cell cultures. Industrial biologics production is directing towards the use of serum-free media because of the high cost and performance variability associated with the use of serum and the advantage of a reduced burden on downstream purification. Previous work in finding serum-substitutes has generally proceeded via trial-and-error experimentation. In contrast, a better understanding of the intracellular responses and mechanisms when serum-replacement supplements are used will facilitate the development of a more rational approach to media design. By using the DNA microarray, we propose to profile the differential gene expression between hybridoma cells cultivated in different media conditions. This allows the simultaneous analysis of interconnected cellular events, such as cell cycling, nutrient transport, metabolism and glycosylation, which is important for producing a functional antibody product.

Dr Winnie Fung Kar Yee
Expertise: Signal transduction of GDNF and NTN receptors in mammalian cells.

Signal Transduction as a Means to Delineate the Functions of GDNF and NTN Receptors in Mammalian Cells
Project Advisor (Singapore): Assoc Prof Too Heng-Phon
Project Advisor (MIT): Prof Harvey F. Lodish
Duration: March 2002 to March 2004

Project Abstract:

Members of the glial cell line-derived neurotrophic factor (GDNF) family, comprising ligands of GDNF, neurturin (NTN), artemin (ART) and persephin (PSP), have been implicated to be crucial for the development, maintenance and survival of central and peripheral neurons. The GDNF ligands (GFL) can either signal through a receptor complex consisting of glycosyl-phosphatidylinositol (GPI)-anchored

coreceptor (GFRα1-4) as a ligand binding component or RET receptor tyrosine as a signaling component, or through a RET-independent pathway stimulated by GDNF. The aim of this project is to understand how the GDNF ligands and their receptors, GFRα1-4 and Ret, signal in neuronal cells, and hence, to delineate their signaling pathways leading to various cell functions. This will not only provide a deeper insight of the functions of GDNF ligands, GFRα1-4 and Ret, in normal development, but also to develop therapeutic strategies for their effects on human diseases such as Parkinson's, MEN2 and Hirschsprung's.

Dr Xue Ying
Expertise: Development and application of computational methods in ligand-protein interaction.

Development of a Fast-Speed Method for Computing Molecular Descriptors used in Computer Aided Drug Design
Project Advisor (Singapore): Assoc Prof Chen Yuzong
Duration: February 2002 to February 2004

Project Abstract:

In computer aided drug design, the characteristics of a drug or a molecule are described by a group of descriptors including those computed by quantum chemistry methods. The computation of these quantum-chemistry based descriptors takes too long CPU time for high-throughput computer screening of drugs, which are either ignored or replaced by simplified alternatives and thus may affect the quality of computed results. This project is designed to develop a fast-speed method for computing these quantum chemistry based descriptors. The speed is to be increased by customarily re-design the code to focus on those computations related to the descriptors, and by further reducing the number of iterations in solving Schrodinger equation without significantly compromising the accuracy.

Dr Yao Jia
Expertise: Property and structure of polyelectrolytes.

Thermodynamics and Physical Characteristics of Stimuli Responsive Amphiphilic Block Copolymers
Project Advisor (Singapore): Assoc Prof Tam Kam Chiu, Michael
Duration: February 2002 to August 2003

Project Abstract:

Well-defined block-copolymers will be synthesized using the ATRP or ring opening techniques. For the delivery of hydrophobic drugs, PEO-PPO-PEO functionalised with LA or CL will be examined. The effect of LA or CA segment length on the microstructure of polymeric micelles in the presence and absence of drugs will be evaluated. For protein drug applications, anionic blocks (e.g. methacrylic acid, acrylic acid) will be used, while cationic blocks (e.g. lysine, vinyl pyridine) are considered for gene and DNA delivery system. In order to achieve our goal, we will evaluate their effectiveness through careful thermodynamics studies using the isothermal titration calorimetry where the interactions between the polymer and drugs under different stimuli will be examined. The structural properties of the complex will be examined using the static and dynamic light scattering system. Detailed mechanism and physics that control the micellization, microstructure and drug/polymer interactions will be developed.

Dr Yu Shi
Expertise: Design, synthesis, and physical study of magnetic nanostructured materials.

Designation and Development of Magnetic Nanoparticles for Drug Delivery
Project Advisor (Singapore): Assoc Prof Chow Gan-Moog
Duration: April 2002 to September 2002

Project Abstract:

While newer and more powerful drugs are continuously developed, increasing interests is being attracted to the methods by which therapeutic agents can be efficiently delivered to targeting organs and cells. In conventional drug delivery, the drug concentration in the blood rises when the drug is taken, then peaks and declines. Since each drug has a plasma level above which it is toxic and below which it is ineffective, the plasma drug concentration in a patient at a particular time depends on compliance with the prescribed routine. Therefore, the advantages of targeted drug delivery using magnetic carrier is evident as follows: (a) magnetic carrier can deliver the agents to the target cells in a short period with the aid of a magnetic field; (b) drug quantity required to achieve a therapeutic effect may be greatly reduced; (c) the drug release rates can be repeatedly controlled on demand by just interval application of an oscillating magnetic field.

Dr Fang Bin

Expertise: Computer vision, pattern recognition, image processing in biometrics, document processing, and medical image processing.

Tumor Cell Identification using Features Rules

Project Advisor (Singapore): Assoc Prof Wynne Hsu

Duration: September 2001 to September 2002

Project Abstract:

Advances in imaging techniques have led to large repositories of images. There is an increasing demand for automated systems that can analyse complex medical images and extract meaningful information for mining patterns. Here, we describe a real-life image mining application to the problem of tumour cell counting. The quantitative analysis of tumour cells is fundamental to characterizing the activity of tumour cells. Existing approaches are mostly manual, time-consuming and subjective. Efforts to automate the process of cell counting have largely focused on using image processing techniques only. Our studies indicate that image processing alone is unable to give accurate results. In this paper, we examine the use of extracted features rules to aid in the process of tumor cell counting. We propose a robust local adaptive thresholding and dynamic water immersion algorithms to segment regions of interesting from background. Meaningful features are then extracted from the segmented regions. A number of base classifiers are built to generate features rules to help identify the tumor cell. Two voting strategies are implemented to combine the base classifiers into a meta-classifier. Experiment results indicate that this process of using extracted features rules to help identify tumor cell leads to better accuracy than pure image processing techniques alone.

Dr Zhang De

Expertise: Information retrieval, data mining, and machine learning.

Question Answering

Project Advisor (Singapore): Asst Prof Lee Wee Sun

Duration: January 2002 to January 2004

Project Abstract:

What a current information retrieval system or search engine can do is just "document retrieval", i.e., given some keywords it only return the relevant documents that contain the keywords. However, what a user really wants is often a precise answer to a question. For example, given the question "Who is the first American in space?", what a user really wants is the answer "Alan Shepard", but not to read through lots of documents that contain the words "first", "American" and "space" etc. The focus of current Question Answering research is a fully automatic Question Answering system, which can answer factual questions based on very large unrestricted-domain document collections such as the World Wide Web.