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High Performance and High Yield MIM Capacitor

Student : Arun Sreeranganathan
SMA Supervisor : Assoc Prof Choi Wee Kiong
Company Supervisor : Mr My The Doan

Project Abstract:

Conventional doped silicon and poly silicon approaches for the fabrication of capacitors have performance limitations at GHz frequencies due to the excessive capacitive loss to the substrate and the high resistivity of one or both the plates, resulting in a poor quality factor (Q). Metal-Insulator-Metal (MIM) capacitors provide depletion free, high conductance electrodes, which make them much desirable for high frequency applications. With the technology nodes entering the deep sub micron domains, it has become necessary to explore new dielectric materials with higher dielectric constant (*k*) values for MIM capacitors. This increases the capacitance per unit area of the component thereby reducing the area occupied by the capacitor on the die which translates to lower cost. This project involves feasibility studies of HfO_2, ZrO_2, and Ta_2O_5 as the capacitor dielectric material and their integration into copper metallization based RF circuits.

Growth, Characterization and Development of Ultra-Thin (1-2nm) Gate Dielectric Using a Combination of Nitrous Oxide and Oxygen

Student : Au Yin Kheng
SMA Supervisor : Assoc Prof Choi Wee Kiong
Company Supervisor : Dr Bera Lakshmi Kanta

Project Abstract:

The aggressive scaling of MOSFETs into the sub-100nm region requires gate dielectrics of thickness in the region of 1 – 2nm. To achieve the ultra-thin gate dielectric using a current CMOS compatible furnace oxidation process, oxygen (O_2) as the oxidizing agent no longer proves feasible due to the high oxidation rate which renders the resulting thickness unpredictable and unrepeatable. Nitrous oxide (N_2O), through the incorporation nitrogen (N) atoms at the silicon –silicon oxide interface has a self-retarding growth rate and is thus, a suitable replacement for oxygen. Various growth conditions such as variations in oxidation duration, temperature, flow rates of oxidation gases, as well as combination of oxidation gases, were investigated. Results show that oxidation in N_2O is much more controllable compared to O_2. Oxide thickness of less than 2nm was successfully grown in an N_2O ambient. The exact physical thickness of the grown dielectric layer was determined through the use of cross-section TEM analysis. The distribution of the N profile in the dielectric layer, which directly affects the quality of the layer, was investigated through the use of characterization techniques such as XPS and SIMS. It is found that the incorporation of N near the interface improves the reliability of the grown dielectric layer. MOS capacitors were fabricated to investigate the electrical characteristics of the oxide layer. Various electrical tests were carried out to investigate the characteristics and quality of the dielectric layer. It was found that the developed growth process produces a smaller equivalent oxide thickness (EOT) as compared to oxidation in O_2 using similar oxidation condition. Oxidation using a combination of N_2O and O_2 does not improve the characteristics of the single N_2O grown

dielectric layer. The interface trap density of the developed process was also found to be comparable to that obtained from a conventional O_2 oxidation process. The N_2O oxidized gate dielectric was also found to exhibit better reliability compared to conventional O_2 oxidation as well as the combined N_2O and O_2 process. Charge-to-breakdown in the N_2O oxidized sample was found to be much higher than that in the other two processes.

Photodectors Based on III-v Materials

Student : Cheow Lei Kun
SMA Supervisor : Prof Chua Soo Jin
Company Supervisor : Dr Ramam Akkipeddi

Project Abstract:

The main objective of this project was to gain fundamental understanding of the operation of a p-i-n photodiode operating at 1.3µm and 1.55µm. Material chosen as the absorption layer is In0.53Ga0.47As that is lattice-matched to InP substrate. The absorption coefficient of In0.53Ga0.47As at these two wavelengths were theoretically calculated to be 1.26µm-1 and 0.67µm-1 respectively. Efficiency and responsivity curves were generated and led to the condition that long intrinsic layers are favorable for maximizing efficiency and responsivity. Further, p-i-n photodiodes working at 1.3µm show high efficiency ~1over a larger range of active layer thickness. The bandwidth of the p-i-n was shown to be limited by two mechanisms. RCeffects dominate when the active region is short, while transit-time effects limit the bandwidth at longer active region lengths. Optimum bandwidth is found when the effects of these two mechanisms are comparable. Large area junction shows poor bandwidth. Calculated bandwidth as high as 65GHz was obtained. Determination of a suitable active region length was based on the efficiencybandwidth product, a figure of merit that accounts for the efficiency-bandwidth tradeoff. The optimum design at 1.55µm has bandwidth of 56GHz and 57GHz at 1.3µm. The corresponding efficiencies are 0.29 and 0.47. Two dielectric films were evaluated as antireflection coatings. The thicknesses required to reduce surface reflectance to less than 5% were calculated. The efficiency-bandwidth tradeoff can be overcome to a certain extent with the use of a resonant-cavity enhanced structure. Additionally, waveguide-type p-i-n photodiodes developed for OEIC can remove the interdependence of efficiency and bandwidth.

Shrink 0.13nm Backend Structure Using Resolution Enhancement Lithography Assisted by Chemical Shrink (RELACS) Process

Student : Foong Yee Mei
SMA Supervisor : Prof Chua Soo Jin
Company Supervisor : Ms Moitreyee Mukherjee-Roy

Project Abstract:

The mature and reliable 248nm lithography technology is reaching its limits of resolution at 0.18µm technology. To further enhance the resolution, an innovative technique, namely resolution enhancement lithography assisted by chemical shrink (RELACS) is employed to shrink the 0.13µm dual damascene backend structures. The concept of this technology is simple; it utilizes the residual acid around the resist pattern edge to

catalyze the thermal cross-linking reaction. A smaller critical dimension (CD) of a feature will then result after the RELACS development. In this study, the KrF excimer laser (248nm) was used. Two of the acrylatetype chemically amplified resists (ESCAP) were used to react with the RELACS material in order to shrink the 0.20µm via and 0.18µm trench. The dependencies of shrinkage performance for RELACS process in terms of different resist thickness, mixing bake (MB) temperature, via pitches, via sizes and exposure dose were evaluated. The results showed that about 40nm (20%) and 60nm (30%) shrinkage have been observed for dense and isolated vias respectively at MB temperature 100oC. These studies showed that the shrinkage performance for RELACS process largely depends on the resist chemistry such as the photoacid generators (PAG) chemistry and the mixing bake temperature.

Polycrystalline Silicon Germanium as a Gate Material in CMOS

Student : Ganapathi Subrahmanyam
SMA Supervisor : Assoc Prof Choi Wee Kiong
Company Supervisor : Mr Simon Chan

Project Abstract:

Poly SiGe was used as part of the gate stack in CMOS. Its suitability to existing process lines was tested. A first lot was run with a split of no predope and anneal and with predope and anneal. Measurements were done on this lot and the results were recorded. Based on the results of the first lot some changes were made in the second lot that was run to alleviate the problems faced like cobalt salicidation and NMOS degradation. The change used in the second lot to solve the NMOS degradation problem was a redistribution anneal of germanium done to distribute the Ge content in the stack uniformly so that NMOS performance comes close to conventional poly silicon levels. The results from the second lot revealed that NMOS performance is still very poor. Therefore other effects that cause NMOS degradation were analysed.

Growth and Characterization of Ta and Ta Nitride as a Diffusion Barrier in Cu/SiO2 Structure

Student : Gong Zheng
SMA Supervisor : Assoc Prof Pey Kin Leong
Company Supervisor : Dr Pan Jisheng

Project Abstract:

Tantalum Nitrides (TaN_x) thin films were deposited on thermally grown 100nm SiO_2 layers on Si (100) substrates by using multi-target dc magnetron reactive sputtering of Ta in different N_2/Ar ratio gas mixtures. TaN_x thin films with different N_2/Ar ratio (10%~50%) in TaN_x/SiO_2 and $Cu/TaN_x/SiO_2$ multilayer structure were investigated using X-ray photoelectron spectroscopy, Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS), and X-ray diffraction (XRD). In-situ XPS studies show that the TaN_x/SiO_2 interface was stable up to 700 ^oC. Comparative studies on the depth profile of Cu/SiO_2 and $Cu/TaN_x/SiO_2$ indicate that TaN_x films are good diffusion barriers and the N atoms inhibit Cu diffusion.

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The Impact of CMOS Processes on Negative Bias Temperature Instability

Student : Irwan Bin Karim
SMA Supervisor : Assoc Prof Choi Wee Kiong
Company Supervisor : Dr Ang Chew Hoe

Project Abstract:

Negative bias temperature instability (NBTI) is a major reliability issue in CMOS processes. It causes the threshold voltage to shift during device operation resulting in circuit malfunction. In this thesis, the author has surveyed a series of back-end of line (BEOL) and front-end of line (FEOL) processes and their impacts on NBTI. The threshold voltage shift is found to obey a power law dependence with time consistent with that reported in the literature.

For BEOL, the impact of using different etch stop layers, forming gas anneal (N_2/H_2 alloying) and metal antenna ratio have been analyzed. The hydrogen introduced during the back end processes proved to play a significant role in worsening NBTI performance. The breaking of Si-H bonds is the precursor to the start of NBTI. The presence of more Si-H bonds will lead to greater NBTI effect. Plasma charging damage can have different impacts on NBTI. Defects generated by this mechanism can be annealed by hydrogen; however, they will be reactivated later by NBTI. Alternatively, without hydrogen annealing the Si-H bonds will be broken resulting in poorer initial oxide characteristics but better NBTI performance. NBTI can be reduced from the back-end stage by using the right combination of N_2/H_2 alloying as well as by carefully designing the device to minimize plasma induced charging damage.

For FEOL processes, the focus is on the oxide nitridation and the gate oxidation scheme. Decoupled plasma nitrided oxides (DPNO) are found to have better resistance to NBTI than rapid thermal nitrided oxides (RTNO). This is attributed to the fact that in DPNO, nitrogen is displaced away from the gate oxide interface. It has been earlier known that NBTI will get worse with increase in nitrogen concentration. In addition, the quality of the oxide grown using partial wet oxidation is found to have worse NBTI degradation compared to dry oxidation.

Study of Nickel Silicidation Process on Device Performance

Student : Kan Shidong
SMA Supervisor : Assoc Prof Pey Kin Leong
Company Supervisor : Dr Chi Dongzhi

Project Abstract:

Electrically active defects induced by the formation of nickel mono-silicide have been studied in n-type silicon using Deep Level Transient Spectroscopy (DLTS). A Ni-related electron trap level around E_C – 0.40eV was observed after silicidation at 550, 650, 750 and 800ºC. The lowest total defect concentration was observed in the sample silicided at 750ºC, which also has low leakage current. This observation suggests that the defect induced by the nickel silicidation process can be minimized by choosing the proper RTP conditions.Studies of the current—voltage characteristics of p^+/n and n^+/p diodes silicided with nickel have been performed. Majority of the diodes show good I-V characteristics while some diodes show high leakage current and abnormal I-V

characteristics. Our results show that the forward current in the diodes with good I-V characteristics is dominated by diffusion current mechanism. For the diodes with high saturation current, it has been concluded that both forward and reverse currents in some diodes are dominated by the current following through Schottky contacts. Due to inadvertent penetration of silicide spikes through the junction, and some of those currents are dominated by generation-recombination processes which may due to the nickel-related defects induced in silicidation process.

Nickel Metal Gate for CMOS Devices

Student : Kuang Weiwei
SMA Supervisor : Prof Chua Soo Jin
Company Supervisor : Dr Chi Dongzhi

Project Abstract:

To elucidate the feasibility of Nickel (Ni) as metal gate in CMOS transistors, the thermal stability and surface morphology of Ni/SiO2/Si in the temperature range of 400-800˚C have been investigated. Four-point probe, X-ray Diffraction, Scanning Electron Microscopy, Atomic Force Microscopy, Secondary Ion Mass Spectrometry have been employed to characterize the samples. It was found that with a 5 nm-thick thermal oxide, there is no obvious diffusion of Ni through the thin gate oxide, and no obvious nickel silicide formation was observed even at a high temperature of 800˚C. With increasing annealing temperature, the Ni films agglomerated with grooving of the grain boundary. SiO_2 was thus exposed to the surface. At 800˚C annealing, severe agglomeration was observed.

Vertical Profile Control in High Aspect Ration Low-K Dielectric Contact Hole

Student : Lan Peiyuan
SMA Supervisor : Assoc Prof Choi Wee Kiong
Company Supervisor : Dr Vladimir N Bliznetsov

Project Abstract: Confidential

Silicidation on Poly-SiGe Gate Stacks

Student : Li Yisuo
SMA Supervisor : Assoc Prof Pey Kin Leong
Company Supervisor : Dr Lee Pooi See

Project Abstract:

Co silicidation over poly SiGe was studied for 01um MOSFET technology. Ge diffusion and its influence on the silicidation were studied in this thesis. Ti interlayer and Ti cap were used to improve the silicidation process. And the optimization was tried to improve the performance of Co silicide over the SiGe gate. TEM, AFM and XRD experiments were done to study the silicidation process over the poly Si Ge gate. The simulation was done to study the Ge diffusion in order to optimize the silicidation process. Implantation and stress simulation were performed to study the Ge diffusion. Thin Co metal layer with Ti cap has uniform results and low sheet resistance.

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Triple Gate Oxide Integration for System-On-A Chip

Student : Liu Xiaohong
SMA Supervisor : Assoc Prof Chim Wai Kin
Company Supervisor : Mr Simon Chan

Project Abstract:

Demands for system-on-a-chip (SoC) are increasing from the viewpoint of performance, power, chip size and chip cost. In this work, a dual gate oxide process to mimic the triple-gate-oxide technology has been investigated for SoC applications of input/output thick gate devices, low power (LP) devices and core devices for 0.10-μm-generation CMOS platform technology. Electrical characterizations have been performed to evaluate and optimize the process. The results show a good agreement between the physical thickness and the electrical thickness of LP and thin gate oxides. Moreover, the oxide thickness of thin gate devices can be reduced by the LP gate process. LP nitridation has no significant impact on the LP device mobility while the thin gate device performance is degraded by the LP gate process. A new process with a resist scheme can be used to reduce the impact of the LP process on the thin gate.

Corrosive Effect of Trace Contaminants on Metal Surface

Student : Ng Soon Sing
SMA Supervisor : Prof Andrew Tay Ah Ong
Company Supervisor : Dr Thomas Liew

Project Abstract:

A corrosion testing setup was developed where humidity, temperature and corrosive gas, SO_2 concentration were controlled. These tests are designed to simulate possible galvanic corrosion, for which the metal foils such as copper and iron, were characterized by the formation of oxide and sulfate containing corrosion nodules. The evolution of the corrosion process was elucidated by inducing different degrees of corrosion on the foils, and these distinct corrosion stages were characterized morphologically by atomic force microscopy and chemically by x-ray photoelectron microscopy and auger electron microscopy compositional analysis. In particular, the effects of trace contaminants as corrosion accelerators are discussed.

Study on the Reduction of Leakage Current of CMOS for N-Channel MOS Field-Effect Transistor

Student : Ng Wei Beng
SMA Supervisor : Assoc Prof Chim Wai Kin
Company Supervisor : Mr Dhruva Kant Shukla

Project Abstract:

The report describes the feasibility study of reducing transistor leakage current I_{off} for the n-channel transistor of a 0.25μm CMOS technology without affecting other transistor parameters. Experiments are carried out to study the effect of boron and indium pocket

implant, wet gate oxide with different thickness variation on I_{off} and other n-channel transistor parameters. Although p-type pocket implant is able to reduce I_{off} to a satisfactory low range (< 10pA), the saturation current I_{sat} is reduced simultaneously and other transistor parameters are affected as well. There is an increase in I_{off} compared to the standard dry gate oxide process when a wet gate oxide of the same electrical thickness is used. The experimental study is complemented by simulation for relative studies by using SUPREM and MEDICI. Based on experiments carried out so far, it is concluded that the current transistor architecture of the technology under study ensures the lowest I_{off} both for the NMOS and PMOS transistors.

Junction Leakage Characterization in Silicided Junctions

Student : Nikholas Gerochi Toledo
SMA Supervisor : Assoc Prof Pey Kin Leong
Company Supervisor : Dr Lee Pooi See

Project Abstract:

Different silicidation schemes of Ti-capped nickel-silicided area and STI-intensive (comb) diodes and Ti-capped cobalt-silicided area diodes are presented with their corresponding characteristics. Ti-capped Ni-devices silicided at 400°C have lower leakage currents, high sheet resistances and suffer from the narrow line effect indicating that total phase transformation of NiSi has not yet been achieved. Ti-capped devices silicided at 500°C have been found to have a comparable reverse leakage current to that of pure NiSi. The sheet resistance of the 120ÅNi/100ÅTi silicided at 500°C is higher than 160ÅNi silicided at 450°C but it has a more consistent saturation current compared to pure NiSi even at very shallow STI-intensive structures. The thin silicide layer makes Schottky contact formation difficult to occur making it a good scheme particularly for shallow comb structures. The 200ÅNi/150ÅTi (500°C) has the lowest sheet resistance but resulted in Schottky contact formation. This metal-semiconductor interface is due to silicide roughness (spikes) penetrating the depletion region or worse, the junction itself. The 200ÅNi/100ÅTi (500°C) is a good compromise as it has a comparable sheet resistance and leakage current as 160ÅNi (450°C) but is less likely to form Schottky contacts in very shallow area diodes and in comb diodes whose junction is not too shallow. The leakage mechanisms are also presented for Co/Ti, 160ÅNi and 160ÅNi/125ÅTi structures. In p^+n area, n^+p area and comb diodes, the forward current mechanism is diffusion dominated specifically the minority carrier diffusion in the neutral region of the heavily doped side. The shallow p^+n comb diode has both Schottky contact and diffusion behavior in the forward active region. The reverse leakage mechanism in Co/Ti devices is dominated by tunneling for p^+n area diodes and dislocation current for n^+p area diodes.

Characterization of HF Aluminate as a Gate Dielectric

Student : Pan Manyi
SMA Supervisor : Assoc Prof Chim Wai Kin
Company Supervisor : Dr Ang Chew Hoe

Project Abstract:

The reduction of complementary metal oxide semiconductor (CMOS) device dimensions through transistor scaling is in part limited by the silicon dioxide (SiO_2) dielectric layer

thickness. As the SiO_2 layer is thinned, leakage currents increase rapidly. Below 30 Å at a given voltage, the leakage current increases by approximately one order of magnitude for each 2 Å reduction in thickness. Most of the high-*k* materials are thermally unstable so that low-*k* interfacial layers are formed when directly contacted with the silicon substrate. Furthermore, the influence of metal contamination on electrical properties is unknown. It seems difficult to develop CMOS technology using high-*k* materials on a scaling road map. Atomic layer deposition (ALD) of ultrathin high-κ dielectric films has recently appeared in the research and development lines of several major memory and logic manufactures due to the promise of unprecedented control of thickness, uniformity, quality and material properties. Genus ALD process was used to develop the hafnium aluminate film for the gate dielectric application in sub-0.1µm CMOS technology. HfO_2, Al_2O_3 and Hf aluminate with various compositions were grown by the Genus Lynx2 atomic layer deposition process at a deposition temperature of 300ºC. The thickness of each film was measured by spectroscopic ellipsometry. Both physical and electrical characterizations were made.

Atomic Layer Deposition of Low Dimensional Structures on HOPG Surfaces

Student : Poon Siew Wai
SMA Supervisor : Assoc Prof Chim Wai Kin
Company Supervisor : Dr Pan Jisheng

Project Abstract:

The nature of the interaction between highly oriented pyrolytic graphite (HOPG) and adsorbed cobalt (C_o) is examined by X-ray photoelectron spectroscopy (XPS). By monitoring C 1_s and C_o $2p_{3/2}$ spectra, it showed that C_o does not chemically bond to a pristine HOPG surface. Slow increase of C_o $2p_{3/2}$ intensities against deposition time implies that this surface is a *priori* unable to support layer-by-layer growth. A chemical reaction occurs only when oxygen is incorporated. The possible role of contaminants in the metal adsorption process were also addressed. Images from atomic force microscopy (AFM) revealed that layer growth is seen at very low atomic percentage of C_o. At higher atomic percentage of C_o, three-dimension islands are seen. Effects of post-deposition annealing were also addressed and exhibited different surface morphologies for different surface qualities. These differences were believed to be associated with the role played by the contaminants. Results from time-of-flight secondary ion mass spectroscopy (TOF-SIMS) were used to assist the investigation on the effects of annealing on the diffusivity of ad- C_o atoms. It was found that some of the ad- C_o atoms diffused into the bulk upon annealing. Stranski-Krastanov growth mode was predicted for deposition of C_o on HOPG surfaces with contaminants, based on both of the XPS analyses and AFM imaging.

Process Improvement in 0.25 Micron CMOS Logic Process to Have Better Hot Carrier Reliability

Student : Rajivakshan Ramanathan
SMA Supervisor : Assoc Prof Chim Wai Kin
Company Supervisor : Mr Dhruva Kant Shukla

Project Abstract:

This report seeks to understand hot-carrier injection effects along with the various methods for measuring the hot-carrier lifetime of 0.25-micron CMOS devices. The report also surveys different hot-carrier resistant device structures and suggests methods to improve the reliability of MOSFETs without affecting their electrical characteristics. The main experiments conducted to improve the lifetime were to replace the dry gate oxide with a wet oxide, use of nitrided wet gate oxides and the use of a longer polysilicon gate. The nitrided wet gate oxide yielded a 1.38 to 2 times improvement in hot-carrier lifetime depending on the gate oxide thickness used and the non-nitrided wet gate-oxide yielded a 3 times increase in lifetime for an oxide thickness comparable to the dry oxide. However, the non-nitrided wet gate-oxide decreased the threshold voltage 'V_t' below the required value, which resulted in very high drain saturation current 'I_{dsat}'. To counter this parametric variation, the polysilicon gate length was increased by 40 nm. This not only helped in achieving the required voltage and current levels but also improved the hot-carrier lifetime by 900% (9 times improvement). The second part of this report investigates the quality of the wet and dry gate oxides in order to understand the reasons behind the improvement in reliability. The interface-state density in the two oxides was characterized by using the Terman's method i.e. by performing high-frequency Capacitance-Voltage measurements and comparing them with a generated theoretical curve. The interface trap density was found to be slightly higher in the dry oxide, which could be responsible for faster degradation. The substrate current values for the different gate oxides also support these findings. A method for implementing the Large-Angle Tilt Implanted Drain structure to improve the hot-carrier lifetime has also been proposed. The author feels great satisfaction in having met all the objectives of the project and would like to thank all those involved in the endeavor.

Design, Simulation, Fabrication and Test of Microfluidic Silicon-Based Bio-MEMS Devices with Patterned Self-Assembled Monolayer Surface Modification

Student : Shu Wenmiao
SMA Supervisor : Prof Andrew Tay Ah Ong
Company Supervisor : Dr Victor D Samper

Project Abstract: Confidential

Design and Simulations of Spring and Hinge Mechanism for MEMS Micro-Mirror Devices

Student : Sohini Bose
SMA Supervisor : Prof Andrew Tay Ah Ong
Company Supervisor : Dr Janak Singh

Project Abstract:

A micromirror device, electrostatically actuated, and supported by torsion bars with a novel flexure spring design is investigated. A complete theoretical analysis of the proposed micromirror device is done, by considering individual parts separately. Simulation by Finite Element Analysis software MEMCAD is carried out. Simulation results obtained in the form of displacement magnitudes are converted to corresponding angles of rotation. Results obtained are compared with theoretically obtained values. Based on simulation results, a set of optimized design parameters for the system is obtained.

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Simulation and Modeling of Nanometer Scale Magnetic Devices

Student : Steby Rodriguez
SMA Supervisor : Prof Chua Soo Jin
Company Supervisor : Dr Wu Yihong

Project Abstract:

Thin film technology has become a crucial player in the present day technological advancement. It has gained particular importance in the hard disk data storage industries because multiple layers of thin films are used both in the magnetic media and heads. The physical properties and performance of these devices often crucially depend on their interfacial structures. Therefore, atomic level control and characterization of the structure of the ultra thin films have become increasingly important. The typical thickness of the individual layer in a magnetic multilayer is in the range of several nanometers. In order to obtain high performance magnetic media and head, it is important to ensure that the layer of the thin film have a structure as perfect as possible with a smooth interface between the layers. Thus, characterization has to be done to gather information on the properties of the thin film. X-ray reflectivity (XRR) is believed to be able to offer accurate thickness values for both thin films and multilayers with the same precision, as well as densities, surface and interface roughness. This project is aimed at simulating the Low angle X-ray reflection of Magneto-Resistive (MR) head consisting of multilayers of thin film. Thereby correlating the surface and interfacial characteristics of multilayer with its observed magnetic and electronic properties.

Microstructure and Mechanical Behavior of Lead-Free Solder Joints

Student : Su Chun Wei
SMA Supervisor : Prof Andrew Tay Ah Ong
Company Supervisor : Dr Yang Qianjin

Project Abstract:

This research investigates the tensile properties of 95.8Sn-3.5Ag-0.7Cu Pb-free solder alloy in the micro-scale. It is found that the solder alloy shows good tensile strength but a relatively lower stiffness compared to eutectic Sn-Pb solder alloy. It also studies the effects of temperature and strain rate on the tensile properties. It is found that the yield stress, tensile stress and Young's Modulus are very sensitive to temperature and strain rate. Microstructure of the solder alloy is studied. It is found that the microstructure differs vastly from eutectic Sn-Pb solder alloys. The Sn-Ag-Cu microstructure consists of Sn matrix interlaced with lamellae structured Ag_3Sn. Micro hardness test is performed and the Sn-Ag-Cu solder alloy shows a good hardness compared to Sn-Pb solder alloys. Sn-Ag-Cu is a potential Pb-free replacement for Pb-based solder alloys.

Fabrication and Characterization of ERS2 Silicide Infrared Photodetector Application

Student : Su Ning
SMA Supervisor : Prof Chua Soo Jin

S.M. Project Abstracts 2001/2002
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Company Supervisor : Dr Chi Dongzhi

Project Abstract:

Erbium silicide films were grown on (100) n-type silicon substrate by DC plasma sputtering, followed by rapid thermal annealing (RTA) treatment at different temperatures (4000C –7000C) for one minute. To prevent erbium silicide films from oxidation contamination, titanium was deposited as a capping layer. Two batches of samples were prepared: (a) 50nmEr/(100) Si (b) 20nm Ti/ 50nm Er/ (100) Si. Erbium silicide films of thickness about 20nm obtained were characterized by various techniques such as XRD, Micro-Raman, TOF-SIMS, XPS, SEM, and sheet resistance measurement at room temperature. ErSi2 formed at temperatures above 5000C and it was either epitaxial or highly textured with (100) crystalline orientation relationship wit h silicon substrate. Ti capping layer was found to have a beneficial influence on erbium silicide films in that it decreased the ErSi2 formation temperature and improved the film quality. Microraman spectrum for ErSi2 obtained in this work shows that ErSi2 is Raman active and demonstrates the feasibility of using Micro Raman to monitor the erbium silicide phase formation. Nonuniformly distributed pinholes were present on the films surface. The features of pinholes were identified and possible mechanisms for pinhole formation were proposed and discussed in this work.

To Study the Effect of Oxidation of AlGaAs on the Quality of the Upper GaAs Layer

Student : Vernon Goh Tat Boon
SMA Supervisor : Prof Chua Soo Jin
Company Supervisor : Mr Jason Tan

Project Abstract:

For gallium arsenide (GaAs), the formation of a mechanically stable and low refractive indexed oxide from the wet oxidation of $Al_xGa_{1-x}As$ has led to great advances in optoelectronics, in particularly in the field of LEDs and vertical-cavity surface-emitting lasers (VCSELs). In this project, wet oxidation of $Al_xGa_{1-x}As$ is studied under different conditions of time, temperatures and Al composition. The oxidation process was found to be linear with time and the oxidation rate increases with increasing temperature. In addition, the process is found to have a strong Al composition dependence where the oxidation rates increase by almost an order of magnitude going from Al composition= 92% to 98%.

No further oxidation is observed beyond the oxidation process when oxidized samples are subjected to high temperature treatments of 400-500°C in an inert ambient for up to 3 hours. A DLTS structure is proposed to measure the deep level traps in the upper GaAs layers and the corresponding samples were fabricated. Delamination at the oxide-semiconductor interface was observed from samples whose Al content is 98% while no delamination was seen for samples of 92% Al content. This is attributed to increased volume shrinkage as Al content increases. No significant DLTS signals were obtainable due to the small diameter of the top Schottky contacts as compared to the larger DLTS system's probe tip.

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Correlation Between the Post Copper ECP Anneal and The Microstructure in Copper Metal Lines & The Effect of Microstructure on Copper Metal Lines Properties

Student : Vikas Jindal
SMA Supervisor : Assoc Prof Pey Kin Leong
Company Supervisor : Mr Alex See

Project Abstract:

The role of microstructure of copper in metal interconnect on various device properties was studied. For this study Copper lines in Damascene trenches and in blanket form were annealed at temperature from 150ºC to 250ºC in furnace. Microstructure of Cu was investigated using various characterization techniques including Transmission Electron Microscopy (TEM), Focused Ion Beam (FIB) and Atomic force Microscopy (AFM). It was found that the final grain size strongly depends on the annealing process. Grain growth is found to be a strong function of anneal temperature and anneal time. Another relevant parameter studied was the trench width of copper metal lines. The minimum feature dimension of the width or height of the damascene trenches limited the average grain size. The resistance of the copper metal was found to decrease with grain size. The electromigration property of the copper was not a function of grain size, which supports the idea that in electromigration mechanism in copper is dependent on other than grain boundary self-diffusion.

Applications of Laser Scanning Microscopy to Integrated Circuits Failure Analysis

Student : Wang Jianwei
SMA Supervisor : Assoc Prof Chim Wai Kin
Company Supervisor : Dr Ong Soon Huat

Project Abstract:

The optical beam induced current (OBIC) technique was studied and applied to the failure analysis of integrated circuits. It was used to measure junction depth but with limited accuracy. Concentration gradient of single type dopant could produce OBIC signal. Logic state detection by OBIC was affected by the circuit connection topology. Potential of floating junctions was affected by photo generated carriers. Latchup could be induced and sensitive area could be located by laser scanning. Strong transients affect the image quality. Reflection from metal either enhance or reduce carrier generation in the backside OBIC. Other factors like scan rate, topography, laser power and bias are also discussed.

Photodectors Based on III-V Materials

Student : Wang Kejia
SMA Supervisor : Prof Chua Soo Jin
Company Supervisor : Dr Ramam Akkipeddi

Project Abstract:

Avalanche photodetectors (APD) are of great importance in modern long-haul highbit-rate optical communication systems with high sensitivities. Avalanche photodetectors

are of particular interest because they can provide: 1) the good quantum efficiency at a given wavelength, 2) high response speed, and 3) high signalto-noise ratio. In this work, design issues including absorption process, multiplication process, models used to simulate the performance of the avalanche photodetectors, and noises in the avalanche photodetectors are discussed. An avalanche photodetector working at 1.55 μm based on InGaAs/InP is designed. The results are presented in Chapter 5 and discussed in Chapter 7. The design photodetector shows a gain-bandwidth over 40 GHz.

Design and Simulation of Thermal Bimorph Actuator and XY Micro Stage for Applications in Optical Communications Network

Student : Yong Mee Lee
SMA Supervisor : Prof Andrew Tay Ah Ong
Company Supervisor : Dr Janak Singh

Project Abstract:

Design and simulations of a thermal bimorph micro actuator for applications in optical communications networks were achieved. The dimensions of the micro actuator that enabled the required out of plane actuation were obtained. Design work was performed on the X-Y micro stage. Theoretical and experimental data for the main component of an X-Y micro stage were successfully correlated. The main component of the thermal bimorph micro actuator is the Aluminium and silicon dioxide composite cantilever, and the working principle is based on the difference in the coefficient of thermal expansion of the two materials. The resistive heating model was used to ensure most of the electrical heating is concentrated at the cantilever beam. Another analytical model, the electric-thermal analogy model, was developed to make sure that the dimensions (length, width and thickness of each layer) and layout of the micro actuator enabled a low voltage, current and power consumption to activate the optical switching at a certain temperature change. Deflection due to thermal changes was theoretically formulated and thermal-structural simulation was done. The simulation model was verified by comparison with published experimental data. Theoretical deflection due to as-deposited stresses was studied and calculated using values of as-deposited stresses determined from a simple wafer level experiment. Verification of the deflections was made using fabricated samples. The final proposed dimensions of the thermal bimorph micro actuator are 870 ± 25 mm in length and 60mm in width with patterned metal layer strips 16mm-wide. Sets of thicknesses of (0.3, 1.3) or (0.5, 1.5) micrometers with a tolerance of ±0.1mm for metal and oxide layers respectively will enable a 100o rotation angle at DT of 164K. The design requires an applied voltage of 0.1V, a current of 11mA and a low power consumption of 1.09mW. Samples of comb drives actuators having depth of 40mm were fabricated using the DRIE process. These samples were tested for displacements due to electrostatic forces. The measured data correlated well with the theoretical values. Data points of displacement versus the applied voltage were fitted using the least square method. These displacements are proportional to the squared value of the applied voltage. Actuation of 10mm in both the positive and negative x directions was achieved at 35V. The spring constant extracted from the slope of the displacement-voltage square graph is within 0.2Nm-1 of the theoretical prediction. The Young's modulus (173 GPa) of the polysilicon layer obtained from the static displacement-to-voltage measurement is within the reported range of past literatures. Comb drive actuators are the main component of an X-Y micro stage. Various designs of the X-Y micro stage were proposed based on different arrangements of these comb actuators.

S.M. Project Abstracts 2001/2002
AMM&NS Programme

Surface Modification and Characterization of Low-K Dielectric Films

Student : Zhou Xing
SMA Supervisor : Assoc Prof Choi Wee Kiong
Company Supervisor : Dr Pan Jisheng

Project Abstract:

Oxygen plasma treatment is an indispensable process to remove the photoresist. It has the influence on the surface of low k dielectric films, which will lead to degradation of the device. Three process parameters such as treatment time, oxygen pressure and RF plasma power were controlled to find out their effects on the properties of low-k films. X-ray Photoelectron Spectroscopy (XPS), Time-of-flight Secondary Ion Mass Spectrometry (TOF-SIMS) and Fourier-Transform Infrared Spectroscopy (FTIR) techniques were used to analyze the composition, chemical bonding and depth profile of the samples under different treatment parameters. Low carbon concentration region was found after O_2 plasma treatment. The width of this region increases with the increasing pressure, time and RF power. C 1s chemical shift from 284.5 to 287.6eV shows the oxidation of carbon. FTIR results show the disappearance of Si-H bond and appearance of Si-OH bond after O_2 plasma treatment. This will lead to an increase of the k value. Finally a new plasma technology was used to attain the least influence on low k films.

S.M. Project Abstracts 2001/2002
HPCES Programme

Transient Analysis of Fluid-Structure Interaction in 2D
Student : Ajaykumar Rajasekharan
SMA Supervisor : Assoc Prof Khoo Boo Cheong
Company Supervisor : Dr Kantharaj Murali

Project Abstract:

In this project, a computer aided simulation of the fluid-structure interaction phenomena pertaining to hydrodynamic applications is presented. Stand-alone fluid and structure finite element codes are written and coupled with the help of a sequential segregated coupling algorithm. Significant effort has been put in to development of algorithms to control the deformation of the fluid mesh by treating it as a pseudo-structural system. Effort has also been thrust on the development of a monolithic velocity potential-displacement coupled formulation for the fluid-structure system. A cantilever metal plate in fluid flow subjected to different boundary conditions is studied here. The method of coupling the fluid and structure equations is then extended to study the more complex, free surface fluid-structure interaction phenomena.

Scattering from the Interior Surface of Air Inlet
Student : Chien Tze How
SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisors: Dr Gan Yeow Beng, Dr Wang Chao-Fu

Project Abstract:

The motivation for this work lies with its important application in analyzing the electromagnetic scattering behaviour of air inlet in the military platform. The presence of jet engines has considerable effects on the overall electromagnetic scattering response of real targets. For example, the engine inlet and exhaust ducts have significant contributions to the electromagnetic signature of modern jet aircraft. The analysis of high-frequency scattering from electrically large open cavities is therefore a critically important part in the complete prediction of the radar signature of complex targets. An iterative method is used to compute the scattered electric fields at the apertures of large perfectly conducting cavities. This field iterative method (FIM) uses the Kirchhoff's approximation to initiate a two stage iterative process, involving both the magnetic field integral equation (MFIE) and the electric field integral equation (EFIE), to calculate the electric current on the internal cavity walls and the electric fields across the aperture of the cavity. This technique combines the flexibility of the boundary-integral method with the speed necessary to efficiently analyze large-scale cavity problems

Virtual Prototyping Development of Head-Actuator Hard Disk Drive
Student : Ding Fei
SMA Supervisor : Assoc Prof Liu Guirong
Company Supervisor : Dr Yang Jiaping

Project Abstract:

This dissertation studies the Electromechanical Hysteresis in Rotational Actuator numerically and investigates dynamic characteristics of the integrated system. Firstly, the dynamics of Actuator-Slider is studied and finite difference method is used to solve the nonlinear two-order partial derivative equation. Frequency response is analyzed. Secondly, based on the equation for Slider-Actuator, a macro model of the Actor-Slider-Suspension system is built, and electrostatic analysis and mechanical analysis are performed. Finite difference method is used to solve the system dynamics equations. Frequency response for the system is analyzed.

Simulation of Air Flow Structure in a Near – HDD Configuration

Students : Dong Peng
SMA Supervisor : Assoc Prof Lee Kwok Hong
Company Supervisor : Dr Ong Eng Hong

Project Abstract:

Upon the demand for mass-storage hard disk drives, technological advances have led to rapid improvements on data storage characteristics. The reduced track widths have increased the importance of head positioning accuracy, especially for disk drives under high-speed disk rotation. One major factor affecting positioning of the magnetic head is arm vibration. In this project, a computer simulation model of two co-rotating disks inside a cylindrical enclosure was used to gain an insight into the airflow structure inside disk drives. Furthermore, models with arms extending into the space between the disks were simulated to understand the effect of arms on airflow. Results were compared between various models to study forces causing arm vibrations when the geometry of the arm varies.

Automatic Crane Sequencing

Student : Duong Hong Duc
SMA Supervisor : Asst Prof Toh Kim Chuan
Company Supervisor : Dr Tan Kok Choon

Project Abstract:

Automatic crane sequencing forms a very important part of automated material handling and its performance affects directly the efficiency of the entire system. The objective of this project is to develop an efficient deployment algorithm scheme, which will schedule automatically the jobs for each quay crane so that to minimize the *makespan*, i.e., the time it takes to complete the entire loading and unloading operation for the ship and also minimize the operation cost. Furthermore, the sequencing must guarantee that all the constraints are satisfied during the operation time. The constraints or violations here are the conditions that cause the *quay crane* (QC) cannot operate properly or it affects to the stability of the ship during the operation time. A variety of sequencing or scheduling algorithms are available but none of the existing methods can be applied directly. This is because, in most existing scheduling the variables of objective function and that of constraints are time variables, however in this problem the constraints base mainly on the space variables, whereas the objective function uses time variables. Hence, a dynamic programming is a proper approach to deal with this problem. However, a set partition problem is implemented as the first phase to reduce the computations in the

dynamic programming problem. The algorithms are implemented in C++ and Visual basic, besides the performance of the program and the experimental results are analyzed. A detailed description of the algorithms and specific details of implementation in C++ are provided.Computational experiments show that the combination of set partitioning and dynamic programming methods generates excellent solutions to solve crane sequencing problem. Furthermore, the sequencing results express an effective solution in the scene of minimizing the *makespan* and the operation cost as well as maximizing the clearance.

Simulation of Air Flow Structure in a Near – HDD Configuration

Students : For Chee Wei
SMA Supervisor : Assoc Prof Lee Kwok Hong
Company Supervisor : Dr Ong Eng Hong

Project Abstract:

Vibration of head carriage arm is a cause of magnetic head positioning error in hard disk drives. This project uses numerical simulation to investigate the extent to which obstructions of different geometries are affected by high speed air-flow in a hard disk drive. Also, an obstructed disk drive flow is compared with an unobstructed disk drive flow.A computer simulation model of two stacked disks rotating uniformly at 10krpm is calculated with the standard k-ε model of turbulence. The geometries of obstruction compared are the rectangular and aerofoil-shaped obstructions of 2 different lengths each. It is found that short obstructions generate larger turbulence and velocity gradient in the region around the obstruction tip. The aerofoil-shaped obstructions have a larger turbulence and velocity gradient in region around the obstruction tip while the rectangular obstructions generate larger turbulence and velocity gradient at regions around the obstruction near the shroud.

Timetable Scheduler for ITM (Integrated Training Manager)

Students : Ho Liang Yoong
SMA Supervisor : Assoc Prof Teo Chung Piaw
Company Supervisor : Mr Yeo Jan Chee

Project Abstract:

A web-based scheduling system is pursued by Singapore's Defense Science Technology Agency (DSTA) to fully leverage from the advancement of optimisation techniques as well as information technology. The current scheduling system which has been manually deployed could not cater optimally to the scheduling needs of training programs from Ordnance Engineering Training Institute (OETI), a training branch of the Army. This project attempts to meet the demands of such a web-based system.As the concept is fresh an untried, a proof of concept is therefore essential prior to the in-depth modeling of the problem. The proof of concept is achieved through a system platform that uses Java Native Interface (JNI) as a link between the optimization engine and the user interface. The engine will be built upon using C++ language through the application of constraint programming while the Graphical User Interface (GUI) will be built upon using Java Swing Packages.A simple test model is built and the concept is proven as successful. With this new basis, real data set from OETI needs to be applied onto this

model. However, an unique characteristics in one of the resource, namely instructor, made the modelling effort extremely difficult as a large data set needs to be processed within small computational time. Hence, heuristic techniques need to be utilized to perform the allocation of instructors within small computation time while not compromising the optimality of the solution.

Treating Framework for LP / MIP Programmes

Student : Kalyana Chakravarthy
SMA Supervisor : Assoc Prof Huang Huei Chuen
Company Supervisor : Mr Gosselin Vincent

Project Abstract:

The purpose of this project is to improve our ability to test optimization models better by building a framework, wherein optimization models are tested regressively over sets of *intelligently generated* test data. The test data generated has to reflect in itself the object level relations as specified by a higher level modeling language namely UML or by a Database schema. All the data generated to test the model needs to conform to the data base schema of the optimization model that is provided. It is assumed that the model for which test data is being generated has clear higher level description in terms of Class Diagram and the Database Schema. Formal specifications as given by UML and the database schema (*assumed to be done in Rational Rose®*) give us an opportunity to understand the object level relations in an unambiguous manner thus enabling us to create sensible test data as needed to test the optimization model. The given Rose® model was used to create a standardized XML (eXtensible Markup Language) representation namely XMI (XML Metadata Interchange) format of the model. This XMI model being a textual form can be parsed and is used to obtain the object relations of the given model. The object relations so identified are used in generating test data and the test data is then populated into the database. The Database schema conformity of this test data is also to be ensured.This test data can later be used to regressively test optimization models in general. This forms the basis for a testing frame work for optimization models.

Combining HW/SW Partitioning and Chip Planning for System-on-Chip (SOC) Design

Student : Guan Li
SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr Olivier Peyran

Project Abstract:

In traditional SoC design, pure HW/SW partitioning and chip planning are implemented separately. This strategy incurs some kind of blindness in carrying out the partition stage and the result getting from it is only theoretical optimal but not realistic, due to some unpredictable factors such as accurate delay information and the meet of user defined time budget. In this project, basing on previous researches in related areas, we try to find a totally new approach to combine those two stages and using the information of each other to improve the final result. In this way, make the design more efficient and closer to real problem. Some famous and classic partition heuristics are studied and

incorporated in the solving algorithm, such as Kernighan/Lin (KL) and the extension of Fiduccia/Mattheyses (KLFM). An Integer Programming (IP) formulation is formed to get a final solution at last.

Timetable Scheduler for ITM (Integrated Training Manager)

Students : Keh Chin Chai
SMA Supervisor : Assoc Prof Teo Chung Piaw
Company Supervisor : Mr Yeo Jan Chee

Project Abstract:

A web-based scheduling system is proposed by Defense Science Technology Agency (DSTA) to solve the problem of scheduling training programs for an Army Institute, Ordnance Engineering Training Institute (OETI) which has always been done manually. Being a fresh idea, a proof of concept is first carried out before the in-depth modeling of the problem. A system design is drafted out which suggests the use of Java Native Interface (JNI) to act as a link between the engine which is built on C++ platform, using constraint programming, and Java which is used as for User Interface and output graphics. JNI is used to draw the necessary information from the database which is built by SQL Oracles. Using a simple test model, the concept is proven to be a success. The concentration of the project then moves to the formulation of the real data set from OETI. The data set has unique characteristics in one of the resources, namely instructor. The special characteristics make modeling of the resource very difficult especially when the computational time is to be small with large data set. A 2-stage approach thus is proposed. In the first stage, heuristics are used to generate a schedule in polynomial time. In the second stage, allocation of instructors is done, within seconds, using specially designed algorithms.

Multiobjective Flight Control System Design

Student : Lam Wooi Fun
SMA Supervisor : Assoc Prof Murali Damodaran
Company Supervisor : Dr Yang Guang Hongo

Project Abstract:

Two types of multiobjective flight controller are designed. The first multiobjective flight controller is a controller that can be used during normal flying condition to control the aircraft from some disturbances and on the same time, this controller can also be used when control surfaces like aileron or elevator fail to do their respective control job. To design this controller, state feedback control law involved and Linear Matrix Inequality (LMI) based approach is used. Two types of LMI based approaches are implemented. The first approach is standard LMI based approach and the second approach is iterative LMI based approach. The controller designed using iterative LMI approach achieved a significantly better performance in normal flying condition, whereas in failure case, the controller maintained an acceptable performance. Overall, iterative LMI approach is more outstanding than standard LMI approach because its related optimization and simulation results proof wise. Both approach use H_∞ performance as the criterion for the aircraft to achieve robust stability and to reject the flying disturbances.The second

multiobjective flight controller that is been considered is a controller that can guide an aircraft down a predetermined flight path to the end of a runway and provide safe landing for the aircraft. Output feedback control is implemented and iterative LMI design technique is used to design this multiobjective flight controller. H_∞ performance and H_2 performance are introduced as the criteria so that the designed controller can result the aircraft to be more stable and regulate the tracking error to become zero.For the first controller, F-16 aircraft model is used as an example to proof that the standard LMI approach and iterative LMI approach can be used to design the multiobjective controller. On the other hand, to proof that the iterative LMI approach can be used to design the second type of the multiojective controller, a medium-sized transport aircraft model is considered.

Simulation of Cavitating Flows

Student : Lee Kien Leng, Lawrence
SMA Supervisor : Assoc Prof Khoo Boo Cheong
Company Supervisor : Dr Tsai Her Mann

Project Abstract:

The CE/SE method for solving the conservation laws is a high resolution and multidimensional numerical method that may have applications in the solution of many practical engineering problems. Its development lies in solving the integral form of the conservative equations and by discretizing the domain into Solution Elements (SE) and Conservative Elements (CE). The uniqueness of the CE/SE method lie in the fact that space and time is treated as a single entity that can be represented as coordinates in the Euclidian space. This report attempts to examine the numerical accuracy of the CE/SE method by solving some common engineering equations and problems. Good results were obtained. A CE/SE solver is then constructed to solve for a pipe flow problem with cavitation. Cavitation refers to the process of nucleation in a liquid flow where the pressure falls below the vapor pressure, the presence of Cavitation in fluids may cause certain problems in many engineering applications. A homogenous two-phrase flow model defined by a barotropic relationship between fluid pressure and density has been adopted for the cavitation model in this report. The model is applied to a Water Hammer problem which attempts to simulate the oscillatory flow in a pipe after an instance where the outlet or inlet valve is suddenly closed. It was observed from the results obtained that the current model adopted can model the pressure surges associated with the oscillatory flow but cannot model the cavitation accurately. This leads to suggestions that some conditions have to be specified in order to initiate the cavitation process.

Reliability of Multiprocessor Embedded System

Student : Liu Shudong
SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr Rajendra Patrikar

Project Abstract:

Embedded systems employed in critical applications demand high reliability and availability in addition to high performance. With SOC devices this requirement has

become more stringent because of common mode failures. Fault tolerant multiprocessors embedded systems can offer high performance as well as reliability. In such systems reliability depends upon the physical placement and logical placement. Because of the thermal generation, clock networks issues and most importantly distribution of manufacturing defects, placement issues have to be studied closely to achieve maximum reliability and yield. In this project, various topologies of multiprocessor system have been studied from physical implementation point of view. A program has been been developed with C++ to evaluate the reliabilities of different systems using combinatorial models and Markov models. Optimization of area and reliability will be done for commonly used network topology.

Modeling and Optimization of a Micro Comb Driven Fiber Optic Switches

Students : Liu Xiaoxing
SMA Supervisor : Assoc Prof Lee Kwok Hong
Company Supervisor : Dr Wang Zhiping

Project Abstract:

The demand for optical telecommunications has boomed during the past few years. In order to satisfy this demand, new optical switches are required to replace the electrical switches used up until now. In this thesis, a 1 X 8 micro-mirror optical switch is proposed. This two-dimensional (2-D) optical switch has large reflecting angles and low pull-in voltages. Electrostatic actuators are used to drive the structure. Theoretical analysis is conducted to investigate the working principles of the system. Three-dimensional finite element analysis is implemented to examine the response of the structure. The coupled-field analysis is realized with the use of the lumped electromechanical transducer elements together with the standard distributed mechanical elements. The pull-in voltages are obtained through increasing the applied voltage in small steps. Through the simulations, the functionality of the new optical switch is proved.

Real Time Crane Deployment

Student : Mayank Gupta
SMA Supervisor : Assoc Prof Sun Jie
Company Supervisor : Dr Tan Kok Choon

Project Abstract:

PSA Corporation is the world's largest container terminal operator and a leading provider of integrated port and logistics services. This project was part of its strategy to provide unrivalled automated container handling services. It involved modeling real time yard crane deployment and proposing an optimal deployment strategy for yard cranes. It also included the development of a deployment engine for the same. The given real-life problem was modeled mathematically based on certain assumptions. The problem was then formulated as a transportation model with various modifications. These modifications included provision for delaying of jobs, non-integral demand of resources, and feedback approach. The total unimodularity property of the transportation network was maintained and it was solved as a Linear Program to achieve integral solutions. The proposed model for the problem was implemented on the Windows Platform In Microsoft

Visual C++ 6.0 environment. Though, ILOG's OPL Studio was used to solve the transportation problem, it is modular in structure and the OPL module can be easily replaced if required. The deployment engine meets the criteria of being sufficiently fast and robust for real-time deployment of yard cranes.

Single and Multiobjective Wing Planform and Airfoil Shape Optimization using Swarm Algorithm

Students : Ng Kuan Ying
SMA Supervisor : Asst Prof Tai Kang
Company Supervisors: Dr Tsai Her Mann, Dr Tapabrata Ray

Project Abstract:

The shape of a wing greatly influences the performance of an aircraft as a poor shape attribute to large drag, lack of control and inadequate strength. The wing planform shape and airfoil optimization problems manifest themselves in different single and multiobjective, unconstrained and constrained forms. In this dissertation, we present various forms of both wing planform shape and wing airfoil optimization problems and report the results of shape optimization using a swarm algorithm. The swarm algorithm is coupled with a flow solver to assess the performance of the wing. Several examples are discussed in this paper; the first deals with the minimization of the drag coefficient (C_D) of a wing planform with a constraint on the lift coefficient (C_L), the second example is a multiobjective optimization problem that aims to minimize both the drag coefficient and the weight of the wing while the third aims to derive the shape of an airfoil for a given planform that minimizes the drag while maintaining a required lift. The results demonstrate the flexibility of the swarm algorithm in solving various wing optimization problems.

Chip Planning for FPGA IC Design

Students : Ong Chen Guan
SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr Olivier Peyran

Project Abstract:

Typically, FPGAs have very hard constraint on size due to its fixed dimension design architecture. Therefore, it is desirable to consider chip planning for FPGA with arbitrarily shaped rectilinear block. This dissertation proposes a two phases approach for rectilinear block chip planning. *Phase I* solves the multi-objective chip planning problem by using Genetic Algorithm. A new concept, which is called the envelope is introduced to minimize the maximum path delay. *Phase II* improve the total layout area utilization while maintaining the optimal delay gained from *Phase I*. A linear programming model is proposed to solve the compaction problem.The benchmark data is modified for experimental testing purpose. The statistical results shows that the area will be improved from 1.93% to 17.51% by using the *Phase II* solution method. In the rectilinear block chip planning, the resulting area outperforms the rectangular block chip planning by 2.63% in average. The result also shows that the optimal delay value gained from the *Phase I* solution method will not be destroyed during the *Phase II* solution method.

S.M. Project Abstracts 2001/2002
HPCES Programme

Optimization of Active Constrained Layer Damping Treatment for Sound Radiation Control of Cylindrical Shells

Student : Pau Shu Heng, George
SMA Supervisor : Assoc Prof Liu Guirong
Company Supervisor : Dr Zheng Hui

Project Abstract:

The structural volume displacement (SVD) of a cylindrical shell with Active Constrained Layer Damping (ACLD) treatments is optimized through optimal design of the open-loop system. It consists of finding the optimal layout of ACLD patches which minimizes the SVD. Evaluation of three different nonlinear optimization methods based on a Euler-Bernoulli beam is first presented and genetic algorithms has proven to be most suitable for this optimization problem. Application of genetic algorithms to layout optimization of multiple patches on a cylindrical shell has obtained an layout with low SVD unattainable through logical deduction. Effects due to number of patches, shape of the patches and total amount of ACLD in terms of % added weight are also determined. Examination of the optimal layouts reveals a general configuration with patches distributed in the axial direction. The optimal design of closed-loop ACLD treatment of beam has also been determined to provide an indication of the possible further sound radiation reduction in the ACLD treatment of cylindrical shell.

Development of Effective Constraint Handling Methods for Constrained Optimization Problems

Student : Poan Choy Ling
SMA Supervisor : Asst Prof Tai Kang
Company Supervisor : Dr Tapabrata Ray

Project Abstract:

Most evolutionary constrained optimization methods make use of better performance solutions to guide the search direction, i.e. the new generations of solutions are the mating results of the good solutions. A new idea of utilizing inferior performance solutions (bad solutions) to guide the search direction is presented in this project. Two strategies and two operators (Bad Cross and Good Cross) are developed in this project. A Performer Classification is performed before both strategies, where the information from the constraint matrix is derived to classify the initial solutions into two lists, namely Good Solutions List (GL) and Bad Solutions List (BL). Individuals in these two lists will be replaced accordingly throughout the iterations. In Strategy 1, all individuals in GL are copied to the next generation. To replace individuals in BL, two solutions with closest parametric values in Bad Solution List are chosen as the parent solutions. Bad Cross operator is applied to the parent solutions to generate a new child solution, which has a better quality in objective value and constraints satisfaction. This step is repeated until all original solutions in BL are replaced by the child solutions generated. In Strategy 2, the better performers in GL are put into Elite List (EL) and the rest remain in GL. EL is directly copied to the next generation to preserve the top performers throughout the generations. Individuals in GL are mated With individuals in EL using Good Cross Operator to generate new child solutions, which will enter next generation. Individuals in BL are replaced as stated in Strategy 1. As proof of their utility, the strategies were used

to solve four well-studied single objective optimal test problems and four engineering problems. Solutions obtained by the strategies compare favorably against those of other optimization approaches documented in the literature.This project is a preliminary approach to utilize inferior performers to generate better quality solutions in the optimum searching process. This idea of using Bad List to guide to search direction has potential to be further developed.

Simulation of One-Dimensional Detonation Waves using the Method of Conservation Element and Solution Element

Student : Sandeep Somani
SMA Supervisor : Assoc Prof Khoo Boo Cheong
Company Supervisor : Dr Tsai Her Mann

Project Abstract:

Detonation waves arise in the study of combustion and flame propagations. Numerical simulation of detonation waves has been a key research area in recent past. Mathematically, hyperbolic conservation laws governing chemically reacting flows describe detonations with special models used for simulating combustion. Due to the large difference between the time and space scales of gas dynamic flow and chemical reaction these problems often show severe 'numerical stiffness', which make them a challenge for the Computational Fluid Dynamics (CFD) tools. In the past, various high-resolution shock-capturing CFD schemes like Total Variation Diminishing (TVD), Essentially non-oscillatory (ENO), piece-wise parabolic method (PPM) have been used for detonation wave simulation. In this work we investigate the viability of a relatively recent method called the *Conservation Element/Solution Element (CE/SE) method*, for simulating detonation waves. CE/SE is a numerical framework for solving hyperbolic conservation laws. In this work, detonation wave simulation on both resolved and under-resolved meshes was done and the results compared with schemes like TVD. On an under-resolved mesh the results were qualitatively better than those obtained by TVD. On a resolved mesh the two methods were found to be almost equivalent. To improve the under-resolved simulation the technique of *Random Projection* was used for the treatment of the source term.

Back Solving Strike and Barrier for Options and Option Based Structures

Student : Song Miao
SMA Supervisor : Asst Prof Toh Kim Chuan
Company Supervisor : Mr Milind Kulkarni

Project Abstract:

Option is a financial product that is widely used in financial engineering and risk management. With its special payoff pattern, option based structures can achieve various payoff pattern so as to satisfy different needs. Due to the complexity of the payoff pattern, it is very common that the customers can only give their requirements of the payoff pattern and the total price, and the dealer should design the products that satisfy their needs. However, the pricing functions for options and option structures are usually too complex to give a straightforward back solving method, and some of them even do not have an analytical formula. Therefore, the procedure to decide the

parameters is done manually, which results in inefficiency of transactions. The purpose of this project is to give an efficient method to design the products. Given the type of option or option based structure, its total premium and one unknown parameter, all the possible values of the unknown should be solved.In this study, this problem is modeled as solving nonlinear equations. When back solving parameters for single options, the back solving method is selected from Newton's method, secant method and Brent's method. The method used must be the one that converges fastest among all the applicable and stable methods. When back solving parameters for option structures, except for back solving strike for synthetic forward, the behavior of its pricing function is hard to predict and the number of roots is unknown. In that cases, back solving method must combine with optimization, root finding and mathematical control logic so as to assure the stability of the method.

Stochastic Search Algorithms for Airfoil Shape Optimization Problems

Students : Tan Chee Meng
SMA Supervisor : Asst Prof Tai Kang
Company Supervisors : Dr Tsai Her Mann, Dr Tapabrata Ray

Project Abstract:

Most stochastic search algorithms use fixed bounds for the design variables. This approach requires a-priori knowledge of the variable bounds and the process of optimization will always result in a solution that is within this space. In this paper, we present a stochastic search algorithm embedded with an Adaptive Search Space Operator (ASO) that is capable of moving the bounds of the search space towards more promising regions through the use of shrinking, expanding and shifting. The behavior of the ASO has been illustrated using four mathematical functions and an airfoil shape optimization example. The study clearly indicates that ASO is easy to implement and it helps an optimization algorithm to explore regions beyond the initial bounds in search for better solutions. Evolutionary Algorithms (EA) and SWARM algorithm (SA) are two different classes of stochastic search algorithms. In this dissertation, EA is compared with SA on a set of five well-studied airfoil shape optimization problems. The examples include the Inverse Airfoil Design, Single Objective Unconstrained Airfoil Design, Single Objective Constrained Airfoil Design and Multiple Objective Airfoil Design. The preliminary findings indicate that the EA outperforms SA in the single objective problems in terms of the computational efficiency while for multiple objective problems, SA exhibits better performance in locating better Pareto fronts. Stochastic search algorithms are known to be computationally time intensive for shape optimization problems. In order to reduce the computational time, it is attractive to incorporate variable fidelity solution schemes within stochastic search methods. Such methods are guided by low fidelity computations during the initial exploratory phases of search and high fidelity computations towards the end of the search. In this dissertation, we present a stochastic parallel search algorithm that is embedded with a decaying variable perturbation mechanism and a multigrid Euler solver that can perform low, medium, high and variable fidelity computations. The performance of the parallel stochastic search algorithm has been studied on two airfoil shape optimization problems. The results obtained using the variable fidelity solution scheme (one that progressively uses low, medium and high fidelity computations) are compared with the results obtained using a low fidelity, medium fidelity and a high fidelity solution scheme on two well-studied airfoil design examples. The study provides insights on the effects of solver fidelity on the progress of

the parallel stochastic search and the quality of the final solution. It highlights that the use of variable fidelity solution schemes can lead to substantial savings in the computational time without significant compromise on the quality of the final solution. The results also suggest that in order to successfully use a reduced level of fidelity to guide a stochastic search, care should be taken to ensure a rank correspondence between the high fidelity and the reduced fidelity schemes.

Selection Model for Ship Selections

Student : Tan May Ling
SMA Supervisors : Assoc Prof Murali Damodaran, Assoc Prof Teo Chung Piaw
Company Supervisor : Mr Mark Lim Yew Guan

Project Abstract:

The Marine Port of Singapore (MPA) conducts inspections on vessels that call in the Port of Singapore. The department in MPA reponsible for foreign ship inspections is the Port State Control (PSC) department. Depending on the individual Authority's national policy and capability, a targeted number of ships need to be inspected each year. This project aims to calculate the maximum capacity of Port State Control department so as to set an attainable target and determine the number of men needed to fulfil the future regional target of Tokyo MOU. Another aspect of ship inspection is the selection of ships to be inspected. The role of the Port State Control department is to make the Straits of Singapore safe for shipping. It strives to reduce the number of sub-standard ships operating in the region. Therefore ships more probable of detention should be chosen for inspection. From an experienced inspector's previous selection data, a selection model with constraints faced by inspectors was developed so that ships could be selected automatically and the ships selected will be similar to what an inspector would select manually. The attributes that are considered during ship selections are assigned values in order of its detention rates. Weights corresponding to each attribute's importance to the inspector's selection. The weights depend on each attribute's importance to the inspector's selection. The weights are then further adjusted with several sets of selection data to find a calibrated set of weights to be used in the selection model.

Computational Fluid Dynamics Study of High Performance Liquid Chromatography

Student : Tan Sock Ngin
SMA Supervisor : Assoc Prof Khoo Boo Cheong
Company Supervisor : Dr Lim Chia Ni

Project Abstract:

The separating characteristics of high performance liquid chromatography (HPLC) columns with different inlet and outlet geometry are investigated using computational fluid dynamics (CFD). Gradual expansion and contraction is introduced at the inlet and outlet in fritless columns and columns with frits. Column efficiency is measured in terms of the height equivalent of a theoretical plate (HETP) and skewness of the eluted peak. For fritless columns, performance is improved at the expense of higher drop while performance is reduced for columns with frits.

S.M. Project Abstracts 2001/2002
HPCES Programme

Timetable Scheduler for ITM (Integrated Training Manager)

Students : Teo Soo Kng
SMA Supervisor : Assoc Prof Teo Chung Piaw
Company Supervisor : Mr Yeo Jan Chee

Project Abstract:

The Defense Science Technology Agency (DSTA) is considering the development of a web-based scheduling system that will replace the existing process of manual timetable planning done in Ordnance Engineering Training Institute (OETI), which is an army training school. The feasibility of such a concept was proved to be workable when a web-based scheduling prototype was successfully developed that incorporated a Java interface with an Oracle database and a C++ scheduling engine. The Java interface is used to invoke the entire process by extracting the relevant information pertaining to the course from the database before dispatching it to the C++ scheduling engine. The results obtained are then returned back to the Java interface and subsequently displayed in the form of a Gnatt chart. Thus, the focus of the thesis after the initial development work is to focus on the formulation of the actual data obtained from OETI. Due to the complexity and size of the problem, a decomposition (two-stage) approach to solving the problem was adopted. This thesis will focus on the first stage of the problem, which is the scheduling phase and in particularly the heuristic search technique used to improve the computational time and quality of the solution. The results of the scheduling phase obtained using our heuristic technique and the predefined search goal in ILOG Scheduler's library are both presented for a variety of problems and we can verify that our heuristic technique tends to perform better for the type of problem that we are considering.

Benders Decomposition for Stochastic Program

Student : Ting Shang Kee
SMA Supervisor : Assoc Prof Huang Huei Chuen
Company Supervisor : Mr Gosselin Vincent

Project Abstract:

Benders Decomposition is a method used to solve multistage stochastic problems. This class of problems is often exponential in size. In this project, a Multistage Benders Decomposition program is created, using ILOG CPLEX 7.1 as the linear programming engine. This project also formulates a multistage maneuver problem that is solved using the Benders Decomposition program created. Comparison is made between solving the problem directly using ILOG CPLEX as one big problem versa the Benders Decomposition. Results show that solving the problem directly is much faster than using the decomposition technique. However, when the problem size becomes too big for the direct method, Benders Decomposition is the alternative method for solving the problem. Lastly, the project also simulates the maneuver problem with the help of JACK, an agent-oriented programming software.

Virtual Reality for Reverberation Chamber E Field Simulation

Student : Wang Hailong

S.M. Project Abstracts 2001/2002
HPCES Programme

SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr Zhang Daming

Project Abstract:

Over the past several years, reverberation chambers have grown in popularity for radiated immunity testing. Firstly, this paper introduces the statistical nature of a reverberation chamber. Then, methodology and procedure of using Ansoft HFSS to simulate the electric field distribution in a reverberation chamber are given. Finally, details of a software tool developed for visualization of the electric field distribution in the reverberation chamber are given. This software tool is written in OpenGL and C++ languages. It presents the virtual reality of pattern change of E field distribution in the visualization facility, CAVE. Pictures of scene of simulation in CAVE are shown.

Numerical Investigation of the Performance of Fluid Film Journal Bearings
Student : Wang Zhengyuan
SMA Supervisor : Assoc Prof Murali Damodaran
Company Supervisor : Mr Zhang Qide

Project Abstract:

This dissertation numerically investigates the performances of both plain journal bearings and herringbone groove journal bearings, with special attention to the latter. The attitude angle, load capacity, stiffness coefficients and damping coefficients are computed. The effects of groove number, groove angle, groove depth, ridge/groove width ratio as well as bearing length on the performances of the bearing are presented in details. Some results are compared with related literature and agreements are reached. Some guidelines for bearing design are then drawn.

Modeling and Optimization of Micro Comb Driven Fiber Optic Switches
Student : Xu Jianfeng
SMA Supervisor : Assoc Prof Lee Kwok Hong
Company Supervisor : Dr Wang Zhiping

Project Abstract:

Two kinds of comb driven mirror switches based on the silicon fabrication technique are investigated in this work. The switches introduce comb driven actuators. The finite element method was employed to determine the electrostatic and mechanical behavior for both kinds of switches. Detailed analysis was carried out using a lumped modeling technique, as well as using the finite element software package ANSYS v6.0. The stress distribution in a comb structure was studied at a given input voltage. The response rate of mirror in switching operation was also established. Further optimization of the comb driven mirror structure to decrease the resonant voltage was also studied.

Single Carrier Cyclic Prefix Assisted CDMA for High Speed Wireless Communication Systems
Student : Yang Kai

S.M. Project Abstracts 2001/2002
HPCES Programme

SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr A. S. Madhukumar

Project Abstract:

Brand Wireless access technologies, offering more than tens of megabits bit rates, are attractive alternatives to broad wired access technologies. Single Carrier Cyclic Prefix Assisted CDMA system(SCRIP-CDMA) with Frequency Domain Equalization, which combines the advantages of Single Carrier CDMA (SC-CDMA) and Multi-carrier CDMA(MCCDMA), is a potential technology candidate for this wideband access. In this project, the downlink receiving scheme with Frequency Domain Equalization and Diversity Combining is implemented. The Bit Error Rate performance for each Diversity Combining methods are evaluated for Single user and Multiuser cases. Furthermore, We suggest a novel Multiuser Detection (MUD) method for the asynchronous uplink transmission, which applies the Successive Multistage Interference Cancellation (MSIC) with Interference Rejection Weight Control (IRWC). In order to reduce the demodulation time delay we propose a hybrid system which combines the Successive Interference Cancellation (SIC) and Parallel Interference Cancellation (PIC). A new channel estimation method based on space-time processing is also suggested for this system. Substantial simulation work is used to evaluate the performance of this scheme. The result demonstrates Single Carrier Cyclic Prefix Assisted CDMA with Frequency Domain Equalization is an attractive candidate for future wideband wireless access technologies to broadband internet.

Error Performance of a Multiple Access Based Ultra-Wide Band System
Student : Zeng Huiwen
SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr Francois Chin

Project Abstract:

This thesis introduced some basics on Ultra-wideband signals, including the history and special features about these UWB signals followed by the on-going research effort in this area. A possible scheme with low complexity for multiple access based UWB is proposed, which have been proved by the simulation of this project to have better performance in multi-user and multi-path environment. Simulation models are explained in details and the result is analyzed and compared with a special CDMA system based on complete complementary codes. Simulation result shows that this UWB system excels conventional CDMA systems especially in a multi-access environment.

A Heuristic for Real-Time Container Load Sequencing
Student : Zhang Changyong
SMA Supervisor : Assoc Prof Sun Jie
Company Supervisor : Dr Tan Kok Choon

Project Abstract:

The problem of real-time slotting, generating a sequence to load all export containers for one vessel and modifying the sequence in real-time, is discussed. Since the number of

containers to be loaded in the yard is equal to that of the cells available on the vessel, slotting can be regarded as a contain-to-cell assignment problem. Usually, the speed for a quay crane to handle a container is approximately twice as that for a yard crane to do. Therefore, in order to minimize the turnaround time of a vessel, it is required to reduce the possibility of yard clash, one quay crane eating two consecutive containers from the same yard crane, which will force the quay crane to wait for the arrival of the second container. The problem is proved to be NP-hard, and two algorithms are developed for the whole process. The first one is a greedy algorithm to do slotting before the berthing of a vessel; the other one is aimed to modify the loading sequence in real-time, according to the practical arrival order of the containers. The latter is implemented under C++ and Visual C++. It is tested by practical data files from PSA, and it turns out that the algorithm works well.

Method for a Bridge Toplogy of 3-Level IGBT Converters

Student : Zhao Zhengyi
SMA Supervisor : Assoc Prof Li Le-Wei
Company Supervisor : Dr Rajendra Patrikar

Project Abstract:

Modelling and simulation for semiconductor devices are growing interested by the electrical and electronics researchers, engineers as well as the manufacturers. Especially, when they try to deal with smaller and smaller devices, the problem becomes more and more complex. Conventional approach by modeling from the physical equations becomes even more complex, while another approach by numerical modeling seems more attractive by its straightforward idea. From the application's or manufacture's point of view, some advanced semiconductor devices are invented by combining the advantage of the conventional devices. One example of such devices is IGBT(Insulated Gated Bipolar Transistor), who combines the advantage of the gate property of MOSFET(Metal Oxide Semiconductor Field Effect Transistor), and the conduction property of BJT(Bipolar Junction Transistor). They just appeared before people could model and simulate for them. This paper tries to find an approach to modeling for IGBT as well as a modeling scheme for general semiconductor devices. Then applying this model, a kind of bridge topology in 3-level IGBT converters is simulated. A lot of research is carried on the Look-Up Table(LUT) methods, including the coon's surface patching and B-spline generation, both of which form the origination of this LUT method. Much comparison is made between the popular simulation softwares and the new-developed simulation software – SEQUEL(Solver for circuit Equations wi th User-defined Elements) which is based on the LUT modelling scheme. The structure of IGBT is introduced before a circuit model of IGBT is introduced. It will be noted that the circuit model seems quite different from the physical model. However, this circuit model is very efficient and is also valid, which is demonstrated by the DC(Direct Current) analysis. NPC(Neutral Point Clamping) three level topology is a much younger one for power converters than the conventional two level topology. Its operation, as well as the snubber unit, has much more unique properties than the two level converters. So, the simulation for a bridge topology of 3-level IGBT converters is really a task for the simulators as well as the researchers. After detailed analysis, the simulation procedure is carefully designed and the task is solved by only two separate schematics. The schematics can run under the student version of TopSpice. And Final result is

satisfactory, because it can demonstrate the validity of the proposed bridge topology or 3-level IGBT converters.

S.M. Project Abstracts (2001/2002)
IMST Programme

Analysis, Appraisal And Improvement On Airbag Sensor Assembly Line

Students : Cao Zhe, Keh Teng Yang, Xu Qing
SMA Supervisors : Assoc Prof Bryan Ngoi Kok Ann (Singapore),
Prof Kamal Youcef-Toumi (MIT)
Company Supervisor : Dr Teo Kiat Choon

Project Abstract :

In this project, sensors most frequently used in automated assembly lines are studied, including displacement sensor, flowrate sensor, level sensor, proximity sensor, temperature sensor, pressure sensor, etc. Coriolis mass flowmeter is analyzed and proposed to provide control over opening and closing of glue dispenser. A displacer level sensor is carefully chosen to replacement the current ultrasonic sensor for better robustness in sensing fluid level. In addition, currently used proximity sensors-photoelectric and inductive-are benchmarked against others for better performance. Furthermore, the flexibility and accuracy of the cover pressing process are improved with a modular level design of the lever, and the application of aperture. Varying joint speed and acceleration of Cartesian and cylindrical robots using IGRIP simulation, different sets of cycle time are obtained for the idea of line balancing. Cartesian and cylindrical robot manipulators with the same paths are simulated for comparison of cycle time. Such data as torque and speed for each joint are obtained with IGRIP, and working envelope is calculated. Advantages and disadvantages of manipulators are discussed, and differences are compared.

Collaborative Product Commerce For The Product Life Cycle Of Hard Disk Drive Industry

Students : Chen Ke, Lee Sheng Yang, Tian Quan, Wong Pei Lee
SMA Supervisors : Assoc Prof Loh Han Tong (Singapore),
Prof David Hardt (MIT)
Company Supervisor : Dr Liu Zhejie

Project Abstract :

This research endeavor was carried out under the support of the Data Storage Institute of Singapore. In the course of the research, information was obtained from both the HDD industry and the technology vendors through interviews, web-search, literature research and hands-on usage of CPC solutions. Investigations revealed that while indeed CPC solutions offer benefits capable of streamlining an enterprise operation, the available technology is perhaps not packaged and presented in the optimum way for industry take up. There exist avenues for accommodation by both parties to bring out the full benefits of CPC solutions. Based on the information and impression gathered in the course of the research, a set of recommendations for both the technology vendors and HDD industry players was proposed. It is hoped that these recommendations will help to strike a compromise upon which both parties may act to enjoy better mutual benefits.

Multi-Agent System-Based Supply Chain Coordination

Students : Cheong Lee Fong, Jeong Woo Sung, Pallav Chhaochhria,
Yin Zhijie

S.M. Project Abstracts (2001/2002)
IMST Programme

SMA Supervisors : Asst Prof Rohit Bhatnagar (Singapore),
Dr Stanley Gershwin (MIT)
Company Supervisor : Mr Roland Lim

Project Abstract:

The 4PL is able to work with multiple manufacturers and transporters and select the best options available from the transporters and manufacturers. Even in the simplest case of 2 manufacturers and 2 transporters, each bidding for 4 quantity levels of the products and 2 lead time combinations for each bid quantity, the results show an improvement of 5.73% on an average and as high as 21% for the 4PL model over the customer's best possible solution, and an average of 63.6% improvement over the customer's worst possible solution. If we extend the 4PL model to include more manufacturers and transporters, and increase in the number of combinations of the quantity levels – lead times that each manufacturer and transporter submits, we will approach a global best solution that selects the "best" combination of manufacturer(s) with the "right" quantities, "right" due date and "right" price, which complements the "best" combination of transporter(s) selected, and the total combination matches the customers' orders.

Building An Intelligent E-Diagnostic System For Reducing Mean Time To Repair (MTTR) Of Wire Bond Machines

Students : Du Xian, Sunil Bhandari, Wang Xiaobo
SMA Supervisors : Assoc Prof Appa Iyer Sivakumar (Singapore),
Prof Kamal Youcef-Toumi (MIT)
Company Supervisor : Mr Gary Chen

Project Abstract:

In today's cost driven semiconductor industry, utilizing the available capacity to its maximum limits is prime for being competitive. With the equipments being expensive and the technology changing very fast, utilization of the available resources, by minimizing the repair time brings to the forefront production capacity that would have otherwise stayed hidden or lost. The other key issue that any company needs to address is that repairing complicated machines (such as Wire Bond) requires training of personnel and this leads to extra costs. Thus a system was felt necessary that would incorporate the knowledge base of the most skilled maintenance engineers and also aid in online breakdown diagnosis, so as to reduce MTTR. The e-Diagnostics system that has been developed as a part of this project aims at making a wholesome online diagnostics tool. This e-Diagnostics system also aims to centralize the database of all the wire bonding machines, thus easing the access of information and providing key information, that would otherwise require another tool such as data mining. This system would hence provide a long-term solution to the company, as it can be modified to serve machines other than Wire Bonding machines.

Issues and Development for an Automated Welding Station Using Robotic Arm

Students : Gu Jiayin, Pan Deng
SMA Supervisors : Assoc Prof Xie Ming (Singapore),
Prof David Hardt (MIT)
Company Supervisor : Assoc Prof Xie Ming

S.M. Project Abstracts (2001/2002)
IMST Programme

Project Abstract :

The objective of the first part of work is to develop a detailed method for collision-free path planning of welding robot at the same time guarantee the welding quality to increase the automation level of welding industry. Three main steps are involved. First, the factors that determine torch orientation are found from the welding quality point of view. Secondly, the mathematical optimization model of torch orientation is built. Finally, heuristic searching method is used to search optimal value of working angle and walking angle, while the rotating angle is determined by binary tree searching. In this thesis, the economic situation of the welding industry has been analyzed, and a conclusion has been made that to do the cost analysis for the welding system is necessary and helpful for such industry to improve productivity, reduce cost, and increase profit. Furthermore, the cost elements of the welding system have been identified, and the corresponding cost calculation method and cost forecast method have been put forward.

Next Generation Manufacturing In Singapore

Students : Ker Han Seah, Liu Ying, Lu Jinhan, Ong Wee Leng, Tang Kum Cheong
SMA Supervisors : Assoc Prof Bryan Ngoi Kok Ann (Singapore), Prof Chun Jung-Hoon (MIT)
Company Supervisors: Mr Warren Wang, Dr Terence Loke

Project Abstract:

It was realized that the much more value has to be added through upgrading the entire manufacturing sector by developing a new set of skills and capabilities, collectively known as Next Generation Manufacturing (NGM). Thus, the main aim of this report is to investigate how NGM can be applied to the Singapore context in preparation for tougher competition in the years to come. Through gathering feedback from postal surveys and research studies, the team managed to identify five essential elements of NGM that include people development in a knowledge-based economy, handling competition in business, enterprise integration or resource pooling, active utilization of new technology and lastly, environmental responsibilities during manufacturing. In addition, these imperatives indicate that for Singapore to emerge successful in the midst of heavy challenges, it is necessary for radical changes to take place. Mindsets have to change before others can be convinced to change and adaptability coupled with agility will become the mainstay of NGM.

Micro-Machining Of Silicon And Metals Using Femtosecond Laser

Students : Koh Wee Leong, Wang Lei, Wong Thai Yuan, Zhang Yilei
SMA Supervisors : Prof Lam Yee Cheong (Singapore), Prof Yue Chee Yoon (Singapore), Prof Lallit Anand (MIT)
Company Supervisor : Dr Zheng Hongyu

Project Abstract:

S.M. Project Abstracts (2001/2002)
IMST Programme

The objective of this project is to investigate the application of femtosecond lasers to micromachining. Specifically, the effects of the femtosecond laser on silicon and metals will be explored. Two specific applications will be considered in this investigation, they are the dicing of silicon wafers and manufacturing of metallic stents. The work done includes the optimization of the laser cutting process and an investigation of the key effects. A simulation of the laser cutting process on silicon was developed. The machining of a planer stent pattern using the femtosecond laser was also carried out. In addition the business and competitivity concerns of using the femtosecond laser for the abovementioned applications will also be studied. This is done to give a complete understanding of the entire process.

Supply Chain Planning Of Global Electronics Manufacturer For Short Life Cycle Products

Students : Lee Kok Eng, Suruchi, Xing Xiaojun
SMA Supervisors : Asst Prof Velusamy Subramaniam (Singapore),
Assoc Prof Appa Iyer Sivakumar (Singapore),
Prof Stephen Graves (MIT)
Company Supervisors: Ms Sharon Leow, Mr Ramesh Nair

Project Abstract:

The following thesis proposes scientific methodologies to look at some issues of the supply chain such as Capacity Planning, Production and Procurement Planning. The performance of supply chain is limited by capacity constraints on the system. Hence, it becomes vital to plan capacity wisely in anticipation of certain demand. The thesis presents an effective method for planning capacity in terms of equipment selection and resource allocation. The next stage after Capacity Planning is that of production itself and various tactical modes for production management are suggested. One model utilizes a fast transportation mode to reduce lead-time while the other model tries to compensate for the obsolescence cost by introducing the concept of obsolescence risk. The high fluctuation in demand also gives rise to the need of an effective procurement plan so as to minimize excess and obsolescence costs. The amount of safety stock that needs to be set in such a scenario is presented, as inventory costs are a significant contribution to the excess costs incurred. The focus is on making the entire system more flexible at the minimum cost.

Tooling Cost Estimation Model for Injection Molding

Students : Padmanaban Ranganathan, Tran Duc Vi, Wang Lan,
Zhu Zhiqiang
SMA Supervisors : Dr Lu Wen Feng (Singapore),
Assoc Prof Tor Shu Beng (Singapore),
Prof Steven Eppinger (MIT)
Company Supervisor : Dr Ivan Lee

Project Abstract:

A tooling cost estimate model on injection molding, which is still in the concept design stage at the moment, is established in this report. Four major cost sources in the injection molding mould fabrication has been considered in this model. They are Design

Cost, Material Cost, Manufacturing Cost, and Testing Cost respectively. A set of formula used to model the relationships between the mould features and cost estimation outputs has also been introduced. Furthermore, an Excel application of this cost estimation model has been elaborated. In addition, two case studies in which data come from the current injection molding toolmaker in Singapore have been applied as model verification. As an alternative solution, we also compare a performance of Neural Network with regression model for different simulated experiments. As conclusion we have analyzed the formulating, implementing the solution and their limitations.

Issues in Manufacturing of Semiconductors For Wireless And Optoelectronics Applications

Students : Subhro Bikash Chakraborty, Wang Shiren
SMA Supervisors : Prof Yoon Soon Fatt (Singapore),
Prof Chun Jung-Hoon (MIT)
Company Supervisor : Dr Lap Chan

Project Abstract:

This paper tries to take an overview of the salient competing materials and technologies prevalent in contemporary semiconductor industry. Physics and figure-of-merit based comparisons are attempted for applications in wireless communications and optoelectronics. Then an attempt is made to arrive at a conclusion on the future of silicon and silicon-germanium technologies as compared to competing gallium arsenide and indium phosphide technologies. The paper ends with recommendations based on the authors' perception of the direction of growth of the semiconductor market in the immediate future period of about five years.

S.M. Project Abstracts (2001/2002)
MEBCS Programme

The S.M. Project Abstracts (2001/2002) for the MEBCS programme are confidential.

S.M. Project Abstracts (2001/2002)
CS Programme

HyperSCSI Network Protocol Driver on Sun Solaris Platform for Network Storage

Students : Aditya Kumar Gupta, Toni, Ou Hanyan, Zhao Qin
SMA Supervisor : Asst Prof Lee Wee Sun
Company Supervisor : Mr Patrick Khoo Beng Teck

Project Abstract:

A new protocol called HyperSCSI is being developed and implemented by DSI. This protocol is used for the transmission of Small Computer Systems Interface (SCSI) family of protocols across a network and multi-technology device support. It is an alternative solution to current methods exist for network storage. In this report, a feasibility study of Local HyperSCSI over Ethernet (HS/eth) implementation on Sun Solaris operating system is discussed. Important concepts involved in the implementation, e.g. DLPI, STREAMS and kernel module programming, are explained. Different strategies for its implementation design are analyzed and compared. Also, the implementation of a working framework for the HS/eth driver on Sun Solaris platform is explained.

Adaptive Update of Training Data for Gene Discovery System

Students : Ameya Virkar, Ang Huey Ting, Kunal Agrawal, Li Guoliang
SMA Supervisor : Assoc Prof Tan Kian Lee
Company Supervisor : Prof Vladimir B. Bajic

Project Abstract:

Bioinformatics is a newly emerging field that is attracting a lot of attention. In our project, we are working on some fundamental tasks in bioinformatics - the identification of various functional regions of a gene. To understand how the gene functions, the least one needs to do is to identify its functional components. In LIT, a gene prediction system is being built and our project forms the building block for this system. We built classifiers that identify the splice sites, translation initiation site and terminal exons of a gene. Genome sequences downloadable from public databases have either incomplete or unverified annotations on these functional regions. Our classifiers are used to clean up this data before they are used for further analysis.

Mobile Learning – "Learning Anytime, Anyplace"

Students : Anuradha, Shakun Mahajan, Wu Jie, Wu Yonghua
SMA Supervisor : Assoc Prof Leong Tze Yun
Company Supervisor : Dr Wing Lam

Project Abstract:

Mobile E-learning is a natural development in the product evolution of conventional E-learning. In many ways it is recapitulating the evolutionary process that E-learning experienced as it emerged from traditional classroom training. The progression towards mobile E-learning is part of a general trend toward ubiquitous and pervasive computing.
The convergence of mobile communications and handheld computers offers the opportunity to develop technology that will assist individuals and groups to learn

Anytime, Anywhere. The project delivers an integrated learning strategy by combining e-learning and mobile learning. A thorough technological study and assessment of current e-learning methodologies is followed by development of a working prototype system for imparting knowledge via personal mobile systems for life-long learning. The entrepreneurial aspect of the project deals with developing a commercial and technological strategy for ISS.

MPEG-7 Based Indexing and Summarization of Digital Media for Online Learning

Students : Chen Yan, Low Wai Chong
SMA Supervisor : Assoc Prof Wong Weng Fai
Company Supervisor : Dr Edward Altman

Project Abstract:

Current online courseware does not provide end-users with the flexibility that is inherent in traditional course materials such as textbooks and live lectures. One way of achieving this is to have an index of lecture videos. Video analysis is done on the lecture videos to identify events that occur in order to segment the video into event descriptions. These events include underscoring events, pointing events, erasing events, drawing and writing events. A program was written to facilitate the video analysis by providing the end-user with various video processing techniques, and thus the ability to semi-automatically or automatically index the video. Analysis techniques on lecture videos taped by a single camera include five steps: boundary detection, hand detection, hand tracking, track calibration and events identification. The lecture browser provides the end-user with functionalities not present in generic video players. XML technology was used to provide the index of the lecture materials. In addition to allowing the end-user to navigate through the videos and slides by topic, the lecture browser allows the end-user to do a search through the content using keywords. Two methods of navigation were implemented: the hyperbolic tree, and the table of contents. A survey was conducted among students of the SMA-CS course, and proved that the idea of having a lecture browser is a step in the right direction to providing better tools for efficiently making use of online courseware. However, the hyperbolic tree is a less preferred form of navigation as students find it to be slightly confusing.

Feasibility Studies in the Globus Toolkit

Students : Edward Sim Joon, Qiu Long
SMA Supervisor : Assoc Prof Teo Yong Meng
Company Supervisor : Ms Tan Joo Geok

Project Abstract:

Grid computing has emerged as an important new field of research in computer science that is distinct from conventional distributed computing with its promise of large-scale, flexible, secure and coordinated resource sharing. The Globus project is a world-leader in Grid research and the Globus toolkit has been developed for the purposes of providing a Grid infrastructure. This report focuses on the findings the authors found in their study of the Globus toolkit. The Globus toolkit is explained in detail with the issue peculiar to the Grid being fleshed out. The report concludes with its evaluation of the

Globus toolkit and a discussion of its relevance to the common understanding of Grid research.

Computerized Assessment of Essays

Students : Gunjan Kathuria, Wu Wenjun
SMA Supervisor : Assoc Prof Wynne Hsu
Company Supervisor : Dr Looi Chee Kit

Project Abstract:

Several standard text categorization and information retrieval techniques have been applied to the problem of automated essay grading. This project is rational reconstruction of Latent Semantic Analysis (LSA), an effective method for extracting and representing contextual usage meaning of words by applying statistical computations to a corpus of text, to develop a prototype application for grading essays. The intuitive idea behind LSA is that the meaning of a document is the aggregate of the meanings of the contained words. Inspite of its limitations in distinguishing word order, LSA is a very appealing technique due to its simplicity, its success in emulating human representation of knowledge and its superiority in tackling the synonymy problem. All techniques that enhance LSA's discriminating ability; text pre-processing, information theoretic weighting, singular value decomposition with dimension reduction and cosine similarity measures, have been incorporated to culminate in a complete prototype. The adequacy of the prototype in assessing essays has been established by experimentation on a corpus on Great Depression. The results achieved are comparable to those of Intelligent Essay Assessor, a popular application also based on LSA.

Sound Model Representation

Students : Ma Keng Teck, Zhang Xianfeng
SMA Supervisor : Prof Ooi Beng Chin
Company Supervisor : Dr Lonce Wyse

Project Abstract:

We are looking for an efficient method to categorize the general sounds. The first thing is the representation of the sounds. An efficient presentation of sounds can keep the important feature information more densely than the complete spectral representations. We use two kind of representation of the sounds here: Mel Frequency Cepstral Coefficients (MFCC) and Independent Subspace Analysis (ISA). Both of them reduce the dimensions of sounds. We use two methods to train the models to categorize the sounds: Saul Jordon Net (SJNet) and Hidden Markov Model (HMM). The different models are implemented, and empirical evaluations of the models are conducted. An extension to the ISA , which is the pre-classier is also derived and implemented and the empiricial evaluations are conducted.

Diffserv Implementation Using IXP

Students : Qian Haichun
SMA Supervisor : Assoc Prof Wong Weng Fai
Company Supervisors: Dr Jit Biswas, Mr Teo Eng Hwa

S.M. Project Abstracts (2001/2002)
CS Programme

Project Abstract:

The development of Internet has required the network to provide Quality of Service (QOS) using programmable routers. In the paper, IXP1200, one kind of network processor is introduced and Differentiated Service (Diffserv) structure is studied. Also we implemented Diffserv structure based on IXP testbed in the core network to provide QOS. In the Diffserv structure, some scheduling and queue management algorithms are used to provide different behaviors among different priority of queues. Some outputs are analysed to demonstrate the performance of Diffserv.

A Very High Speed Traffic Aggregator

Student : Qiu Qiang
SMA Supervisor : Assoc Prof Wong Weng Fai
Company Supervisor : Dr Jit Biswas

Project Abstract:

The exponential growth of network traffic is raising the line speeds of routers and switches. In addition, advanced services protocols and Quality of Service (QoS) control mechanisms, such as Differentiated Services (DiffServ), Multi-protocol Label Switching (MPLS), are being integrated into traditional packet forwarding router. Packet classification is needed for such advanced services that require the capability to distinguish and isolate traffic in different flows for suitable process. This thesis describes the design and implementation of a Very hIgh Speed Traffic Aggregator (VISTA) that uses the IXP1200 network processor to provide very high speed packet classification and packet forwarding. VISTA exhibits the following several features: a.) It could process packets at very high speed in *Data Plane*, e.g. packet classification and labelling, b.) The signalling protocols, e.g. Label Distribution Protocol (LDP), are supported in *Control Plane* without degrading the performance at *Data Plane*, c.) The set of services function supported is extensible by loading the particular forwarder on the fly.

Integrated Routing Algorithms for IP/DWDM Networks

Students : Yu Bei, Yu Jia
SMA Supervisor : Asst Prof Lee Wee Sun
Company Supervisor : Dr Zhou Luying

Project Abstract:

This paper presents new algorithm for dynamic provisioning and protecting the connection requests at IP/DWDM network. Provisioning the requests is to establish lightpaths at the optical layer as virtual connections for the requests. Protection is routing two link disjoint lightpaths for the request at the same time, so that in case of failures at the primary lightpath, the traffic on the primary lightpath can be transferred to backup lightpath to achieve QoS. The key point of this paper is to consider sharing the bandwidth of the backup lightpath to optimise utilization of network resources. The amount of sharing can be achieved is decided by the information available to the algorithm. Three information scenarios are considered. However, partial information scenario is our focus because it requires little information dissemination in the network.

S.M. Project Abstracts (2001/2002)
CS Programme

We developed algorithm that uses partial information to achieve good performance of sharing bandwidth. We simulated our algorithm in both IP/DWDM network and combined GMPLS network. The simulation results show that the proposed algorithm can efficiently improve the network utilization.

Intelligent Internet Video Content Caching

Students : Zhang Sheng, Yu Xiaoxue
SMA Supervisor : Assoc Prof Leong Tze Yun
Company Supervisor : Mr Michael Sipusic

Project Abstract: Confidential