S.M. Project Abstracts (2003/2004)

Explore and Enhance the Possibilities of Accelerated Testing during Short Life Cycle Product Development and Transfer to Mass Production

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Project Abstract :

This project focuses on the possibilities of enhancing the accelerated life testing of semiconductor interconnects. A reliable evaluation and measurement technique is developed, based on online monitoring of electrical parameters with high measuring resolution. Local monitoring of temperature and humidity with increased sampling rate provides a higher resolution and is far more effective in understanding the degradation mechanisms of semiconductor interconnects. Thus the new system provides a good predictive capability of the Mean Time to Failure (MTF) of adhesive interconnects. Also the present system isn't friendly enough for data handling and interpretation. Hence separate programs called – 'Real World & Deeper Analysis' have been developed for easy data handling and analysis.

Design, Implementation and Evaluation of Dynamic In-Flight Equipment Exchange Policy for Airlines Industry

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Project Abstract :

Many airlines, including Singapore Airlines (SIA), carry unused in-flight equipment between airports due to the need of balancing the number of equipments at the terminating airports. This current operating procedure is termed inventory deadheading or equal equipment exchange. Although simple by nature and guaranteeing a high service level, this policy wastes fuel and precious space onboard. The objective of this project is to build upon previous year's work to design a more robust Dynamic Equipment Exchange (DEE) policy and ultimately carry out a trial implementation to test its feasibility in real-life. In the first part of this thesis, the previous year's work is evaluated and an improved DEE algorithm that pegs the amount of equipment carried to an adjusted forecasted passenger load is explained. Differences in the equipment loaded for a number of inbound and outbound flights are tabulated and compensated for by distributing the net surplus or deficits over subsequent flights. In addition, factors like last minute passenger go-show/no-show to account for forecast error and equipment leakages are also taken into consideration using safety stocks. In the second part, a feasibility study on SIA's flight network was carried out to ascertain the flight routes suitable for the DEE implementation. Suitable routes are typically characterized by large variability in weekly demands for the specific flight routes and the presence of buffer inventories at the overseas stations. Having pinpointed the flight routes suitable for DEE implementation, software simulations were carried out on a specific flight route's data to validate the DEE algorithm. Results show that this new policy is able to minimize the amount of in-flight equipment by up to 50%. In addition, a lower level of buffer inventory could be achieved with less variability. Finally, in the last part, the implementation methodology on how to execute this policy is explained. The operational changes that need to be effected in various departments of SIA and its in-flight caterers were discussed, together with the various stages of implementation that would minimize the disturbances introduced into the airline's existing operations. A comparison of the policy's effectiveness over the existing system in terms of cost savings, operational efficiency and service levels is also provided to evaluate the success of this project.

Analysis, Scheduling and Planning of Wafer Fabrication Systems

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Project Abstract :

The wafer fabrication (fab) industry is a highly competitive industry. To stay in business, semiconductor companies compete not only on cost but also on other performance metrics, such as cycle time and on-time delivery. Wafer fab manufacturing has one of the most complex manufacturing systems. As such, to improve the wafer fabrication systems efficiency means to understand their complex operations. In this project, the authors are working on 3 specific operation fields: impact of variability on fab performance, capacity planning approach, and production scheduling methodologies at Chartered Semiconductor Manufacturing Ltd.

At first, a simplified wafer fab model is built by using a simulation tool, Autosched AP. Then selected scenarios are run on the simulation model. Analytical models are also built to analyze some parts of the fab. The overall objective is to investigate:

- Major factors affecting and interacting to influence the objective of stable cycle times and consistent wafer outputs.
- Desirable location of bottleneck that will ensure plant capacity meet targeted product mix and volume, be cost effective and minimize impact of variability.
- Optimum wafer release or any other scheduling methodologies that will reduce the capacity losses of some bottleneck furnaces.

Experiments carried out in this project show that wafer fab performance could be greatly improved by control over major factors affecting fab performance, optimal position of bottleneck at capacity planning level and optimal wafer scheduling policies.

Reduction of Production Lead Time in Metal Injection Molding (MIM) Process

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Project Abstract :
With miniaturization, products designed for commercial, domestic and military purposes are progressively smaller, lighter and more compact. MIM process has the advantage of low cost, high performance and shape complexity. This project adopts a holistic approach in developing a series of lead-time reduction improvements at the systems level (job shop scheduler) and process level (debinding process). On the systems level, the scheduling of time critical resources like debinding ovens and sintering furnaces are improved by an automated scheduler developed. The scheduler employs a hybrid of heuristics, greedy search and intelligent genetic programming techniques to continually approach the global optimal solution. On the process level, an investigation on the thermal debinding oven characteristics is done to provide a base for further process lead-time improvements. The identification involves modeling both analytically and numerically, based on the experimental data. It was found that the lag between the control temperature and the actual temperature of the part is mainly due to the heat resistance and capacitance of the part and secondly due to the inert gas flow rate used during debinding process.

Inline Color Sensing and Control Device for Printing Systems

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Company Supervisors	:	Mr Winson Lan & Dr Zhang Neng Sheng (A & P Co-ordinator Pte Ltd)

Project Abstract :
Color consistency is a major concern at the industry level, especially in print-media companies. Many studies had been carried out and it is shown that cyan-magenta-yellow-black (CMYK) colour values are not consistent between monitor and printed output, as well as visual interpretation. In other words, the color values are devices dependent. The same image can appear differently after a printing process under different conditions; color consistency is compromised.

Currently, colour print correction is still very much performed manually which relies on the eyes of a skilled and experienced operator to make the necessary adjustments to the printing machine. This method is highly subjective, time consuming, and leads to a lot of wastage. At present, there are very limited solutions to effectively replace the operator and make color correction more objective and efficient.

Existing color correction solutions mainly rely on using a scanner to obtain the picture output data from a printed sheet, performing the correction using a computer and updating the information to the printer for correction. Scanning is done offline, and requires manually transferring the paper from printer to scanner, making the process slow and tedious. A few patents have been filed that made claims on using inline sensing methodology to retrieve the image output and feedback the information to PC for correction.

The objective of this project is to develop an Inline Color Sensing and Control Device (ICSCD) for printing systems. The task is to set up the prototype of the inline colour calibrating system which consists of a scanning device, calibration mechanism, and final output device, and to demonstrate proof-of-concept of the inline colour calibration process. The scanning device used is a sheet-fed scanner, the calibration mechanism is the company's patented Focoltone software preinstalled on PC, and the final output device is the printer.

This project is focused on the two main aspects. The first aspect is to explore the control system for the scanning device and printer system to find possible ways of loading raw data from the microprocessor of the scanning device. In addition, investigation of possible ways of implementing direct control over the printer toner will be performed as well. In short, the first aspect of the project is to build the interface between the software of the colour control algorithm and the hardware devices, scanner and printer. The second aspect focused on the mechanical design and control of the paper-feeding mechanism for the inline sensing system. Ultimately these two different aspects are to be combined to complete the overall system level integration of the ICSCD.

Process Improvements in MAGMA and PELE Slotted IA Production Lines

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Project Abstract :

Several main challenges are faced by the HP IA Department in its efforts to improve the process productivity for its latest inkjet generations, code named as Pele and Magma. These issues include understanding the lifted flex problem, quantifying the waviness in the flex and reducing the variability and cycle time in the encapsulation process through design of dual needle dispensing system and curing oven optimization. The lifted flex and the waviness in the flex have caused a decrease in the production yield at the IA and final assembly. Though some efforts had been put to solve these problems, they had not been completely eliminated due to lack of understanding of the root cause of the lifted flex and absence of a standard index to quantify the degree of flex waviness. In order to solve these issues, material analysis and experimentation were conducted to find the possible root cause of the problems, including tensile test, thermogravimetry analysis and chemical analysis. In order to establish a suitable flex waviness index, measurements were done for tensioned flexes using the coordinate measuring machine (CMM). Data analysis was performed and several indexes were explored including the R-squared regression index, the average roughness indexes (Ra and Rq) and the Fourier transform magnitude index. In addition to these two aspects, the project also aimed at improving the encapsulation process. Currently, the encapsulation process is the bottleneck among the IA processes. To reduce the cycle time of this process, the dual needle dispensing technique was explored as opposed to the current single needle system. The

main challenge with this new technique was in balancing the microfluidic flow between the two needles to minimize the dispensing variability. Several mechanical changes were implemented and tested, taking into account the cost of manufacturing and the accessibility of the dispenser for cleaning. In line with the efforts to reduce the encapsulation cycle time, oven size optimization was conducted to minimize the oven length while still achieving the specified percent cure for the encapsulation. The optimization had to take into account the trade off between the line speed, the curing time (oven length) and the temperature. Design of experiments (DOE) were conducted to find the correlations between these factors and to find the optimized oven conditions. Looking at a broader perspective, the project also aimed at investigating the current available encapsulation technologies as well as the potential future technologies to meet the ever tighter specifications in the inkjet cartridge manufacturing.

Robust Algorithms for Identifying Sources of Yield Impact in a Reentrant Manufacturing System

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Project Abstract :

The highly competitive nature of the ink jet supplies business has resulted in shorter product cycles and lower profit margins amidst greater customer expectations. The early identification and resolution of sources of yield loss, especially during the product ramp-up stage, is vital to the continued profitability of the HP wafer fabrication facility in Singapore. Conventional yield analysis methods currently being employed, which may rely on heuristics and intuition, have been deemed inadequate in accelerating the identification of potential sources of yield loss. Unconventional yield analysis methodologies which are accurate and easy to use are required to uncover unknown sources of yield loss.

Equipment Commonality Yield Analysis was used to continually evaluate the best and worse performing machines for a particular operation and process step. The analysis was based on robust statistical methods to reduce the possibility of false alarms, as well as path analysis, a unique method of determining which machines in the entire wafer flow history impacted yield. A comparison between the results of the developed methodology with those from a previously commissioned study has shown the efficacy and accuracy of the developed methodology. Preliminary results have also been encouraging; as majority of the machines flagged by the methodology have been

subsequently validated by process owners as truly problematic. The tool has also been implemented as the primary method of identifying Golden Machines.

Electrical Parametric Yield Analysis was used to determine which of the numerous electrical test parameters have hidden relationships with either the observed wafer yield or other, more critical parameters, even when excursions are not observed. A formal process to extract these hidden relationships, based on the principles of robust statistical methods, was used to determine which electrical parameters are good indicators of the specified effect. The effect of the parameters, including interaction effects, were then quantified through a stepwise regression equation, to provide stakeholders with a means of prioritizing the monitoring of electrical parameters, based on the predicted effect of the yield. Electrical Parametric Yield Analysis can also be used in conjunction with the Equipment Commonality Analysis, in determining which parameters a particular source of impact has affected. Preliminary analysis has been performed, with encouraging results.

Noise Disturbance Investigation and Quality Improvement in Precision Component

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Company Supervisor	:	Mr Kevin Lim (MMI Holdings Ltd)

Project Abstract :
The purpose of this project is to 1) investigate unexpected noise disturbance and 2) recommend several control measures for countering them during the machining of precision component. Investigation involved shop-floor observations and supported with analyses on data collected. In order to achieve the second objective, the project involved implementing three methodologies. Firstly, Finite Element Analysis (FEA) was used to study the structural deformation of the component under the influence of machining forces. Subsequently, physical experiments were carried out to determine the significant inputs as well as their experimental levels for Design of Experiment (DOE) and fail safe design. DOE resulted in a recommended set of optimal process parameters, which were applied on a test machine, and its process performance is reported. Finally, feedback control system-Cycle to Cycle (CTC) was suggested and evaluated to reduce the noise disturbance. The final outcome of this project was the achievement of overall quality improvement by these methodologies in a systematic approach.

The Development and Management of Outsourced Manufacturing in the Production of Flexible Products

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Project Abstract :
As company continues to capture larger market share, in-house capacity expansion is necessary to meet the demand. Production capacity expansion involves new equipment acquisition, floor space expansion, new hiring and so on in which huge capital investment is inevitable. However, due to the rapid technological change and fluctuating demand, investment in terms of machinery and resources induced great amount of business risk as it restricts flexibility and responsiveness to changes. Therefore, an alternative to encounter this dilemma in increasing capacity would be to allow involvement of third party manufacturer through outsourcing. Despite having minimum investment to release in-house capacity, outsourcing provides sufficient flexibility towards the change. However, outsourcing poses some risk level that will bring negative impact to the company's growth if it is not managed properly. This thesis was done in Super Multi-Packaging Limited (SMPL), Study had been carried out to establish methods and frameworks to initiate and managing outsourcing processes in flexible packaging products.

The study began with identifying suitable in-house product to outsource. Framework was established to determine the current capacity of the production, ways to determine the quantity to be outsourced for a certain period of time and ways to decide at which process stage that outsourcing should be carried out. Subsequently, upon knowing the quantity and the type of product to be outsourced, outsourcer is contacted. Before certain relationship is established between both parties, certain evaluation is essential.

As decision making for outsourcing activities in SMPL tends to be dynamic, considerations in choosing the most suitable outsourcers vary. Based on the nature of business and objectives of outsourcing activities, factors in selecting outsourcers are pricing structure, technical capabilities, pool of resources and quality of services/products. A pre-qualification evaluation scorecard was designed to meet the needs of SMPL in the process of outsourcer selection. Trial run was implemented to test the fitness of pre-qualification evaluation scorecard in fulfilling the ultimate objectives of outsourcing activities. In addition, advantages and disadvantages in choosing multi-outsourcer or single

outsourcer were evaluated in the context of SMPL.

After relationship is well established, managing the relationship is important to ensure the smoothness of the operation. The following section of thesis illustrates methods in managing relationship in terms of control, communication and legal aspect. Control mechanism in quality management and logistics planning are studied to ensure the objective of the company is met. Several scenarios corresponding to each of these areas were analyzed and recommendations were suggested. In addition, to avoid any misunderstanding in managing the relationship, framework in dealing with certain changes e.g. changes in product design and order quantity were established. The last section of this thesis outline the legal aspect of outsourcing activity to ensure that protection of law is established to maintain company's interest. Three main areas were focused on, which are identifying the legal relationship between both parties; developing legal agreement and, establishing the audit policy. The Statement of Service Requirement (SoSR) was established, based on which the full legal agreement contents are identified, elaborated and evaluated.

How to Maximize the Benefits of SCOR for a Lead Logistics Provider

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Company Supervisors	:	Dr Alex Lin & Mr Loh Chee Keong (SembCorp Logistics Ltd)

Project Abstract :
This project examined the impact of inventory visibility and business intelligence on supply chain by carrying out a series of experiments based on the popular Beer Distribution Game. These experiments are conducted in the context of simple, serial supply chain with 4 echelons at two institutions of higher learning in Singapore. Instead of implementing the experiments in the traditional board or online beer game setting, a modified model of the game was developed. The experiment was conducted as a business competition whereby participants physically involved in the supply-chain business of selling fast moving consumer products (FMCG).

Supply Chain Operation Reference Model (SCOR), which is developed by Supply Chain Council, was used as a reference model for supply chain performance measurement. The research quantifies the cost reduction and other supply chain performance measures achievable by enterprise with the employment of inventory visibility software and decision support system. Consequently, it would be able to help enterprise to increase their profit and market share with the capability of effectively matching the supply and demand.

Hypothesis testing, aggregate and non-aggregate analysis has been carried out for the data collected from the experiments to provide both macroscopic and microscopic view of our experimental outcome. The outcome of the research suggested that sharing dynamic inventory information and employing business intelligence tools will improve the supply chain performance by reducing overall supply chain cost. However, the benefits were not uniform across different supply chain members. Supply chain members from the higher echelon level tend to benefit more (higher cost reduction) than members of the lower echelon level. Under the experimental settings and assumption developed throughout this research, a simple mathematical model was also developed for both inventory visibility and business intelligence.

Development of a Logistics Network Configuration Template

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Project Abstract :
At the present moment, most third party logistics providers still make various decisions based on their intuitions, and experiences without a structured methodology to analyze and optimize their supply chain performance. Efforts have been made in this project to view the supply chain management as a science rather than an art. The group was tasked to develop a generic logistics network configuration template that serves as a basic supply chain analysis tool. Four major problems were identified by the Project Company as the most vital areas of interest, namely, warehouse location selection, suppliers selection, warehouse capacity planning, and vehicle routing planning.

For the warehouse location selection problem, an optimization algorithm was developed to analyze and optimize the number of warehouses required from a set of potential warehouse locations to reduce the total associated cost.

The major concern in the suppliers selection problem is to develop a model that can accommodate various cost structures commonly encountered in inbound logistics. An optimization model which accommodates various cost structures such as linear, fixed charge, piecewise and minimum charge cost was developed

with the objective of finding a set of suppliers that gives the lowest total cost. All these costs are included in one unified model such that total cost associated with suppliers is minimized. Warehouse capacity planning problems are not only matters of deciding how many cubic meters one should have in their warehouse. The decision is complicated with different types of storage facility such as different types of racks with the normally available bulk storage area. Flexibility too is one additional aspect to be looked into, which is highly related to what kind of storage location policy is used in a particular warehouse. At the end of the day, one wants to answer what is the best capacity planning layout for one's warehouse such that it will minimize the space requirement and yet still meet the storage requirement demand. The result of this study with an example of the Accord's warehouse in Singapore is presented.

For the Vehicle Routing Planning, an optimization model that seeks to obtain a set of routes for a number of identical vehicles which gives the shortest total travelled distance and concurrently the minimum number of vehicles required was developed. The optimization algorithm adopted was capable of solving both the basic capacitated VRP and the one with time windows constraint.