



**INTEGRATED FEED FORWARD SYSTEM FOR CHEMICAL  
MECHANICAL POLISHING OXIDE REMOVAL PROCESS  
AUTOMATION TO IMPROVE PRODUCTIVITY**

**SAMAD BIN RAMLAN**  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DOCTOR OF ENGINEERING**

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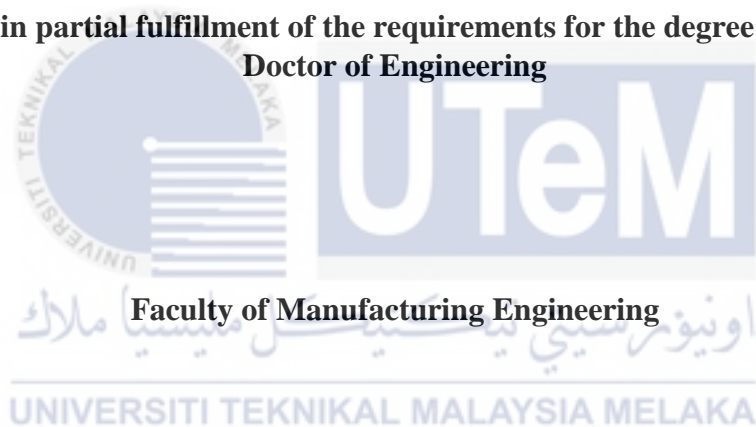
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**INTEGRATED FEED FORWARD SYSTEM FOR CHEMICAL MECHANICAL  
POLISHING OXIDE REMOVAL PROCESS AUTOMATION TO IMPROVE  
PRODUCTIVITY**

**SAMAD BIN RAMLAN**

**A thesis submitted  
in partial fulfillment of the requirements for the degree of  
Doctor of Engineering**



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2022**

## DECLARATION

I declare that this Choose an item. entitled "INTEGRATED FEED FORWARD SYSTEM FOR CHEMICAL MECHANICAL POLISHING OXIDE REMOVAL PROCESS AUTOMATION TO IMPROVE PRODUCTIVITY is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



Signature

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21 September 2022

## APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Engineering.

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## DEDICATIONS

All praises belongs to ALLAH.

To my beloved wife and children



## ABSTRACT

Chemical Mechanical Planarization (CMP) is one of the main processes in semiconductor wafer fabrication. It is the only process that has contact physically with the wafer, where a pad is placed directly onto the wafer and polished in a circular motion at a particular speed to planarize the wafer surface. For a typical CMOS devices, the downstream process for CMP is the film depositions process and the upstream is the lithography process in which both requires high precision machine capabilities. The process is repeated 10 to 15 times with 300 to 1000 process steps of a wafers cycle dependings on the Integrated Circuit device complexities. Due to the acceptance process tolerance which is measured at a nanometer level and with very tight process controls, excessive polishing on the oxide layer cannot be reworked. Therefore, there is a need to control and monitor closely for each recipe used to process the wafer. Additionally, SiITerra wafer fabrication facility is loaded with more than 200 devices that require to process 5000 to 6000 wafers daily. These devices require variations of processing sequences as well as different settings to be manually conducted. Subsequently, these devices eventually contribute to longer setup times, and commonly lead to human mistakes and equipment interruption of up to about 3000 events a year. That could lead to the need for further inspections or corrections of more than 60,000 wafers. The CMP process for this study is on oxide process. In order to achieve the consistency of an ideal process scenario which is to polish at the appropriate targeted removal rate, an integrated feed forward system is proposed to collect, integrate the information and automate the decision making process. This system is proposed to bridge the gaps particularly for process qualifications and the targeting procedures. Failure Mode and Effect Analysis (FMEA) method is applied to breakdown the process of obtaining the data, computing the data to as the input to the required parameter and applying the parameter to polish the wafers. From FMEA, it is then translated to feed forward system to collect and to integrate between process qualification data on non-production wafer until to apply targeting procedures on production wafers. Supporting functions are developed based on the SECS/GEM equipment interface protocol by Semiconductor Equipment Materials International (SEMI). Based on the observations and data collected, it is found that the system is successful in reducing the cycle time for about 17% from an average of 6 hours to 5 hours as well as reducing the wafers scrap rate from an average of 17 wafers per year to zero scrapped.

## **ABSTRAK**

### **SISTEM SUAPAN HADAPAN BERSEPADU BAGI PROSES PENGAUTOMATAN PENYINGKIRAN OKSIDA PENGGILAP MEKANIK KIMIA UNTUK MENINGKATKAN PRODUKTIVITI**

*Penggilap Mekanik Kimia (CMP) adalah merupakan salah satu proses utama dalam fabrikasi wafer semikonduktor. Proses ini adalah satu-satunya proses di mana adanya sentuhan fizikal dengan wafer. Pad diletakkan secara terus ke atas wafer dan penggilapan berlaku dengan gerakan membulat pada kelajuan yang tertentu. Untuk peranti Semikonduktor Pelengkap Logam Oksida (CMOS) kebiasaannya proses hiliran CMP ialah pengendapan filem dan proses huluian ialah litografi yang mana kedua-duanya menggunakan mesin-mesin yang tinggi kemampuan kepersisan. Proses ini diulangi untuk 10 hingga 15 kali dengan 300 hingga 1000 langkah di dalam kitaran wafer bergantung kepada kekompleksan litar bersepadu itu. Oleh kerana tolerans proses penerimaan diukur dalam had terima nanometer dan kawalan proses yang amat ketat, penggilapan yang berlebihan pada lapisan oksida akan menyebabkan wafer tidak dapat dikerjakan semula. Oleh itu, kawalan serta pemantauan ketat menjadi keperluan setiap resipi yang digunakan untuk memproses wafer diperlukan. Tambahan pula, kemudahan fabrikasi wafer di Silterra mempunyai lebih dari 200 peranti yang perlu memproses 5000 hingga 6000 wafer setiap hari. Peranti-peranti ini memerlukan penyediaan pelbagai jujukan proses dan pelarasan secara insani. Kemudiannya, ini menyumbang kepada masa penyediaan yang panjang dan kebiasaannya terdedah kepada kesilapan manusia dan sampukan pada kelengkapan sehingga 3000 peristiwa setahun. Ini juga menyumbang kepada lebih 60000 wafer yang perlu diperiksa atau diperbetulkan. Proses yang dipilih untuk kajian adalah proses oksida. Lantaran itu, untuk mencapai konsistensi dalam proses penggilapan yang unggul, sistem suap-depan bersepadu dicadangkan untuk mengumpul, menyatukan maklumat dan melaksanakan proses membuat keputusan secara automatik. Sistem ini dibangunkan untuk mengisi sela terutamanya dalam proses kelayakan dan tatacara pensasaran. FMEA (Analisis Ragam Kegagalan dan Kesan) kaedah dipilih untuk penghuraian proses mendapatkan data, pengiraan data untuk parameter yang diperlukan dan seterusnya menggunakan parameter untuk menggilap wafer. Dari analisis tadi, ia diterjemahkan kepada sistem suapan ke hadapan untuk mengumpul dan menyepadukan di antara proses kelayakan data pada wafer bukan-pengeluaran sehingga diaplikasikan pada tatacara pensasaran pada wafer pengeluaran. Rangkap sokongan dibangunkan menggunakan perisian dagangan berdasarkan pada protokol antaramuka kelengkapan SECS/GEM yang dikawal selia oleh Badan Antarabangsa Bahan Kelengkapan Semikonduktor (SEMI). Berdasarkan kepada pemerhatian dan data yang dikumpul, sistem ini telah berjaya mengurangkan masa kitaran di sekitar 17% dari purata 6 jam kepada 5 jam dan menurunkan kadar wafer yang rosak dari purata 17 wafer setahun kepada sifar wafer rosak.*



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## TABLE OF CONTENTS

	PAGE
<b>DECLARATION</b>	
<b>APPROVAL</b>	
<b>DEDICATIONS</b>	
<b>ABSTRACT</b>	ii
<b>ABSTRAK</b>	iii
<b>ACKNOWLEDGEMENTS</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF TABLES</b>	ix
<b>LIST OF FIGURES</b>	xiii
<b>LIST OF SYMBOLS AND ABBREVIATIONS</b>	xix
<b>LIST OF APPENDICES</b>	xxv
<b>LIST OF PUBLICATIONS</b>	xxvi
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Background	1
1.2 Failure Mode and Effects Analysis	4
1.3 Feed Forward System	5
1.4 Problem Statement	6
1.5 Research Objective	11
1.6 Scope of Research	11
1.7 Thesis Outline	12
<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>14</b>
2.1 Introduction	14
2.2 Process Control in Manufacturing	16
2.2.1 Process Control in Wafer Fab	17

2.2.2	Process Control by Statistical Process Control	20
2.2.3	Feed forward System in Wafer Fab	24
2.3	Overview of CMP Process	28
2.3.1	Shallow Trench Isolation Process	29
2.3.2	Interlevel Dielectric Process	30
2.3.3	Critical Parameters in CMP process	33
2.3.4	CMP Process and Measurement Equipment	36
2.4	Challenges and Complexity of a Wafer Fab	54
2.5	Applications of Confidence Interval	58
2.6	T-Test versus ANOVA in Statistics	60
2.6.1	Applications of T-Test	60
2.6.2	Applications of ANOVA	61
2.7	Overview of Failure Mode and Effect Analysis	62
2.8	Overview of Computer Integrated Manufacturing System	66
2.8.1	Manufacturing Execution System Applications	66
2.8.2	Manufacturing Execution System Application in Semiconductor Manufacturing	68
2.8.3	MES System Application in Research Facilities	71
2.9	Agent Based System	92
2.10	Significance of Industry 4.0 to Wafer Fab	98
2.10.1	Smart Manufacturing and MES interrelation	101
2.10.2	Wafer Fabrication Contribution to Industry 4.0	103
<b>CHAPTER 3</b>	<b>METHODOLOGY</b>	<b>108</b>
3.1	Introduction	108
3.1.1	Framework of Manual Execution versus Integrated Feed Forward System	114
3.2	System Performance Evaluation via FMEA	125
3.3	Integrating Equipment Data in MES by Applying Data Interceptor Agent	129
3.3.1	Characterization of Model Function	133

3.3.2	Data Indexing	134
3.3.3	Mapping Data to Measurement Parameter	138
3.3.4	Data Interceptor Test Plan	139
3.4	Data Standardization Between Equipment and MES System by Data Carrier Agent	141
3.4.1	Characterization of Model Function	145
3.4.2	XML Parser	147
3.4.3	XML Constructor	148
3.4.4	Data Carrier Test Plan	150
3.5	Mapping Data to Measurement and Recipe Parameters by Data Mapping Agent	153
3.5.1	Characterization of Data Mapping Agent Model Function	153
3.5.2	Data Loader Module	156
3.5.3	Recipe Mapping Module	170
3.5.4	Computational Engine Module	176
3.5.5	Data Mapping Agent Test Plan	184
3.6	Development for Data Storage	185
3.6.1	SQL Executor	190
3.6.2	Data Storage Test Plan	191
3.7	Development and Integration to MES System	192
3.7.1	System Configuration in MES components	193
3.7.2	Auto Path Selection	196
3.7.3	MES Integration Test Plan	198
3.7.4	Integration Testing Environment	199
3.8	Economic Impact Measurement	200
3.8.1	Cycle Time Measurement	201
3.9	Summary	202
<b>CHAPTER 4</b>	<b>RESULTS AND DISCUSSIONS</b>	<b>204</b>
4.1	Introduction	204
4.2	Data Interceptor Agent Analysis	208

4.3	Data Carrier Analysis	217
4.4	Data Mapping Analysis	223
4.4.1	Data Loader Analysis	224
4.4.2	Recipe Mapping Analysis	228
4.4.3	Computational Engine Analysis	229
4.5	Data Storage Analysis	238
4.6	Development and Integration to Current MES Analysis	242
4.6.1	System Configuration in MES Components	242
4.6.2	Step Auto-Selection	242
4.7	System Performance Analysis via FMEA	243
4.8	Economic Impact Analysis	248
4.8.1	Cycle Time Statistical Analysis	250
4.9	Summary	253
<b>CHAPTER 5</b>	<b>CONCLUSION AND RECOMMENDATIONS</b>	<b>255</b>
5.1	Conclusion	255
5.2	Contribution of Research	258
5.3	Benefits and Implication	260
5.4	Future Works	261
	<b>REFERENCES</b>	<b>263</b>
	<b>APPENDICES</b>	<b>286</b>

## LIST OF TABLES

TABLE	TITLE	PAGE
1.1:	Process in wafer fab and its complexity (Limanond et al., 2001; Mönch et al., 2013)	1
2.1:	Critical review on feed forward system	26
2.2:	CMP processes and applications in IC fabrication (Wen-Chen, 2006)	28
2.3:	Summary of work sequence of CMP oxide process (Morisawa et al., 2011)	42
2.4:	Critical review on CMP process control	43
2.5:	Polishing performance parameters (James, 2004)	46
2.6:	OEE components and classifications (Chik et al., 2012)	55
2.7:	Critical review on FMEA	64
2.8:	Main features of FACTORYworks (Applied FACTORYworks 2.6 Technical Brief, 2009)	71
2.9:	EDC components and definitions (Applied FACTORYworks EDC/SPC Configuration, 2010)	79
2.10:	MES common functions (Silterra MES Business Rules, 2016)	81
2.11:	Evolution of SEMI SECS/GEM communication standards (Laghari et al., 2020)	83

2.12: Common functions in equipment automation program (Sonar et al., 2013)	85
2.13: Characteristics of agent as hardware or software-based computer system (Wooldridge and Jennings, 1995)	93
2.14: Summary of industry 3.0 and 4.0 (Yin et al., 2018)	100
2.15: Critical literature review with lesson learned	105
3.1: Methodology break down by the research objectives	108
3.2: Manual Activities in Recipe Validation	114
3.3: Manual Activities in Recipe Execution	114
3.4: Agents Functionality	119
3.5: List of equipment and applications employed in the experiment	124
3.6: FMEA experimental development plan	127
3.7: Data interceptor events and functions	130
3.8: Functions developed for data interceptor	133
3.9: Data interceptor test plan	139
3.10: Data carrier functions	144
3.11: Data carrier model functions	146
3.12: Data carrier test plan	150
3.13: Data mapping model functions	154
3.14: List of data loader function	157

3.15: Recipe loader functions	162
3.16: Recipe mapping events and functions	171
3.17: Computational engine functions and formulas	177
3.18: First layer of calculation involving average and standard deviation	179
3.19: Second layer of calculation involving process validation parameter	179
3.20: Data mapping test plan	184
3.21: List of tables to store the critical data	185
3.22: Data storage test plan	191
3.23: Process and measurement steps for recipe validation and execution	194
3.24: EDC plan and measurement spec on recipe validation measurement step	195
3.25: EDC plan and measurement spec on recipe execution	196
3.26: Thickness measurement status and path selection	197
3.27: MES integration test plan	198
3.28: MES environment server setup	200
4.1: Objectives, methodology and results overview	206
4.2: Data interceptor test plan and results accuracy	211
4.3: Summary of number of events during measurement	213
4.4: Data carrier test plan and results accuracy	220
4.5: Data mapping test plan and results accuracy	234



4.6: Data storage test plan and results accuracy	241
4.7: MES system integration test plan and results	243
4.8: FMEA process flow and results analysis	245
4.9: Confidence intervals different between manual and remote recipe execution	250
4.10: Critical parameter analysis	251
5.1: Functions created for respective agents	257



## LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1:	Flow of Wafer Fabrication Process (Fowler et al., 2015)	3
1.2:	Interruption by processing area in year (Silterra Quality System, 2018)	7
1.3:	Number of wafers scrapped in CMP due to manual recipe execution (Silterra Quality System, 2018)	9
2.1:	Sample of control chart (May and Spanos, 2006)	20
2.2:	Conceptual flow of information and wafers processing in multistep feedback/feedforward control (Chaudhry et al., 1998)	24
2.3:	(a) and (b) Schematic of CMP process equipment from top and front view (Zhao and Lu, 2013)	31
2.4:	Structure of ILD, IMD and metal 1 layer at pre and post CMP (Silterra CMP Process, 2019)	33
2.5:	SFI equipment framework and components (Silterra CMP NOVA Operations, 2018)	40
2.6:	Flowchart of CMP manual recipe validation (Silterra CMP Operations, 2019)	49
2.7:	Measurement of 53 datapoints location on a wafer (Silterra CMP Operations, 2019)	50

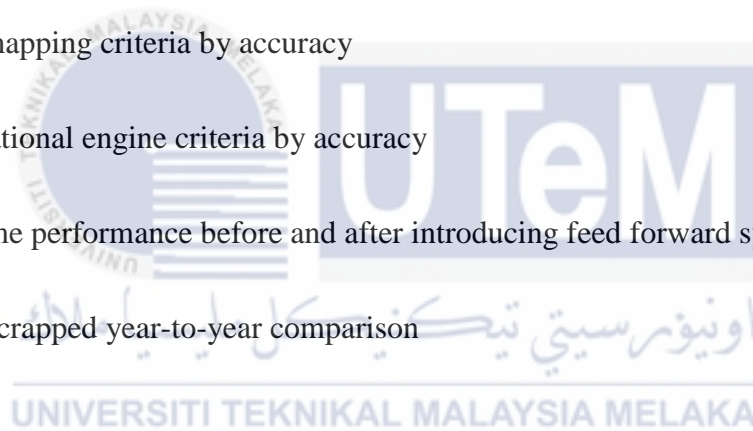
2.8: Process flow of recipe validation (Silterra CMP Operations, 2019)	50
2.9: (a) and (b) Flowchart CMP manual targeting process (Silterra CMP Operations, 2019)	53
2.10: Main losses in production setup (George et al., 2005)	55
2.11: Recipe execution in manual mode (Silterra CMP Operations, 2019)	57
2.12: Recipe execution in remote mode (Silterra CMP Operations, 2019)	58
2.13: Automation hierarchy in semiconductor manufacturing (Liao, 2020)	69
2.14: FACTORYworks MES components (Applied FACTORYworks 2.6 Technical Brief, 2009)	75
2.15: Product, process plan and steps structure in FACTORYworks (Applied FACTORYworks Process Planning Configuration, 2009)	77
2.16: Configuration process flow in FACTORYworks (Silterra Plant Specific Process Flow, 2021)	78
2.17: Process and measurement steps flow for recipe execution(Silterra Plant Specific Process Flow, 2021)	78
2.18: EDC plan and measurement specifications structure (Applied FACTORYworks EDC/SPC Configuration, 2010)	80
2.19: Data flow interactions between MES, business rules, equipment automation program and equipment	86
2.20: CIM system architecture (Silterra MES Business Rules, 2016)	88

2.21: (a) and (b) sequence diagram of transaction between EI, MES and supporting application (Silterra MES Business Rules, 2016)	91
2.22: Characteristics of an agent (Rocha et al., 2017)	92
3.1: Cause and Effect diagram to outline the input and output factors	110
3.2: (a) and (b) Integrated feed forward system overview	112
3.3: Framework of manual execution	117
3.4: Systematic framework of integrated feed forward system	118
3.5: Framework of integrated feed forward system	120
3.6: Experimental Flow Chart	123
3.7: Illustration of general components for measurement equipment and its events, data interceptor and its functions and sequence of communication between the components	130
3.8: Flowchart of data interceptor upon lot arrival to complete event	132
3.9: Mapping of CEID 524 and 506 to the respective parameters	135
3.10: Mapping on CEID 506 to the respective parameters	136
3.11: Mapping of CEID 524 to the respective parameters	137
3.12: Data mapping from CEID 505 event	140
3.13: Data mapping from CEID 524 event	141

3.14: Illustration of general components and functions of data carrier, data interceptor and sequence of communication between the components	143
3.15: Flowchart of XML parser and constructor	145
3.16: XML structure of message received from data interceptor	148
3.17: XML structure of reply message to data interceptor	149
3.18: (a) Store data structure with EDC plan and (b) measurement specs	152
3.19: Store data reply message structure	153
3.20: Illustration of derived data loader components and functions	157
3.21: Derived data loader flowchart	159
3.22: Sample of data loader in managing pre and post thickness measurement	160
3.23: Sample of data loader in managing measurement spec from random to ascending order	161
3.24: Illustration of recipe loader components and functions	162
3.25: Recipe loader flowchart	164
3.26: Recipe loader flowchart to decide on next step	167
3.27: Sample of recipe loader during initial polishing step	168
3.28: Sample of recipe loader on corrected and added polishing time with wafer status	169
3.29: Illustration of recipe mapping components and functions	170

3.30: Recipe mapping flowchart	173
3.31: Fragment of get recipe request message	174
3.32: Fragment of get recipe reply message	174
3.33: Fragment of recipe execution command structure to equipment	175
3.34 Illustration of computational engine functions	178
3.35: DB CMP measurement table	187
3.36: DB CMP polish time table	188
3.37: DB CMP configuration table	188
3.38: DB CMP qualification table	189
3.39: DB CMP history table	189
3.40: SQL select statement integrated to VFEI message	191
3.41: Process flow for recipe execution step	197
4.1: Data interceptor function by accuracy	214
4.2: Wafer slot criteria by accuracy	215
4.3: Store data criteria by accuracy	216
4.4: Thickness measurement data criteria by accuracy	217
4.5: Data carrier function by accuracy	221
4.6: XML parser criteria by accuracy	222
4.7: XML constructor accuracy by criteria	223

4.8: Sequence of pre and post data retrieval and computational engine execution to obtain derived parameters	232
4.9: String of information on wafer sequence, wafer Id, polish head, initial time, add on time and corrected time computation	233
4.10: Data mapping functions by accuracy	235
4.11: Derived data loader functions criteria by accuracy	235
4.12: Recipe loader criteria by accuracy	236
4.13: Recipe mapping criteria by accuracy	237
4.14: Computational engine criteria by accuracy	238
4.15: Cycle time performance before and after introducing feed forward system	249
4.16: Wafers scrapped year-to-year comparison	253



## LIST OF SYMBOLS AND ABBREVIATIONS

SMSB	Silterra Malaysia Sdn. Bhd.
SIA	Semiconductor Industries Association
BKM	Best Known Method
IC	Integrated Circuit
ASICs	Application-Specific Integrated Circuits
CMP	Chemical-Mechanical Polishing/Planarization
SMIF	Standard Mechanical Interface
FMEA	Failure Mode and Effect Analysis
PFMEA	Process Failure Mode and Effect Analysis
RPN	Risk Priority Number
CIM	Computer Integrated Manufacturing
MES	Manufacturing Execution System
SAH	Send Ahead
SPC	Statistical Process Control
BR	Business Rules
MCS	Material Control System
FFS	Feed Forward System
SFC	Shop Floor Control
API	Application Programmer's Interface
GUI	Graphical User Interface
FW	FACTORYworks
DTPF	Distributed Transaction Processing Framework
SEMI	Semiconductor Equipment and Materials International
SECS	Semiconductor Equipment Communication Standard
GEM	Generic Model for Communications and Control of Manufacturing Equipment