

**THE IMPORTANCE OF MINORITY  
CARRIER LIFETIME IN  
SILICON SEMICONDUCTOR DEVICES**

**BY**

**SHAMSUL ZAWAL**

**A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT  
OF THE REQUIREMENT FOR THE DEGREE OF  
MASTER OF TECHNOLOGY ( MATERIAL SCIENCE )  
AT THE INSTITUTE OF ADVANCED STUDIES  
UNIVERSITY OF MALAYA**

**KUALA LUMPUR**

**MARCH 1997**

Perpustakaan Universiti Malaya



A505607749

## ACKNOWLEDGEMENTS

In the course of the study and writing this thesis, I have been encountered, stimulated and advised by many people. It would be difficult to single out all of them for acknowledgement, however, I would like to extend my special thank you my immediate supervisor, Professor Suri Radhakrishna ( Institute of Advance Studies, University of Malaya ) for his efforts, encouragement, guidance and constructive criticism given in the preparation of this thesis. I am also very grateful to my co-supervisor, Dr. Muhd Rasat ( Physic Department, University of Malaya ) for his invaluable advice, ideas and assistance offered. These special thanks also goes to my advisor from MEMC KL, Dr. Krishna Vepa for his willingness to pass his experience and knowledge through our technical discussion which proved to be invaluable throughout the project.

I would like to thank my wife and my family who always have been with me, supporting me through the hardest time and being understanding throughout the whole course. To all my dearest friends, co-workers and superior who have been very supportive, I am very much grateful.

Finally, my gratitude to Institute of Advance Studies, University Malaya and MEMC Electronic Materials Sdn. Bhd. for the opportunity, facilities and financial support given in undertaking the Master in Technology ( Material Science ) program.

# CONTENT

<b>CHAPTER 1 :    <u>INTRODUCTION</u></b>		Page
1.0	INTRODUCTION .....	9
1.1	SILICON WAFER MANUFACTURING TECHNOLOGY .....	10
1.1.1	Trimming	20
1.1.2	Orientation Flattening	20
1.1.3	Ingot Etching	22
1.1.4	Slicing	22
1.1.5	Edge Rounding	23
1.1.6	Lapping	23
1.1.7	Wafer Etching	25
1.1.8	Polishing	25
1.1.9	Cleaning	26
1.2	TYPES OF CONTAMINANTS .....	27
1.3	CHEMICAL CLEANING .....	29
1.4	WAFER SCRUBBING AND SONIC CLEANING .....	31
1.5	MINORITY CARRIER LIFETIME THEORY .....	31

<b>CHAPTER 2 :</b>	<b><u>METHODS AND TOOLS</u></b>	Page
2.0	RECOMBINATION LIFETIME	
	CHARACTERIZATION METHODS .....	42
2.0.1	Photoconductivity Decay Method	44
2.0.2	MOS Capacitor Method	46
2.1	LIFETIME MEASUREMENT TOOLS .....	49
2.1.1	$\mu$ PCD	50
2.1.2	ELYMAT	54
2.2	ELYMAT MINORITY CARRIER LIFETIME	
	MEASURING TECHNIQUE .....	56
2.2.1	Principles	58
2.2.2	Working Principles of ELYMAT	60
2.2.3	Modes of Operations	
2.2.3.1	BPC - Backside Photo Current Mode	63
2.2.3.2	FPC - Frontside Photo Current Mode	68

**CHAPTER 3 :**      **EXPERIMENTAL TECHNIQUE AND RESULTS**

3.0	EQUIPMENT .....	73
3.0.1	Procedures	74

	Page
3.1 MINORITY CARRIER LIFETIME VS WAFER RESISTIVITY .....	75
3.2 MINORITY CARRIER LIFETIME VS HEAT TREATMENT TIME .....	79
3.3 VARIATION OF MINORITY CARRIER LIFETIME WITH WAFER TYPE, ORIENTATION AND INGOT SOURCE .....	87
 <b>CHAPTER 4 : <u>CONCLUSION AND DISCUSSION</u></b>	
4.1 EFFECTS OF DEFECTS ON ELECTRICAL PROPERTIES .....	90
4.1.1 Impurities	90
4.1.2 Oxygen and Carbon	91
4.1.3 Dislocations	94
4.1.4 Stacking Faults	94
4.2 CONCLUSION .....	96
REFERENCES .....	100