INVESTIGATION OF DOPING TECHNIQUES ON THE SILICON BASED CAPACITOR

Thesis is presented in partial fulfillment for the award of the

BACHELOR OF ENGINEERING (HONS) ELECTRICAL

UNIVERSITI TEKNOLOGI MARA (UiTM)

AHMAD AKMALHAKIM BIN YAACOB
FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITI TEKNOLOGI MARA
40450 SHAH ALAM,
SELANGOR, MALAYSIA

MAY 2010

# ACKNOWLEDGEMENTS

This thesis would not have been possible unless I had ample guidance from my supervisor. Therefore, I would sincerely like to thank Mr. Ahmad Sabirin Zoolfakar for the patience, guidance and faith that he has in me. He would always give me that extra push and motivation whenever I needed it the most. My warmest thanks also goes out to my co-supervisor Mrs. Maizatul Zolkapli for her wise advises and endless support. It was an honor for me to work under both of your guidances.

I would also like to express my sincerest appreciation to the people at the Applied Science Fabrication Lab in UiTM who were Mr. Azlan Zakaria, Nashriq, Nadya, Salleh and Ahmad for their kindness and support from the very beginning until the end of the research. Not forgetting the sharing of invaluable knowledge and they were always ready to lend a helping hand whenever needed. Furtheremore, I gratefully acknowledge the laboratory technician, Mr.Khatab for his assistance in the lab.

I am indebted to my many of my colleagues who had supported me throughout conducting the research. To my lab partner, Habibah Zulkefle who had shared a lot of bright ideas and helped most of the time needed. Not forgetting to Furkan Mat Salleh who had offered a lot of help during times I thought I had hit a dead end in this research. Without all the help that I received from you guys, this research would surely be a nightmare experience. Therefore, I really appreciate all of your help.

Last but certainly not the least, I want to dedicate my warmest, deepest and never-ending gratitude and love to both of my parents “Mum” and “Ayah” in praying for my success and giving me guidance in life. Not forgetting to my siblings who had also given me motivations throughout my studies. I am so lucky to have you guys, and without all of you, I would not be where I am right now. Thank you so much.

AHMAD AKMALHAKIM BIN YAACOB
Faculty of Electrical Engineering
Universiti Teknologi MARA (UiTM)
Shah Alam, Selangor Darul Ehsan
Malaysia

ABSTRACT

This paper investigates the effect of doping techniques, type of dopant species and plate size on the capacitance density of a silicon based capacitor. The substrate of the silicon wafers were highly doped using either solid source (SS) or spin-on dopant (SOD) method. The wafers were doped according to their types where the n-type wafers were doped with phosphorus where as the p-type wafers were doped with boron. Three different diffusion temperatures were used in this experiment which are 900^{o}C, 1000^{o}C and 1050^{o}C. The diffusion process was conducted by using the Modu-Lab diffusion furnace. The low-frequency CV measurement using the Keithley 595 Quasistatic CV meter was conducted in order to study the capacitance value in this research. Results show that the diffusion by spin-on dopant gives a higher capacitance density compared to diffusion by solid source and larger plate size would contribute to a larger capacitance value. In addition, the experiment also shows that n-type wafer heavily doped with phosphorus exhibits a higher capacitance density.

Keywords: solid source, spin-on dopant, capacitance density, segregation, pile-up, heavily doped bulk substrate

INVESTIGATION OF DOPING TECHNIQUES ON THE SILICON BASED CAPACITOR

TABLE OF CONTENTS

CONTENTS	PAGE
Declaration	i
Dedication	ii
Acknowledgements	iii
Abstract	iv
Table of Contents	v
List of Figures	viii
List of Tables	x
List of Abbreviations	xi

CHAPTER		PAGE
1	**INTRODUCTION**	
1.1	Overview of the silicon based capacitor	1
1.2	Application of the silicon based capacitor	3
1.3	Objective	5
1.4	Problem Statement	6
1.5	Scope and Limitation of the Research	7
1.6	Significance of the Research	8
1.7	Thesis Overview	9

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF THE SILICON BASED CAPACITOR

Capacitors used in semiconductor devices may be based on the structure of a metal oxide semiconductor (MOS) type, PN junction type, polysilicon-insulator-polysilicon (PIP) type, metal-insulator-metal (MIM) type and many others. Capacitors are typically formed to have a metal/insulator/metal structure [1]. A capacitor is comprised of two conductive plates separated by a non-conducting dielectric layer. The dielectric layer is preferably comprised of one or more materials having a very high dielectric constant and low leakage current characteristics [2]. A typical capacitor comprises a pair of electrode layers having dielectric material there between. Whenever voltage is applied across the electrode layer, a charge is stored in the capacitor with the amount of charge being storable in the capacitor. The capacitance is directly proportional to the opposing areas of the electrodes and the dielectric constant of the dielectric material [3].

Capacitors are generally fabricated in conventional physical shapes and sizes that are dictated by the capacitor materials, the manufacturing process, the end use, and the desired electrical properties. Many kinds of capacitors are currently available and are selected for respective uses, for example, paper capacitors, electrolytic capacitors, mica capacitors, ceramic capacitors, plastic film capacitors, and so on [2].

In general, capacitors have a structure that a dielectric is sandwiched between a pair of parallel electrodes, and function to store electricity utilizing an electrical polarization caused in the dielectric by application of a voltage between the parallel electrodes. The characteristics of the capacitors largely vary depending on the kinds of dielectrics used [1].