TABLE OF CONTENTS

ે શિકાદાય ક	
20 D.D.D 2	Page
Acknowledgement	iii
Abstract in Thai	iv
Abstract in English	v
List of Tables	ix
List of Figures	х
Chapter 1 Introduction	1
Chapter 2 Principle and Basic Instrumentation of Mass Spectrometry	3
2.1 Fundamental concept of Secondary Ion Mass	-
Spectroscopy (SIMS)	3
2.1.1 Ion beam sputtering of solid target	5
2.1.2 Kinetic energy distribution of the secondary ions	7
2.1.3 Separation of the secondary ions	8
2.2 Basic Instrumentation of Mass Spectrometry	8
2.2.1 Ion Source	8
2.2.2 Mass Analyzing techniques	10
2.2.3 Ion Detection	14
2.3 Quadrupole Mass Spectrometers	16
2.3.1 The quadrupole field	16
2.3.2 The applied potential	18
2.3.3 The equation of motion	19

2.3.4 Stability diagram	21
2.3.5 Mass range and resolution	24
2.4 Analytical Information	28
2.4.1 Mass spectrum	28
2.4.2 Depth profiling	29
20 DIRA 62	
Chapter 3 Ion Sputtering of Biological Organism	31
Chapter 4 Experimental and Results	38
Part I: Conceptual design of quadrupole mass analyzer	
4.1 Description of Quadrupole Mass Analyzer (QMA)	39
4.2 Resolution (M/ Δ M) and peak width (Δ M)	39
4.3 Calculation of operating parameters	41
4.4 Electrical connections	42
Part II: Experimental set up of quadrupole gas analyzer	
4.5 Quadrupole gas analyzer	45
4.5.1 General description	45
4.5.2 Principle of operation	48
4.5.3 Calibration of quadrupole gas analyzer	48
4.6 Sample and sample preparation	52
4.7 Ion bombardment 4.8 Mass spectrum Chiang Mai Univers	53 55
All rights reserve	d
Chapter 5 Discussion and Conclusion	63

References

vii



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright © by Chiang Mai University All rights reserved

LIST OF TABLES

กมยนติ

Table	Page
2.1 Comparison of ion beam analysis technique for elemental analysis	5
4.1 The value of Radio Frequency (MHz) when the energy of	
inject ion (eV) varies from 1 to 10 eV at $\Delta M=1$ and 0.3 amu	40
4.2 The value of V_m and U_m , when L = 200 mm, r = 4 mm, and the	
energy of the inject ion varies from 1-10 eV	41
4.3 Characteristics of a Quadrupole Mass Spectrometer for precision	
mass determinations	42
4.4 The connections made between the analyzer and the electronics	44
4.5 List of mass to charge ratio (m/z)	59
AT INTERS	
UNIVE	

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright [©] by Chiang Mai University All rights reserved

ix

LIST OF FIGURES

· 1818186	
Figure	Page
2.1 Schematic representation of the main components of	
a SIMS experiment	4
2.2 Schematic drawing of ion-solid sputtering process	6
2.3 Typical kinetic energy distribution of the sputtered monatomic,	
diatomic and triatomic ion	7
2.4 Schematic diagram of electron impact ionization	9
2.5 Schematic diagram of chemical ionization	10
2.6 The path of the ion under an electric field	12
2.7 The paths of m_1 , m_2 and m_3 in magnetic field	12
2.8 Quadrupole instrument made of the source, the quadrupole	
cylindrical rods and the detector	13
2.9 Schematic diagram of time-of-flight spectrometer	14
2.10 Schematic representation of a Faraday cup	14
2.11 Schematic representation of an electron multiplier	15
2.12 The ideal quadrupole mass filter electrodes having hyperbolic	
Copyrigross-section by Chiang Mai University	16
2.13 Equipotential lines for a quadrupole field C S C D V C	17
2.14(a) The a-q diagram for the Mathieu equation in x direction	
(b) The a-q diagram for the Mathieu equation in y direction	21
2.15 Stability areas for an ion along x and y . The four stability areas	
are labeled A to D and are circled	22

2.16 The stability region normally used in mass filter operation	
showing a typical operating line	23
2.17 Relation of a and q for quadrupole mass apectrometer.	
The higher slope the higher resolution	24
2.18 Diagram showing the peak with high resolution and low resolution	25
2.19 Relationship of resolution and mass range to the instrument parameter	25
2.20 Peaks at different ΔM	26
2.21 Peak of mass M and M+1 with $\Delta M = 3$ amu	27
2.22 Mass spectra of polytetrafluoroethylene (a) positive ion spectrum	
(b) negative ion spectrum	28
2.23 The count rate of secondary ions as a function of time	29
2.24 Depth profile of phosphorus implant to silicon wafer	30
3.1 Mass loss of lactamine as a function of ion dose	36
4.1 Diagram of secondary ion mass spectrometry system	38
4.2 Schematic drawing of QMA with 90° off axis SEM	39
4.3 The connections made between the analyzer and the electronics with	
electrometer amplifier (EP)	43
4.4 The connections made between the analyzer and the electronics	
with connect an oscilloscope directly to the SEM	43
4.5 Quadrupole mass spectrometer system	44
4.6 Box diagram of quadrupole gas analyzer system	46
4.7 The control unit with operation controls and CRT screen	46
4.8 Mass Spectrometer Data Collection code	47
4.9 Mass spectrum of argon (a) before calibration, (b) a library of	
spectra in the NIST- WebBook (c) after calibration	51

(c) carbon and (d) silicon dioxide534.11 Schematic diagram of the ion beam sputtering process544.12 CMU2 heavy ion-implantation facility at Chiang Mai University544.13 Installation of quadrupole gas analyzer to target chamber554.14 Mass spectrum of nitrogen and diagram of fragmentation564.15 Mass spectrum of carbon dioxide and diagram of fragmentation574.16 Mass spectrum of vacuum chamber604.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.10 Four kinds of sample, (a) onion, (b) plastic scintillator,	
4.11Schematic diagram of the ion beam sputtering process544.12CMU2 heavy ion-implantation facility at Chiang Mai University544.13Installation of quadrupole gas analyzer to target chamber554.14Mass spectrum of nitrogen and diagram of fragmentation564.15Mass spectrum of carbon dioxide and diagram of fragmentation574.16Mass spectrum of vacuum chamber604.17Mass spectrum of mechanic pump oil604.19Mass spectrum of plastic scintillator614.20Mass spectrum of SiO2624.21Mass spectrum of onion cell62	(c) carbon and (d) silicon dioxide	53
4.12 CMU2 heavy ion-implantation facility at Chiang Mai University544.13 Installation of quadrupole gas analyzer to target chamber554.14 Mass spectrum of nitrogen and diagram of fragmentation564.15 Mass spectrum of carbon dioxide and diagram of fragmentation574.16 Mass spectrum of vacuum chamber604.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.11 Schematic diagram of the ion beam sputtering process	54
4.13 Installation of quadrupole gas analyzer to target chamber554.14 Mass spectrum of nitrogen and diagram of fragmentation564.15 Mass spectrum of carbon dioxide and diagram of fragmentation574.16 Mass spectrum of vacuum chamber604.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.12 CMU2 heavy ion-implantation facility at Chiang Mai University	54
4.14 Mass spectrum of nitrogen and diagram of fragmentation564.15 Mass spectrum of carbon dioxide and diagram of fragmentation574.16 Mass spectrum of vacuum chamber604.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.13 Installation of quadrupole gas analyzer to target chamber	55
4.15 Mass spectrum of carbon dioxide and diagram of fragmentation574.16 Mass spectrum of vacuum chamber604.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.14 Mass spectrum of nitrogen and diagram of fragmentation	56
4.16 Mass spectrum of vacuum chamber604.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.15 Mass spectrum of carbon dioxide and diagram of fragmentation	57
4.17 Mass spectrum of mechanic pump oil604.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.16 Mass spectrum of vacuum chamber	60
4.18 Mass spectrum of carbon614.19 Mass spectrum of plastic scintillator614.20 Mass spectrum of SiO2624.21 Mass spectrum of onion cell62	4.17 Mass spectrum of mechanic pump oil	60
 4.19 Mass spectrum of plastic scintillator 4.20 Mass spectrum of SiO₂ 4.21 Mass spectrum of onion cell 	4.18 Mass spectrum of carbon	61
 4.20 Mass spectrum of SiO₂ 4.21 Mass spectrum of onion cell 62 62 62 	4.19 Mass spectrum of plastic scintillator	61
4.21 Mass spectrum of onion cell	4.20 Mass spectrum of SiO ₂	62
TA UNIVERSIT	4.21 Mass spectrum of onion cell	62
41 UNIVERSI	The second A	
	AI UNIVERSI	

ลิปสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright © by Chiang Mai University All rights reserved