

## ACKNOWLEDGEMENTS

It's my best pleasure to be a graduate student under the instruction of Prof. Alfred Huan. His rich knowledge about science research especially in physics and his serious attitude to pursue the most precise answer for any problem met in research affected me very much. I've learned a lot from him during the past two years, such as how to develop scientific attitude, how to find ideas from previous work, how to solve problems in a scientific method, and so on. His wise instruction and advice are the most important help for my research work. I would like to thank him very much, for his unwavering support and encouragement during my study.

I would not be able to finish my research work without the kind help given by Dr. Pan Jisheng. He gave me lots of instruction on the experimental techniques and methods without any reservation. His rich experience in experiments and wide physical knowledge prove to be indispensable for me to complete my research. I would like to thank him, for his generous help.

I feel quite happy to make so many good friends here. They gave me lots of help so that I can finish my work on time. In particular, I thank Chai Jianwei, Poon Siew Wai, Zhang Zheng, Ong Wei Jie and Low Ke Bin for their support.

## **ABSTRACT**

### **XPS Study of Nanostructured Surface-Co on Si(100)**

Different coverage of Cobalt from ~0.5ML to ~10ML were deposited on clean Si(100) and H-terminated Si(100) surfaces at room temperature. A strong thickness dependence of the correlation-induced satellite signal in Co 2p photoemission spectra was observed. It was found that relative photoemission intensities of the satellite to Co 2p peak increase when the Co film [on Si(100)] thickness increases. After the Co film was annealed up to 450°C, the satellite disappears. The results can be explained from the intermixing influence of d-d electronic interaction and Si 3p-Co 3d bonding on such reduced-dimension systems.

On the other hand, the evolution of ultra-thin Co films on clean and H-terminated Si(100) surfaces upon annealing temperature in the range from room temperature to 650°C was studied by means of core-level and valence-band in-situ X-Ray Photoemission Spectroscopy (XPS). ~2ML to ~8ML Co was deposited onto Si surface at room temperature and then annealed. The behavior of the Co-Si interfaces upon the annealing temperature was examined using Co 2p core level shifts and valence band measurements. By comparing the experimental with theoretical CoSi<sub>2</sub> and CoSi band structure, together with the investigation of core level shift, the formation of CoSi<sub>2</sub> and CoSi is confirmed.

# CONTENTS

## Chapter 1 Introduction

1.1	An overview of the study in CoSi <sub>2</sub> thin film-----	1
1.2	The problems of the study of Co on Si substrates-----	2
1.3	Our objectives -----	3
	Reference-----	4

## Chapter 2 Literature Review

2.1	Epitaxial growth of CoSi <sub>2</sub> on Si-----	7
2.2	The electronic structures of transition metal silicides -----	8
2.3	Density of states (DOS) of Cobalt silicides-----	10
2.4	Initial stage of ultra thin Cobalt film deposition on Silicon-----	11
2.4.1	The ultra thin Cobalt film deposition on Silicon surface at RT-----	11
2.4.2	The Cobalt silicides phase transition upon annealing-----	12
2.5	Study of the satellite peaks in Photoemission spectra of transition metals---	13
	Reference-----	16

## Chapter 3 Experimental

3.1	Substrate preparation method-----	21
3.2	Ultrahigh Vacuum System (UHV)-----	22
3.2.1	The importance of UHV in the surface analysis-----	22
3.2.2	UHV system layout-----	24
3.3	Co growth method-----	25

3.4	Sample annealing-----	26
3.5	In-situ X-ray Photoemission Spectroscopy (XPS)-----	27
3.5.1	The basic principles-----	27
3.5.2	Instrumentation-----	29
3.5.2.1	X-ray source-----	29
3.5.2.2	Electron energy analyzer-----	30
3.5.3	XPS Spectrum interpretation-----	33
3.5.3.1	Primary structure-----	33
3.5.3.2	Charge compensation-----	35
3.5.3.3	Asymmetric metal line shape -----	35
3.5.3.4	Satellite peak -----	35
3.5.4	XPS data analysis-----	36
3.5.4.1	Spectra acquisition-----	36
3.5.4.2	Background removal -----	36
3.5.4.3	Quantification of XPS -----	37
3.5.4.4	Curve fitting -----	38
3.5.4.5	The subtraction of Si background from the valence band spectra -----	44
	Reference-----	46
 <b>Chapter 4 Observation of the satellite peak in Co 2p photoemission spectra</b>		
4.1	Basic concepts about satellite peak-----	47
4.2	Co 2p satellite peak of bulk Co metal-----	51

4.3	Observation of Co 2p satellite from Co thin films on clean Si (100) surface	57
	-----	
	Reference-----	65
<b>Chapter 5</b>	<b>Evolution of Co films on clean Si (100) substrates upon annealing</b>	
5.1	Reaction of Co on clean Si (100) surface at RT -----	67
5.1.1	Core-level spectra-----	67
5.1.2	Valence band spectra -----	69
5.2	Low coverage of Co on Si (100) upon annealing-----	75
5.2.1	Core-level spectra-----	75
5.2.2	Valence band spectra -----	78
5.3	High coverage of Co on Si (100) upon annealing-----	80
5.3.1	Core-level spectra-----	80
5.3.2	Valence band spectra -----	84
5.4	Summary -----	86
	Reference-----	86
<b>Chapter 6</b>	<b>Conclusions</b> -----	89