

Reactions of atomic hydrogen and oxygen with deuterium-covered silicon (D/Si) surfaces

by

Md. Arifur Rahman Khan

Department of Electrical Engineering and Electronics
Kyushu Institute of Technology
Japan

Supervisor

Prof. Akira Namiki

July, 2008

DEDICATION

I dedicate this thesis to my

MOTHER,

who has given me an appreciation of learning. I also dedicate this to my wife,

SHEELA,

for her unfaltering support and understanding while I was completing this thesis.

Contents

Chapter 1: Introduction	1
1.1 D abstraction by H on Si surfaces.	3
1.2 Possible abstraction mechanisms	6
1.2.1 Eley-Rideal (ER) mechanism	6
1.2.2 Hot-atom (HA) mechanism	7
1.2.3 Hot-complex (HC) mechanism	8
1.3 Oxygen interactions with Si surfaces	10
1.4 Structure of Si surfaces	12
1.5 Aim and outline of this thesis	19
References	21
Chapter 2: Experiment	26
2.1 Atomic beam chamber	26
2.2 Reaction chamber	27
2.3 Sample preparation	29
2.4 Surface temperature (T_s) calibration	30
2.5 QMS calibration and pulsed H-beam profile	31
2.6 FTIR setup	33
References	34
Chapter 3: Adsorption and abstraction of atomic hydrogen on the Si(110) surfaces	35
3.1 Experiment	36
3.2 Various surface species	37
3.2.1 FTIR spectra	37
3.2.2 Thermal desorption (TD) of D ₂	38
3.3 D uptake curve	40
3.4 H-induced reactions on D/Si(110)	41
3.5 Analysis of HD and D ₂ rate curves	43
3.5.1 Proposed rate equations	43
3.5.2 H and D coverages during H exposure	45
3.5.3 Fitting of rate curves	46
3.6 Activation energies	54

3.7	Time response of D ₂ and proposed mechanism	55
3.8	Conclusion	60
	References	61
Chapter 4: Transient desorption of HD and D₂ molecules from the D/Si(100) surfaces exposed to a modulated H-beam.		62
4.1	Experiment	64
4.2	Pulsed desorption of HD and D ₂ molecules	65
4.3	Reaction lifetime of ABS species	67
4.4	Reaction lifetimes of AID species	68
4.5	Temperature dependence of AID species	71
4.6	Atomistic AID mechanisms	72
	4.6.1 0.005s and 0.06s AID species	74
	4.6.2 0.8 s AID species	76
	4.6.3 30 s AID species	78
4.7	Conclusion	81
	References	82
Chapter 5: Reactions of atomic oxygen with the D-covered Si(100) surfaces.		83
5.1	Experiment	84
5.2	D/Si(100) surfaces exposed to O-beam	85
	5.2.1 Direct O-beam effect	85
	5.2.2 Pulsed O-beam effect	87
5.3	Temperature dependence	90
5.4	Activation energies and reaction mechanisms	93
	5.4.1 O-induced D ₂ desorption	93
	5.4.2 O-induced D ₂ O desorption	97
5.5	Conclusion	100
	References	101
Chapter 6: Summery		102

This thesis is based on the results published in ‘ Surface Science ’

Chapter 3

Adsorption and abstraction of atomic hydrogen on the Si(110) surfaces.

A. R. Khan, Y. Narita, A. Namiki, A. Kato and M. Suemitsu.

Surface Science, 602 (2008) 1979-1986

Chapter 4

Transient desorption of HD and D₂ molecules from the D/Si(100) surfaces exposed to a modulated H-beam.

A. R. Khan, A. Takeo, S. Ueno, S. Inanaga, T. Yamauchi, Y. Narita, H. Tsurumaki and A. Namiki.

Surface Science, 601 (2007) 1635-1641

Chapter 5

Reaction of atomic oxygen with the D-covered Si(100) surfaces.

F. Khanom, **A. R. Khan**, F. Rahman, A. Takeo, H. Goto and A. Namiki.

Surface Science, 601 (2007) 2924-2930