

Contents

Abstract	2
Zusammenfassung	5
Introduction	11
1 Fundamental theory	14
1.1 The work function	14
1.1.1 Adsorption on the surface	16
1.1.2 Desorption from the surface	19
1.2 Metal oxide	20
1.2.1 Energy band structure of metal oxide	20
1.2.2 Oxygen adsorption and desorption on metal oxide	23
1.2.3 Reaction on surface of metal oxide	24
1.2.4 Catalysis	25
1.2.5 Electronic contact of metal oxide with catalyst	27
1.3. Work function change measurement	28
1.3.1 The Kelvin Probe	28
1.3.2 Floating Gate Field Effect Transistor (FG-FET)	30
2 Preparation and characterization of metal oxides	32
2.1 Silver oxide (Ag_2O)	33
2.2 Zinc oxide (ZnO)	36
2.3 Tin oxide/Copper (SnO_2/Cu)	40
3 Sensor technology	43
3.1 The FG-FET	43
3.1.1 Hybrid gate	44
3.1.2 Integration the gate on the transducer	44
3.1.3 Integrated heater and thermal isolator	45
3.1.4 Electronic contacts	47
3.1.5 Protection of the wire bonding	48
3.2 Measurement station	48

3.3 Sensor signal	51
3.4 Surface passivation	53
4 Metal oxides as gas sensitive films	56
4.1 Silver oxide (Ag ₂ O) for hydrogen sulfide (H ₂ S) detection	56
4.1.1 Thermal behavior of the Ag ₂ O sensor	58
4.1.2 H ₂ S concentration dependence of the Ag ₂ O sensor	59
4.1.3 Humidity effect on the Ag ₂ O sensor	60
4.1.4 Cross sensitivity of the Ag ₂ O sensor	61
4.1.5 Long-term stability of the Ag ₂ O sensor	62
4.2 Zinc oxide (ZnO) for nitrogen dioxide (NO ₂) detection	63
4.2.1 The temperature effect on the ZnO sensor	64
4.2.2 NO ₂ concentration dependence of the ZnO sensor	65
4.2.3 Humidity effect on the ZnO sensor	67
4.2.4 Cross sensitivity of the ZnO sensor	68
4.2.5 Long-term stability of the ZnO sensor	69
4.3 Tin oxide/Copper (SnO ₂ /Cu) for nitrogen dioxide (NO ₂) detection ..	70
4.3.1 Sensing properties of the SnO ₂ /Cu film	70
4.3.2 Temperature effect on the SnO ₂ /Cu sensor	71
4.3.3 NO ₂ concentration dependence on the SnO ₂ /Cu sensor	72
4.3.4 Cross sensitivity of the SnO ₂ /Cu sensor	73
5 Modification of Pt sensor	75
5.1 Platinum (Pt)	75
5.2 Modified platinum with tin oxide (Pt/SnO ₂)	78
5.2.1 Preparation of the SnO ₂ films	78
5.2.1.1 Surface characterization	78
5.2.1.2 Effect of porous SnO ₂ on the Pt surface	80
5.2.1.3 Interaction between SnO ₂ and H ₂	82
5.2.2 Gas sensing mechanism	83
5.2.3 Sensing properties of Pt/SnO ₂ film	84
5.2.3.1 Temperature effect on the Pt/SnO ₂ sensor	85
5.2.3.2 H ₂ concentration dependence of the Pt/SnO ₂ sensor	86

5.2.3.3 Humidity effect on the Pt/SnO ₂ sensor	88
5.2.3.4 Cross sensitivity of the Pt/SnO ₂ sensor	90
5.2.3.5 Long-term stability of the Pt/SnO ₂ sensor	91
5.2.4 Enhanced stability of the Pt/SnO ₂ sensor at high temperatures	92
5.2.5 Improving sensitivity of the Pt/SnO ₂ sensor at room temperature	92
5.2.6 Annealing effect	99
5.3 Application of Pt and Pt/SnO ₂ films in other sensor configurations	105
5.4 Titanium silicide /platinum (TiSi ₂ /Pt)	107
5.4.1 Preparation and characterization of TiSi ₂ /Pt film	108
5.4.2 Gas sensing mechanism	110
5.4.3 Sensing properties of the TiSi ₂ /Pt film	110
6 Conclusions	118
Appendix A	119
List of figures	120
References	125
Acknowledgments	128