Table of Contents

Acknowledgement
Table of contentsii
Lists of illustration vi
List of tables viii
Chapter one: Introduction
Chapter two: Literature Review
2.1 The sol-gel technology 4
2.2 Sol-gel process5
2.3 Sol-gel research
2.4 Hydrolysis reaction mechanism7
2.5 Silane chemistry 10
2.6 Sol-gel applications
Chapter three: Experimental procedure
3.1 Surface pre-treatment
3.2 Chemical reagents
3.3 Instruments 16
3.3.1 Spin coater 16
3.3.2 Atomic Force Microscope
3.3.3 Scanning Electron Microscope
3.3.4 Thermogravimetric Analyzer 19

3.4 Preparation of sol-gel solution 22
3.4.1 Methodology for sol preparation 24
3.5 Spin coating 25
3.5.1 Developing thin film 25
3.5.2 Drying and sintering 26
3.5.3 The effect of temperature
3.6 Summarization of gel formation route 32
3.7 Heat treatment schedule 33
J. / Hour dealinest belleast
Chapter four: Results and Discussion 34
Chapter four: Results and Discussion 34
Chapter four: Results and Discussion
Chapter four: Results and Discussion

List of illustration

Fig 14. SEM micrograph of 8 mol dm ⁻³ acetic acid catalyzed thin film	
after sintering at 250 °C	41
Fig 15. AFM micrograph image of 8 mol dm ⁻³ acetic acid catalyzed	
thin film after sintering at 250 °C	41
Fig 16. SEM micrograph of 6 mol dm ⁻³ acetic acid catalyzed thin film	
after sintering at 250 °C	42
Fig 17. AFM micrograph image of 6 mol dm ⁻³ acetic acid catalyzed	
thin film after sintering at 250 °C	42
Fig 18. SEM micrograph of 2.0 ml propionic acid catalyzed thin film	
after sintering at 300 °C	45
Fig 19. AFM micrograph image of 2.0 ml propionic acid catalyzed	
thin film after sintering at 300 °C	45
Fig 20. SEM micrograph of 2.0 ml propionic acid catalyzed thin film	
after sintering at 250 °C	46
Fig 21. AFM micrograph image of 2.0 ml propionic acid catalyzed	
thin film after sintering at 250 $^{\circ}\mathrm{C}$	46
Fig 22. SEM micrograph of 1.00 ml propionic acid catalyzed thin film	
after sintering at 250 °C	47
Fig 23. AFM micrograph image of 1.0 ml propionic acid catalyzed	
thin film after sintering at 250 $^{\circ}\mathrm{C}$	47
Fig 24. SEM micrograph of 2.0 ml propionic acid catalyzed thin film	
after sintering at 120 °C	48

Fig 25. AFM micrograph image of 2.0 ml propionic acid catalyzed	
thin film after sintering at 120 °C	48
Fig 26. SEM micrograph of 1.5 ml propionic acid catalyzed thin film	
after sintering at 120 °C	49
Fig 27. AFM micrograph image of 1.5 ml propionic acid catalyzed	
thin film after sintering at 120 °C ·	49
Fig 28. SEM micrograph of 1.0 ml propionic acid catalyzed thin film	
after sintering at 120 °C	50
Fig 29. AFM micrograph image of 1.0 ml propionic acid catalyzed	
thin film after sintering at 120 °C	50
Fig 30. SEM micrograph of 0.70 mol dm ⁻³ malonic acid catalyzed thin film	
after sintering at 75 °C	53
Fig 31. AFM micrograph image of 0.70 mol dm ⁻³ malonic acid catalyzed	
thin film after sintering at 75 °C	53
Fig 32. SEM micrograph of 1.00 mol dm ⁻³ malonic acid catalyzed thin film	
after sintering at 75 °C	54
Fig 33. AFM micrograph image of 1.00 mol dm ⁻³ malonic acid catalyzed	
thin film after sintering at 75 °C	54
Fig 34. SEM micrograph of 1.72 mol dm ³ malonic acid catalyzed thin film	34
after sintering at 75 °C	55
Fig 35. AFM micrograph image of 1.72 mol dm ⁻³ malonic acid catalyzed	
thin film after sintering at 75 °C	55

Fig 36. SEM micrograph of 2.58 mol dm ⁻³ malonic acid catalyzed thin film	
tafter sintering at 75 °C	56
Fig 37. AFM micrograph image of 2.58 mol dm ⁻³ malonic acid catalyzed	
thin film after sintering at 75 °C	56
Fig 38. SEM micrograph of 0.70 mol dm ⁻³ maleic acid catalyzed thin film	
after sintering at 75 °C	57
Fig 39. AFM micrograph image of 0.70 mol dm ⁻³ maleic acid catalyzed	
thin film after sintering at $75\ ^{\circ}\text{C}$	57
Fig 40. SEM micrograph of 1.00 mol dm ⁻³ maleic acid catalyzed thin film	
after sintering at 75 °C	58
Fig 41. AFM micrograph image of 1.00 mol dm ⁻³ maleic acid catalyzed	
thin film after sintering at $75\ ^{\circ}\text{C}$	58
Fig 42. SEM micrograph of 1.72 mol dm ⁻³ maleic acid catalyzed thin film	
after sintering at 75 °C	59
Fig 43. AFM micrograph image of 1.72 mol dm ⁻³ maleic acid catalyzed	
thin film after sintering at $75 ^{\circ}\mathrm{C}$	59
Fig 44. SEM micrograph of 2.58 mol dm ⁻³ maleic acid catalyzed thin film	
after sintering at 75 °C	60
Fig 45. AFM micrograph image of 2.58 mol dm ⁻³ maleic acid catalyzed	
thin film after sintering at 75 °C	60

List of tables

Table 1: The components ratio of various acetic acids sol-gel solution 23
Table 2: The components ratio of various malonic and maleic acid
sol-gel solution 23
Table 3: The components ratio of various propionic acid sol-gel solutions 23
Table 4: The thickness and roughness of acetic acid catalyzed thin films 27
Table 5: The thickness and roughness of propionic acid catalyzed thin films 37
Table 6: The thickness and roughness of malonic acid catalyzed thin films 43
Table 7: The thickness and roughness of maleic acid catalyzed thin films 52
Table 8: the temperature effect on thin film thickness 52