

Table of Contents

| | |
|---|------|
| Acknowledgements..... | ii |
| Table of Contents | iii |
| List of Figures | v |
| List of Tables | viii |
| Summary | ix |
| Chapter 1: Introduction | |
| | 1 |
| Chapter 2: History of the Chemical Sensing Problem | 5 |
| 2.1 History of the Individual Chemical Sensor..... | 6 |
| 2.2 The Introduction of the Chemical Sensor Array..... | 11 |
| 2.3 Thin-Film and MOSFET based Sensor Technologies | 14 |
| 2.3.1 Thin-Film Chemical Sensor Technologies..... | 14 |
| 2.3.2 MOSFET-based Chemical Sensor Technologies | 16 |
| Chapter 3: Hybrid Array Architectures | 19 |
| 3.1 Homogeneous Arrays | 19 |
| 3.2 Heterogeneous Arrays..... | 22 |
| 3.2.1 Temperature as a Heterogeneous Parameter | 22 |
| 3.2.2 Evaluating the Robustness of the Heterogeneous Array | 24 |
| 3.3 Optimizing the Hybrid Array Architecture..... | 35 |
| Chapter 4: Homogeneous Array Processing | |
| | 39 |
| 4.1 Circuit Descriptions | 40 |
| 4.1.1 The Mean Detection Circuit | 40 |
| 4.1.2 Mean Detection with Outlier Elimination | 43 |
| 4.2 Circuit Characterization: Experimental Results | 48 |
| 4.2.1 Typical Circuit Behavior..... | 48 |
| 4.2.2 Accuracy of Mean Calculation | 55 |
| 4.2.3 Resolution in the Mean Detection Circuits..... | 58 |
| 4.2.4 Accuracy of Outlier Removal | 61 |
| 4.3 System Testing | 63 |

| | | |
|--|---|------------|
| 4.3.1 | Experimental Setup | 63 |
| 4.3.2 | Experimental Results..... | 65 |
| Chapter 5: Heterogeneous Array Processing | | 68 |
| 5.1 | The Temperature Array..... | 69 |
| 5.2 | Circuit Descriptions | 71 |
| 5.2.1 | Adaptive Thresholding of an Array of Analog Inputs | 72 |
| 5.2.2 | Rank-order Filtering of a Sensory Input Array | 77 |
| 5.3 | Circuit Characterization: Experimental Results | 87 |
| 5.3.1 | Sources of Error in the Rank-Order Filtering Circuits | 88 |
| 5.3.2 | Adaptive Thresholding: Experimental Results | 89 |
| 5.3.3 | Rank-Order Filtering: Experimental Results..... | 94 |
| 5.4 | System Testing | 101 |
| 5.4.1 | Experimental Set-Up | 101 |
| 5.4.2 | Adaptive Thresholding System Testing | 104 |
| 5.4.3 | System Testing: Rank-Order Filtering | 108 |
| 5.5 | Applications | 109 |
| 5.6 | Comparison to Existing Systems | 111 |
| Chapter 6: Transient Chemical Signal Processing | | 113 |
| 6.1 | The Transient Characteristic of Chemical Sensors | 114 |
| 6.2 | System Description..... | 115 |
| 6.3 | System Testing | 118 |
| 6.3.1 | Experimental Set-Up | 118 |
| 6.3.2 | Wavefront Analysis over a Wide Temperature Range | 122 |
| 6.3.3 | Wavefront Analysis across a Narrow Temperature Range..... | 123 |
| 6.4 | Comparison of Wavefront Analysis to Existing Systems | 125 |
| Chapter 7: Integration and Packaging | | 127 |
| 7.1 | Integration of Thin-Film Sensors with aVLSI Circuits | 128 |
| 7.2 | Integration of ChemFET Sensors with aVLSI Circuits | 133 |
| 7.3 | Packaging of Integrated Chemical Microsystems | 134 |
| Chapter 8: Concluding Remarks | | 139 |
| 8.1 | Contributions of Research | 140 |
| 8.2 | Future Work | 140 |

| | |
|------------------|-----|
| References | 142 |
|------------------|-----|