Abstract

The success of miniature chemical analysis systems in consumer markets has been inhibited not only by reliability problems with individual microelectronic chemical sensors but also by compatibility issues with standard microfabrication processes. In order to enhance the success of these systems, the architecture of the entire system must be designed to overcome the performance issues associated with individual sensors while staying within the constraints of standard fabrication processes.

This research focuses on the development of a signal processing framework that is appropriate for chemical analysis microsystems. Because of the inherent inaccuracies found in many individual microelectronic chemical sensors, it is assumed that robust microsystems will involve large arrays of such sensors that average out problems with drift and reproducibility in individual sensors and provide sufficient variation in array structure and sensor operating conditions to perform reproducible chemical discrimination. When sensing plane real-estate is limited, a trade-off occurs between the accuracy of sensor data provided by homogeneous arrays of sensors and the discrimination capability of heterogeneous arrays of chemical sensors. In this research, the choice of an optimal hybrid architecture is addressed for application to chemical sensing systems; once the architectures of the system is decided, signal processing techniques for both homogeneous and heterogeneous arrays of chemical sensors are outlined. Also addressed is the need for improved response time in chemical sensing systems whose component sensors are inherently slow (on the order of seconds).

The signal processing framework described herein uses both the transient and steady state characteristics of an array of tin-oxide chemical sensors operating at various temperatures to develop and analyze unique signatures corresponding to many reducing chemicals. These architectures are designed to be implemented in an integrated framework of sensors and circuits on a single substrate. Though not explicitly a part of this thesis, the effort to integrate chemical sensors and the circuits described herein is a part of a longer term project associated with this research.