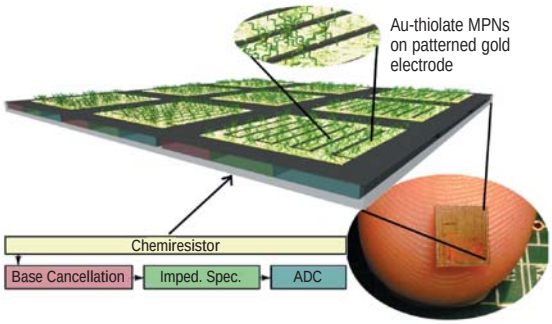
On-Chip Auto Calibrating Impedance Analysis for Gas Sensors

Daniel Rairigh and Andrew J. Mason

Chemiresistors (CR) coated with thiolate-monolayer-protected gold nanoparticles (MPN) exhibit a highly sensitive resistance change in response to absorbed vapors and provide extremely low-detection limits. In practical applications, resolution is limited by the precision of measurement circuits and noise sources in the transducer and electronics. Theoretically, the capacitive response of a CR can be used to improve sensitivity, but this parameter has not been adequately explored due in large part to the absence of appropriate instrumentation circuits. The aim of this project is to develop a microelectronic instrumentation circuit that will elucidate, with high resolution, both the resistive and capacitive response of a CR within a platform suitable for monolithic integration of a gas sensor array microsystem.



Chemiresistors (CR) coated with thiolate-monolayer-protected gold nanoparticles (MPN) form highly sensitive gas sensor arrays when combined with on-chip, low-noise instrumentation capable of canceling baseline drift values and extracting full-impedance spectra response.

The primary challenges for high-resolution CR instrumentation circuitry include 1) presence of significant variance (between elements) and drift (over time) in baseline resistance, 2) smallness of sensor response (~1ppm) relative to baseline value, and 3) measurement of both resistive and capacitive responses to maximize sensitivity. To address these challenges, a new readout circuit for CR sensor arrays has been developed based on impedance spectroscopy (IS). The CMOS analog readout circuit provides rapid, self-calibrated baseline cancellation. After baseline cancellation, IS measurement is applied to extract real and imaginary impedance components as a function of excitation frequency to reveal both resistive and capacitive responses simultaneously. The compact, low-noise instrumentation circuit is suitable for on-chip sensor array integration, which eliminates wiring noise, focuses dynamic range, and maximizes measurement resolution in a single-chip gas analysis system. ■