FROM SENSING TO MAKING SENSE

Delivering Low-false-alarm Multi-gas Sensing Performance In Pervasive Applications By Cross-pollination Between Sensor Electronics And Mathematics Of Traditional Analytical Instruments

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Conventional gas sensors offer low-cost and miniaturized designs but these designs are based on a single output response of a given individual sensor (e.g. resistance, current, light intensity). Thus, under variable ambient conditions all conventionally designed sensors suffer from cross-sensitivity from different gases in complex chemical backgrounds and from response drift: mathematically all single-output sensor designs cannot reject effects from other gases and cannot correct for their drift.

The purpose of our compact vapor chemical agent detector (CVCAD) is to change this status quo by implementing our multivariable sensors that are designed to have independent outputs. The objective of our individual multivariable gas sensors is to quantify multiple gases, reject interferences, and, if needed, self-correct for sensor drift.

The rationale of our research is to design and build such multivariable gas sensors with the unique multi-gas detection and drift elimination performance as the basis of our CVCAD system to allow implementations of gas sensors in diverse applications that cannot afford weekly, monthly, or quarterly periodic maintenance, typical of exquisite traditional analytical instruments.

We have been developing our multivariable gas sensors for several years with an initial commercial product in 2019 as a wireless sensor network for greenhouse emissions in all-weather conditions. Next, we advanced and field tested our multivariable gas sensors in several active mines for monitoring of gases for industrial safety. These developments have resulted in building our platform for detection of gases of multiple categories for CVCAD applications.

Our multivariable gas sensors operate in the radio-frequency portion of the electromagnetic spectrum and utilize dielectric excitation of inorganic materials on the shoulder of their dielectric relaxation peak. Our results demonstrate two outstanding capabilities of our CVCAD that previously were provided of only by traditional analytical instruments. First, is detection of different catagories of chemical agents of importance down to their part-per-billion concentrations to protect the warfighter in diverse ambient conditions of variations of ambient relative humidity, ambient temperature, and diverse chemical background. Second, is the sensor stability achieved by using our radio-frequency multivariable gas sensors with the multi-frequency readout.

In summary, our approach for multi-gas detection coupled with drift self-correction should allow implementations of gas sensors in diverse applications ranging from CVCAD warfighter to many other uses. Our developed CVCAD is a detect-to-warn device, slightly smaller than a smartphone and can operate in handheld, wearable, UAV-integrated or wireless sensor network topologies for perimeter monitoring. Our CVCAD design combines the innovations in gas sensing with contemporary electronics design principles and their manufacturing capabilities to deliver the needed high levels of performance confidence without trade-offs of large power, size, and cost of traditional analytical instruments. Our CVCAD design should be an important step in reaching the desired performance of detect-to-warn devices for DOD applications. The high-performance capabilities of these devices should also be attractive to other applications ranging from medical to consumer and to industrial.

Summary of our initial results: Extraordinary performance of semiconducting metal oxide gas sensors using dielectric excitation, Nature Electronics 2020, 3, 280–289 and numerous patents on USPTO.gov.

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