SYNKERA'S SOLID-STATE ELECTROCHEMICAL SENSORS

Synkera's solid-state electrochemical sensors build upon the commercial success of electrochemical sensors and recent technology developments to create a next generation product that is significantly smaller, faster, more sensitive, stable, and lower cost than anything available today. There are five unique aspects to this innovation: integration of a solid polymer electrolyte (SPE) for leak-free, stable operation; the use of micro-band electrodes for increased sensitivity; novel manufacturing techniques for low cost, reproducible mass production in a novel architecture; and the ability to integrate the sensor directly into the electronic operating circuit.

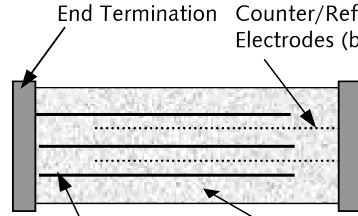

Figure 1: "SPE Sandwich Sensor"- Electrode layers are embedded in SPE.

Figure 1 shows the orientation of the microelectrodes in a chip made of solid polymer electrolyte (SPE) in a multilayer format. End terminations are used to provide electrical connections. The chip size and geometry are comparable to surface mount ceramic electronic components such as capacitors.

SOLID POLYMER ELECTROLYTE AND MICROBAND ELECTRODES

Commercial fuel cell sensors use liquid electrolytes (often sulfuric acid), and are widely known in the sensor industry to suffer from electrolyte leaks under certain conditions, as the need to make electrical connections and allow gas into the sensor inevitably creates several opportunities for leak paths to develop. Additionally, because sulfuric acid is hygroscopic, the volume of the electrolyte changes with relative humidity, leading to changes in the sensitivity of the sensor response. The best solution to these issues is to use a solid electrolyte. Synkera has investigated the performance of several variations on nanocomposite solid polymer electrolytes (SPE) with microband electrodes. To form the SPE a polymer is combined with appropriate inorganic salts and modified with nanostructured inorganic materials, to form composites for optimum conductivity, stability and sensor performance. Synkera has shown that these electrolytes provide adequate ionic conductivity for sensor response at ambient temperatures.

The advantages of using ultra-microelectrodes for electrochemical analysis have been recognized for many years. Ultra-microelectrodes are generally defined as electrodes where at least one dimension is on the micron scale. The advantages of these electrodes include increased temporal resolution (fast response), an ability to operate in less conductive electrolytes (such as SPEs), and higher signal to noise ratios due to an increase of faradaic currents relative to non-faradaic currents. Ultra-microelectrodes can take the form of disks, cylinders or bands. Ultra-microelectrodes with a band geometry, such as those used by Synkera in the solid-state electrochemical sensors, are highly desirable because they are small in only one dimension. Increasing the length of the microband electrode increases the current flow, leading to higher and more easily measured currents.

Use of ultra-microelectrodes have not yet been commercialized as gas sensors, largely due to the high cost of traditional manufacturing techniques. However, the possibility of creating high-quality arrays of microband electrodes using the standard mass manufacturing techniques employed by Synkera allow for the production of innovative, next-generation gas sensors at very low costs, and enables increased sensitivity and the use of SPEs.

MULTI-LAYER PROCESSING

Synkera's solid-state electrochemical sensors can be built using techniques that are widely used in the processing of electronic components such as inductors and capacitors. These techniques, referred to as multilayer processing, are not typically used in the sensor industry. This novel architecture can lead to small, low-cost, highly reproducible sensors that incorporate high quality, micro-band electrodes.

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This approach, which is unique to Synkera Technologies, affords many advantages over traditional gas sensor fabrication methods:

1. It enables the production of very thin micro-band electrodes for improved signal/noise ratio, fast response and the use of less conductive electrolytes
2. It enables the production of very small sensors, with a geometry and size configuration compatible with existing electronic components. Current sensors are produced as 0.175" x 0.175" elements, but have the potential to be reduced further.
3. Manufacturing costs are low due to high volume manufacturing and the degree of automation.
4. Part-to-part reproducibility is high due to significant automation of the fabrication process.

INTEGRATION OF SENSORS INTO ELECTRONIC CIRCUITRY

The unique "chip-style" sensor devices, prepared with a high degree of reproducibility from part to part have a sensor element size and geometry depicted in Figure 1and Figure 2. The geometry of the sensor elements is such that they can be directly mounted to a circuit board, simplifying requirements for packaging, and greatly reducing module cost.

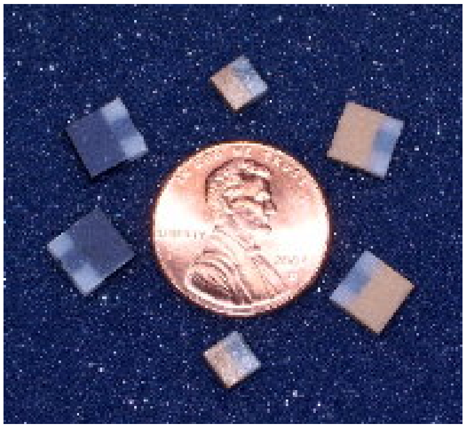

Figure 2: Synkera's multilayer solid – state electrochemical gas sensors (unpackaged).

PRINCIPLE OF OPERATION

In general, electrochemical sensors operate by oxidizing or reducing the target analyte at a working electrode. The target analyte reacts at the interface between the working electrode and an electrolyte. An opposing reaction at the counter electrode balances the reaction at the working electrode, while the electrolyte provides ionic conduction between the working and counter electrode. Most common electrochemical sensors feature a three electrode design; however, the Synkera sensor design produces such a low current at the working electrode that it is able to use a combined counter/reference electrode.

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