

Battery Off-Gas Sensing for Real-Time Thermal Runaway Detection in Lithium-ion Packs

Lithium-ion batteries power everything from consumer electronics to electric vehicles, and with their high energy density, safety is a paramount concern. A battery “health monitor” that can detect the gases released in the earliest stages of cell degradation offers a powerful line of defense: it issues advance warning of thermal runaway, supports predictive maintenance, and preserves post-event data for forensic analysis. Posifa Technologies’ off-gas sensor addresses these needs in a single, compact device designed for seamless integration into the battery management system (BMS) compartment.

Unlike temperature or voltage probes that detect an issue only after internal damage has already begun, the Posifa sensor directly measures critical electrolyte vapors, hydrogen, water vapor, and other off-gas signatures that precede a runaway event. And because the device resides entirely within the BMS enclosure, it requires no additional wiring across modules, simplifying pack design and improving reliability. The sensor’s micro-machined architecture for thermal conduction detection delivers high sensitivity with sub-second response, while immune to poisoning or contamination. These attributes, combined with low power draw, a $-40\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$ operating window, and projected service life beyond 15 years, make the sensor a true set-and-forget solution.

Laboratory tests confirm that the device reacts decisively to the off-gas signatures most closely associated with early thermal runaway. Figure 1 shows the rapid rate of rise recorded when the sensor is exposed separately to 198 ppm hydrogen, 253 ppm methane, and 204 ppm carbon dioxide, and to a combined hydrogen and carbon dioxide mixture. In every case, the signal rises dramatically above the baseline within moments, giving a battery management algorithm ample time to alert the user or disconnect the pack before temperatures escalate.

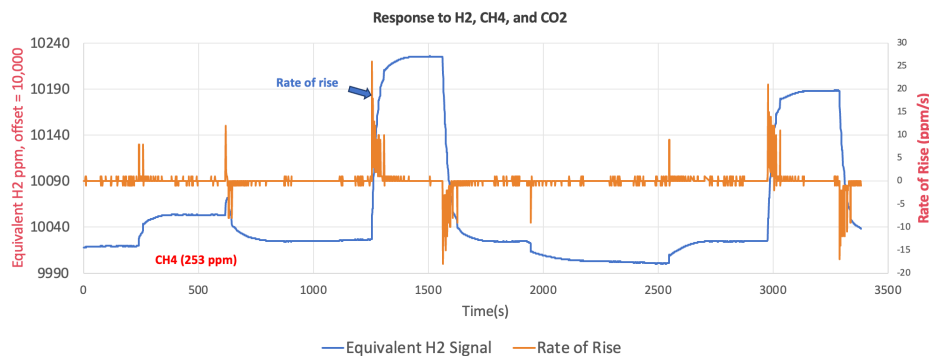


Figure 1. Sensor response curves to 198 ppm hydrogen, 204 ppm carbon dioxide, and a combined hydrogen and carbon mixture, highlighting the rapid rate of rise relative to the baseline.

In addition to flammable gases from decomposition, the Posifa sensor demonstrates strong sensitivity to electrolyte vapors such as EMC, dimethyl carbonate (DMC), and diethyl carbonate (DEC) (Figure 2). These solvents may be released during slow leakage or degradation processes long before any thermal events occur, making them valuable indicators for early intervention and predictive maintenance.

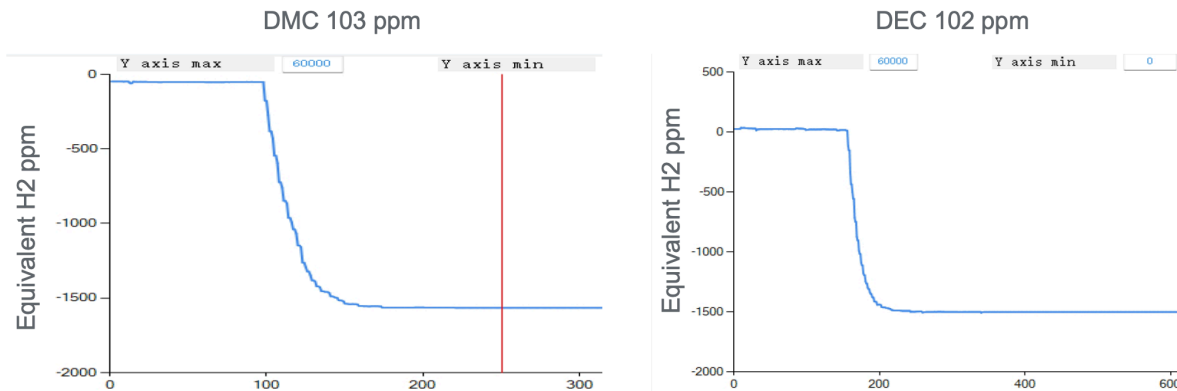


Figure 2. The sensor shows a strong response to common battery electrolyte vapors. In controlled tests, clear signal responses were observed at 103 ppm for DMC and 102 ppm for DEC, further supporting its application as a broad-spectrum battery health monitor.

The sensor is also capable of detecting water vapor, enabling identification of humidity ingress that could indicate a broken seal or other failure mode. Real-time humidity monitoring allows for preventative action before moisture-related damage progresses within the cell stack (Figure 3). In some types of thermal runaway events a rise in humidity is also a precursor.

Temperature °C	H2 ppm (equiv) / %RH
11	12
25	32
45	78
73	342
85	633

Figure 3. Quantitative data also support the sensor's sensitivity to humidity, enabling early detection of water vapor ingress that might otherwise go unnoticed until irreversible damage has occurred.

The sensor’s performance in the field mirrors its bench results. During an induced thermal runaway of a lithium-ion module, the sensor tracked changes in gas concentration in real time, producing clear, unambiguous signals well in advance of flammable gases reaching explosion limits (Figure 4). This real-world validation underscores the value of off-gas monitoring as a first-line safety measure and as a rich data source for fleet-wide trend analysis.

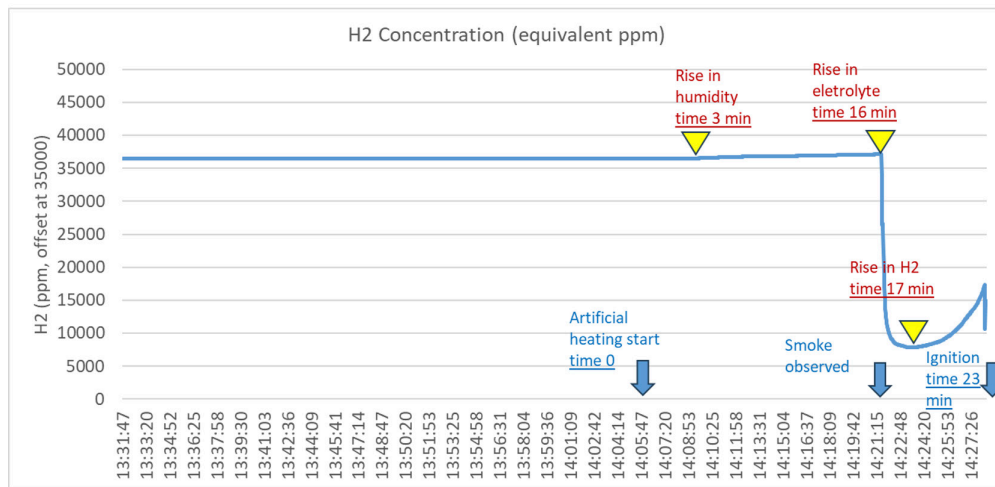


Figure 4. Real-time output of the off-gas sensor during an actual lithium-ion thermal runaway event, showing an immediate signal surge that precedes the temperature spike.

Posifa offers two versions of its off-gas sensor. The PGS5100 series provides a fully enclosed module that mounts inside the BMS compartment, while the PGS5200 series supplies the same sensing core on a low-profile PCBA for direct integration onto a host board. Both sensors are currently undergoing AEC-Q100 qualification to meet the stringent demands of automotive and industrial markets.

Conclusion

Direct off-gas sensing closes a critical gap in lithium-ion safety architecture. By capturing the chemical precursors of failure, Posifa’s sensor enables earlier intervention than temperature, pressure, or voltage-imbalance methods, thereby reducing the risk of catastrophic events and lowering total cost of ownership through predictive maintenance and detailed post-incident diagnostics.