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FaradaIC[®]

World's smallest electrochemical gas sensor

faradaic.com

OPTIMIZE FRESHNESS

Smart Data Tracking with the World's First Oxygen Sensor on a Chip



Optimize Freshness

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Maintaining freshness and ensuring the best quality of products from farming to the end-user is a complex challenge in modern supply chains. By implementing targeted interventions to optimize logistic processes and leveraging sensors with our proprietary chip technology, businesses can achieve full visibility into product conditions at every stage. Automated quality processes enable real-time monitoring, reducing waste and cost while guaranteeing the best quality for consumers. This application note explores how these advanced solutions transform supply chains, ensuring products retain their freshness and quality throughout the journey.

In the ever-changing landscape of fresh-produce storage and transport, maintaining optimal conditions for fresh food is paramount to ensure extended shelf life, reduce waste, and deliver premium quality to consumers. Controlled and modified atmosphere have emerged as a crucial technology in this regard. FaradalC® introduces MECS-Technology®, the ground-breaking use of advanced gas-sensing technology on a chip for monitoring food freshness during storage and packaging under modified or controlled atmosphere especially in CAP (controlled atmosphere packaging) and MAP (modified atmosphere packaging), i.e. for dry food. This provides food producers, wholesalers, packers, and shippers the much-needed flexibility to sell products at the perfect time.

Further advantages:

- **Precision monitoring:** FaradalC's advanced O₂ and CO₂ gas sensors provide unparalleled accuracy in monitoring the gas concentration. Precision is critical when aiming for the optimal conditions that ensure prolonged freshness.
- **Real-time feedback:** Real-time monitoring capabilities allow for swift adjustments to the atmosphere, ensuring that any deviations from the desired conditions are promptly addressed. This is particularly beneficial for preventing spoilage and maintaining the quality of produce throughout its journey from storage to the consumer.
- **Improved quality control:** By leveraging FaradalC's gas sensing technology, organizations can enhance their quality control processes. The ability to monitor and analyse gas concentrations provides valuable insights into the effectiveness of controlled and modified atmosphere solutions (CAP and MAP), allowing for continuous improvement and optimization.

The MECS-Technology® from FaradalC also addresses industry specific challenges

- **Post-harvest variability:** Maintaining optimum freshness is made difficult by the natural fluctuations in post-harvest conditions. Our MECS-Technology® overcomes this challenge by allowing the controlled or modified atmosphere to be adjusted in real time, ensuring consistent shelf life regardless of the initial conditions.
- **Biological and environmental factors:** Bio-sensing technology combined with gas sensing solutions provides a comprehensive approach to freshness monitoring. This dual perspective allows for a holistic understanding of the interplay between biological and en-

vironmental factors, contributing to more effective controlled atmosphere (CAP) or modified atmosphere (MAP) storage.

- **Supply chain efficiency:** Optimizing food logistics demands real-time feedback on produce conditions. Integrating our sensors into supply-chain operations enhances efficiency, ensuring food maintains its freshness throughout transportation, ultimately reducing waste and improving overall logistics.
- **Unique produce type optimization:** Different foods require specific gas concentrations for optimal preservation. Our sensors offer the flexibility to tailor atmosphere conditions based on the unique needs of each produce type, maximizing freshness and shelf life.

In the rapidly evolving landscape of fresh-produce storage and transportation, the integration of our advanced gas-sensing technology is the key to unlocking new levels of precision, efficiency, and quality control.

By integrating sensors with MECS-Technology® from FaradalC into appliances or packaging solutions, producers and distributors can set new standards for freshness monitoring in controlled and modified atmospheres and predict shelf life more accurately. This not only benefits consumers, but also reduces waste and consolidates the position of producers as pioneers in this field. Together, we can revolutionise the way the world approaches the storage of fresh produce and contribute to a more sustainable and efficient future for the industry.

These advantages highlight the significance of sensor-based technologies in accurately predicting and extending the shelf life of various products, ensuring quality, minimizing waste, and fostering a more sustainable food supply chain. To summarise, the unique advantages of FaradalC's MECS-Technology® are as follows.

- **Accurate Monitoring:** Sensors enable real-time and continuous monitoring of various parameters (such as temperature, humidity, gases) critical to food deterioration, providing accurate data for shelf-life assessment.
- **Precise Environmental Conditions:** These sensors help maintain ideal storage conditions by ensuring that temperature, humidity, and other factors remain within optimal ranges, thus prolonging product freshness and extending shelf life.
- **Early Warning Systems:** Sensors equipped with predictive algorithms can detect deviations from optimal conditions, providing early warnings of potential spoilage or degradation and allowing for timely intervention to preserve product quality.
- **Reduction of Food Waste:** Accurate shelf life prediction using sensor data aids in inventory management and helps reduce food waste by preventing the premature disposal of products that are still safe and consumable.
- **Quality Assurance:** Continuous monitoring ensures that food products meet quality standards, allowing producers to maintain consistency and ensure that consumers receive products of the highest quality. By optimizing storage conditions and reducing waste, sensor-based shelf-life prediction methods contribute to cost savings for producers, retailers, and consumers alike.

- **Regulatory Compliance:** Sensors aid in compliance with food safety regulations by ensuring that products are stored under optimal conditions.
- **Consumer Confidence:** Enhanced shelf-life prediction and quality maintenance through sensors build consumer trust by delivering fresher, safer, and longer-lasting products to the market.
- **Innovation and Research:** The data collected by sensors contribute to ongoing research and innovation in packaging, storage, and preservation techniques, leading to continuous improvements in extending shelf life.
- **Sustainability:** Efficient shelf-life prediction minimizes waste and contributes to sustainability efforts by reducing the environmental impact.

In the field of freshness monitoring and shelf-life prediction, the development and application of micro-electrochemical sensors using MECS-Technology® have led to significant advances. These sensors, which can detect and measure gas concentrations with high precision and efficiency, also play a key role in various other industries, particularly in environmental monitoring, industrial processes and medical technology.

Micro electrochemical sensors from FaradaIC are sensors with MECS-Technology® and complex systems that utilise chemical reactions to detect and quantify gas concentrations. These sensors work on the principle of measuring electrical currents generated by reactions related to gas concentration, providing accurate and fast measurement of gas concentration. Due to their novel chemical structure, they do not dry out like other electrochemical sensors and can therefore also be used in dry environments with 0% relative humidity and industrial temperature ranges of up to 85 °C. The structure is similar to that of MEMS (Figure 1) and is optimized for use in high-volume applications.

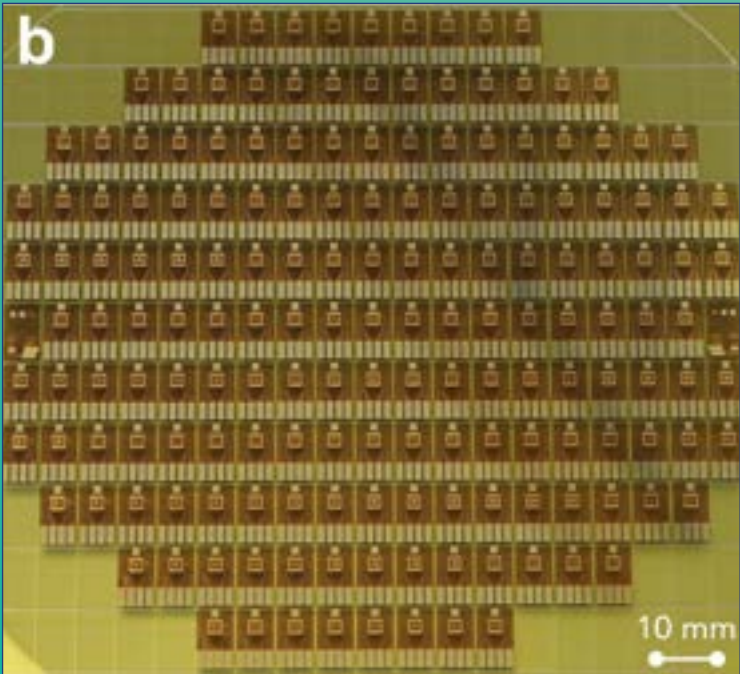


Figure 1: Multiple electrochemical sensors on a single wafer utilizing MECS-Technology®



Figure 2: World's smallest oxygen sensor

Our sensors can be integrated into bags and packages, enabling users to track and monitor the food condition inside during transportation and storage in real time.

The differences between FaradaIC's MECS-Technology® and other

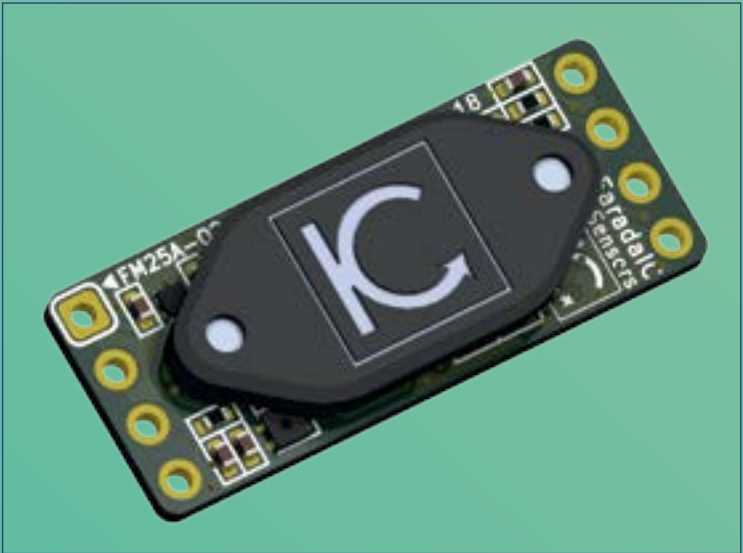


Figure 3: Smart digital oxygen gas measuring module

gas sensing technologies can be seen in the table of Figure 7. Miniaturizing the electrochemical gas sensor onto a chip, the most desired features can be combined onto a single platform.

By incorporating our sensors into bags and packages which are stored in a warehouse, our customers can set new standards for freshness monitoring in controlled and modified atmospheres. Additionally, our MECS-Technology® can easily be integrated into BLE (Bluetooth® Low-Energy) based real-time location systems (RTLS), locating each and every bag together with its freshness status.

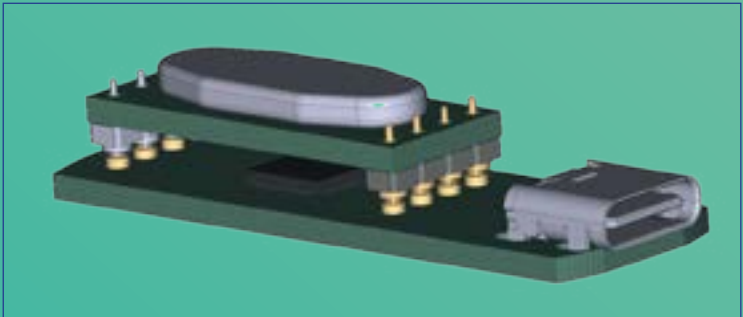


Figure 4: Smart data device with Bluetooth® BLE or USB interface from x-log Elektronik GmbH

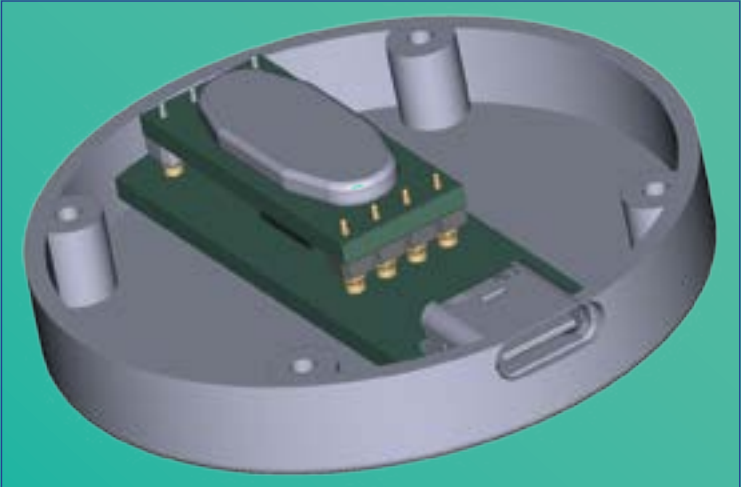


Figure 5: Smart data tracking device for modified atmosphere packages (MAP) from x-log Elektronik GmbH

With the latest improvements in BLE technologies and data transfer into cloud systems, freshness monitoring combined with location tracking becomes an ideal solution. This combination enables the transfer of sensor data together with their location to the cloud via mesh networks. There, the data is analysed and forwarders can determine the best sales time for each individual package and deliver them to the point of sale.

Asset tracking is already a requirement in warehouse systems, and the new BLE technologies enable simultaneous data transmission from inside bags and even through food and packaging, providing many real-time benefits such as:

- shelf life prediction for every single package
- detailed condition monitoring with real-time localisation
- transparency of food freshness in every bag and package
- reduce food waste and increase food quality
- finding the bags with the best time of sale at the best price
- licensing complete packaging system
- recalibration of sensors via the network

Technology	MECS-Technology® Micro Electro Chemical Systems	MOX Metal- Oxide	Infrared NDIR for non dispersive gases	Electrochemical	Photoacoustic
Miniaturized	✓	✓	✗	✗	✗
Cost-effective	✓	✓	✗	✗	✗
Selective	✓	✗	✓	✓	✓
Ultra-low power	✓	✗	✗	✓	✓
High volume manufacturing	✓	✓	✗	✗	✓

Figure 7: Gas sensors: Technology comparison



Figure 6: Storage of MAP bags with best-in-and-best-out system