

NO_x Monitoring From Mobile Sources

Ceramatec, Inc.

2425 South 900 West
West Valley, UT 84119-1517
(801) 972-2455

<http://www.ceramatec.com/>

EmiSense Technologies, LLC.

4205 West 1980 South
Salt Lake City, UT 84104
(949) 502-8440
<http://www.emisense.com>

Environmental Problem

Nitrogen oxides (NO_x), which are among the primary pollutants emitted from vehicle exhaust, cause significant environmental and human health issues. Adverse respiratory effects associated with NO_x include airway inflammation in healthy people and increased respiratory symptoms in individuals with asthma. NO_x exposure concentrations in vehicles and near roadways are appreciably higher than in other locations and are of particular concern for susceptible individuals, including children and the elderly.

Monitoring the NO_x concentration in exhaust streams is critical for the reduction of NO_x emissions and compliance with EPA's clean air regulations.

SBIR Technology Solution

With support from EPA's Small Business Innovation Research Program (SBIR), Ceramatec, Inc. has developed multiple types of sensors that can monitor the NO_x concentration generated by combustion in diesel engines. These devices offer fast response and high sensitivity to NO_x, low cross-sensitivity to other species, such

as carbon monoxide (CO) and sulfur dioxide (SO₂), and can perform for extended periods in engine exhaust from mobile sources. These sensors will improve emissions monitoring and enforcement of emissions regulations for both on-road and off-road mobile sources.

Many promising emissions-reduction devices have been developed in recent years, such as NO_x absorbers, selective catalytic converters (SCR), exhaust gas recirculation (EGR), and oxygen-enriched air injection (OEA) technology. Information obtained by online NO_x monitoring can be fed back into the process control system so that process variables can be optimized to reduce pollution. Ceramatec's ceramic-based sensor successfully withstood high temperatures present in an engine exhaust stream (500-600° C). When measuring NO_x concentrations, the sensor was not affected by the gas input nitric oxide (NO)/nitrogen dioxide (NO₂) ratio; the sensor voltage was found to be proportional to the total NO_x concentration. The sensor had no response to cross-sensitivity with carbon dioxide (CO₂) and water vapor, although cross-sensitivity to up to 1,500 ppm of CO and 15 ppm of SO₂ affected the baseline voltage of the sensor. The NO_x sensor demonstrated sensitivity to NO_x levels as low as 1 ppm. As a final step in Phase II, Ceramatec miniaturized the sensor into a smaller device that could be threaded into an exhaust port.

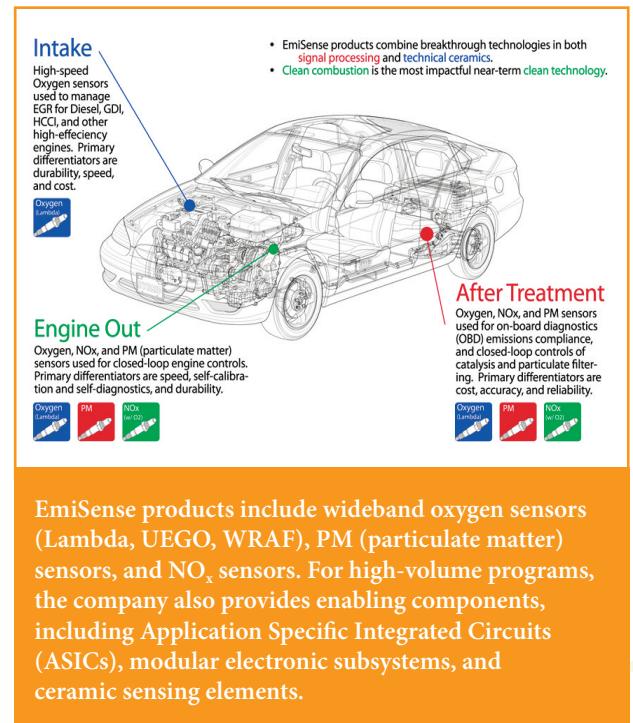
Commercialization Information

In November 2009, a new company, EmiSense Technologies, LLC, was formed to commercialize this efficient, durable, and cost-effective NO_x sensor. Ceramatec is providing advanced diagnostic and analytical services to EmiSense.

EmiSense is commercializing other advanced sensors, including electronic-field particulate matter (PM) sensors and oxygen or Lambda (air/fuel ratio)

sensors, to promote clean emissions and help address the global challenges of fossil-fuel dependence and climate change. High-volume ceramic foundry services are provided to the company by CoorsTek (see below).

EmiSense's intake high-speed oxygen sensors are used to manage exhaust gas recirculation for diesel, gasoline direct injection, homogeneous charge compression ignition, and other high-efficiency engines. The company's engine out oxygen, NO_x, and PM sensors are used for closed-loop engine controls. Its after treatment oxygen, NO_x, and PM sensors are used for on-board diagnostics emissions compliance and closed-loop controls of catalysis and particulate



filtering. The advantages offered by EmiSense's sensors include:

- Superior response time
- Automatic calibration for sensor drift compensation
- Simplified, low-cost controller implementation
- Simplified single-cell wideband sensors
- Detailed sensor diagnostics
- Individual-cylinder balancing
- Misfire detection
- Faster "light off" time
- Improved resistance to thermal shock
- Improved resistance to mechanical shock

Company History

Ceramatec was founded in 1976 as a technology spin-off from the University of Utah. The company specializes in the use of ceramics to develop cutting-edge technology. In its first 25 years, Ceramatec focused on sodium-sulfur batteries and their applications in industrial environments. Since 1990, the company also has focused on fuel cells, oxygen separation, new energy, and environmental technologies. In 2006, Ceramatec was a Utah Innovation Award Finalist for best NO_x sensor. Because of the company's success, the number of Ceramatec employees has tripled during the past 7 years. In 2008, Ceramatec was acquired by CoorsTek, North America's largest supplier of technical ceramics, serving diverse industries, including automotive, industrial, and semiconductor segments.

EmiSense was formed in 2009 via a merger of assets, intellectual property, product lines, trade secrets, and capital from CoorsTek, Inc. and Innovate! Technology, Inc. Prior to this merger, the EmiSense

research team developed advanced emissions sensor technology as a part of Ceramatec, a CoorsTek R&D subsidiary. The new company integrates CoorsTek intellectual property and high-volume global manufacturing capacity with Innovate!'s award-winning DirectDigital™ sensor technology and signal-processing patents.

EmiSense develops smart sensors for clean emissions. Its products are critical enablers for next generation, high-efficiency engines and generators, which help address the global challenges of fossil-fuel dependence and climate change.

SBIR Impact

- Monitoring the NO_x concentration in vehicle exhaust streams is critical for the reduction of NO_x emissions and ensuing human health impacts as well as compliance with EPA's clean air regulations.
- Ceramatec, Inc.'s regular-sized and miniaturized ceramic-based sensors can monitor the NO_x emissions generated by combustion in diesel engines.
- Ceramatec was a 2006 Utah Innovation Award Finalist for best NO_x sensor, and the number of its employees has tripled in the past 7 years.
- EmiSense Technologies, LLC was successfully launched to commercialize the NO_x sensor supported by EPA's SBIR Program.

