Laser-Based Technique for Real-Time Measurement of Emissions in Diesel Engine Exhaust

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Environmental Problem

Recent studies on the adverse health effects of air pollution show that high levels of soot and other submicron particles found in large and mid-size cities increase the risk of premature death from cardiopulmonary problems and lung cancer. Studies by the American Cancer Society have concluded that as the concentration of soot particulates increases, the risk of early death rises by 4 to 8 percent and increases the number of aggravated asthma cases, depending on the concentration and long-term exposure.

Particulate size, mass, and concentration can affect the health of humans and other organisms, and also can impact the global climate. It is known that particles in the 0.3 µm size range can deposit inside the lungs, and particles smaller than 0.3 µm can find their way into the alveoli. Recent evidence indicates that, irrespective of their chemical composition, these fine particles have harmful health effects. Soot particulate emitted from combustion systems fall in this range. Fortunately, soot particulates emitted by cars, trucks, power plants, factories, aircraft, and other combustion processes have been reduced substantially over the past decade through new technologies developed by the engine manufacturers. However, vehicular particulate emissions will need to be reduced further to meet existing and pending environmental regulations.

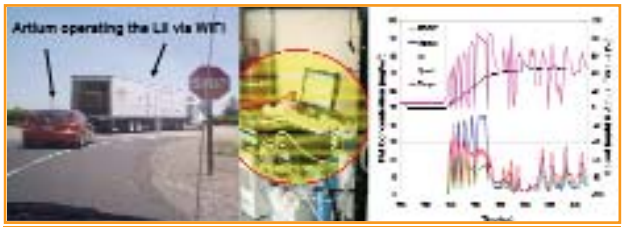
The unavailability of suitable instruments capable of providing accurate measurements of the particulate matter (PM) at low concentrations has contributed to our inability to fully understand the adverse health effects of PM. Advanced PM characterizing instruments are needed for developing test protocols, standards, and regulations that will help preserve the environment and limit risks to health.

SBIR Technology Solution

The development of processes and techniques for limiting the emission of soot particulate and enforcing regulations requires the concurrent development of suitable means for reliably measuring various soot-related parameters. These methods must have adequate measurement range to be able to monitor and characterize the pollutant emissions over a very wide range of concentrations. They also must be able to operate under a range of environmental conditions from *in situ* exhaust to atmospheric monitoring. In the case of PM, information on the particle mass, size, and volume fraction is needed.

Laser-induced incandescence (LII) has emerged as a technique for measuring soot concentration and primary particle size. The LII method has been demonstrated as a reliable means for precisely determining particulate concentration in diesel and other engine exhausts. Size and the number density of primary particles also are measured. The LII technique is capable of real-time PM measurements over any engine transient operation. LII also is more sensitive, by orders of magnitude, than the existing gravimetric technique. The wide dynamic range and lower detection limit of LII make this technique a preferred standard instrument for PM characterization. The research and development efforts of Artium Technologies, Inc., have clearly demonstrated these capabilities of the LII technique.

The primary application for the LII system is for monitoring the soot particulate emissions from engines (diesel, gasoline, and gas turbine). Artium is convinced that the LII instrument could be used for enforcing U.S. Environmental Protection Agency (EPA) regulations on particulate emissions. A version of the instrument also can be used for research and development (R&D) purposes. Specifically, this instrument will produce real-time measurements to help engine manufacturers develop low emission engines and products for emissions control by equipment manufacturers. The instrument also will be useful in assessing regulatory compliance, as an alternative to gravimetric procedures that are time consuming, especially when dealing with the current low emissions standards, require dilution and filtration, and are prone to sampling errors. Artium's R&D partner, the National Research Council (NRC) of Canada, is continuing to develop enhancements that will allow the simultaneous measurement of the size and shape of the soot aggregates and their particle size distribution.



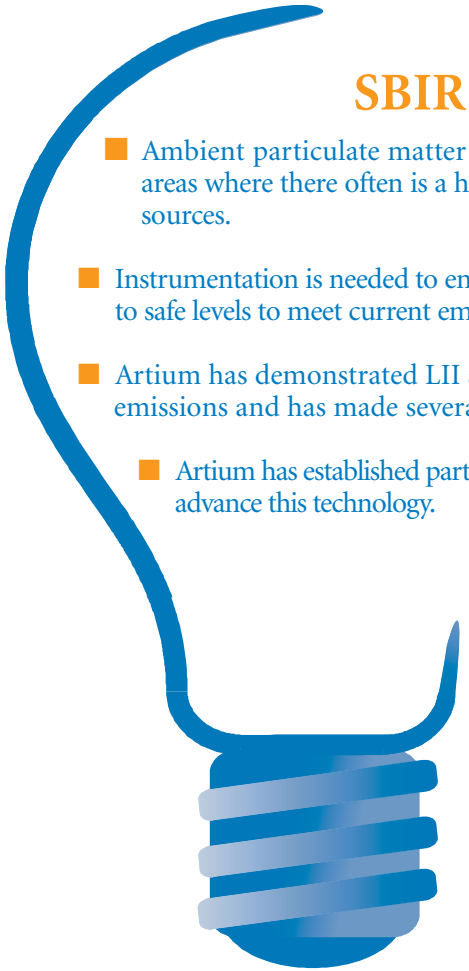
Wireless Operation of Artium's Emissions Monitoring Technology

Commercialization Information

Artium has licensed patents and technology from NRC Canada and has been actively developing the instrument under additional National Aeronautics and Space Administration (NASA) and National Institute of Standards and Technology (NIST) funding for the past 8 years. During the period of the EPA SBIR contract and in subsequent years, Artium formed a collaborative program with Sandia National Laboratories and NRC Canada to advance the technology and become involved in real-world particulate emissions testing. The California Air Resources Board (CARB) will evaluate and conduct advanced development of the instrument. The CARB program involves working with various engine manufacturers as well as loan prototype instruments for evaluation in their laboratories and test cells. They also are working with NASA to investigate the possibility of applying the LII instrument to gas turbine (jet aircraft) engine particulate emissions monitoring. Several instruments have been sold to large engine manufacturers for monitoring diesel and gas turbine particulate emissions. Artium has established a worldwide marketing system with representatives in the major industrial countries and is actively marketing the LII instrument as a commercial product. Artium also is developing the method for online monitoring in the production of carbon black.

Company History

Founded in 1998, Artium Technologies, Inc., based in Sunnyvale, California, specializes in the innovation and development of optical diagnostics for sprays, spray combustion, environmental monitoring, and cloud physics research. The company has supplied instruments to various government agencies and laboratories for studying icing clouds and aircraft icing, cloud physics, biomedical applications including coating stents and biological material, fuel sprays, and soot particulate emissions. Artium has received several grants and awards from federal and state government agencies including the EPA, Department of Defense, NASA, NIST, and CARB.



SBIR Impact

- Ambient particulate matter poses a serious health hazard, especially in urban areas where there often is a high concentration of vehicles and other combustion sources.
- Instrumentation is needed to enable engine developers to reduce particulate emissions to safe levels to meet current emissions regulations.
- Artium has demonstrated LII as a robust, reliable technology for monitoring emissions and has made several sales to large engine manufacturers.
- Artium has established partnerships with NRC Canada and Sandia National Labs to advance this technology.