# Project Summary

Texas Department of Transportation

# 0-5239: Nanotechnology Synthesis Study

## Background

For the past two decades scientists have been making great strides in their ability to create new molecules and substances from available materials. An array of techniques has been developed for building structures in nanometer scales. After more than a decade of progress, nanotechnology has just begun to impact highway materials and construction. New properties of nanomaterials have revealed a big world for the development of new sensor systems and smart construction materials for transportation engineering.

The potential nanotechnology applications in highway pavements are mainly in two different categories: *smart materials* for pavement construction, and *sensors* for transportation and pavement infrastructure condition monitoring. Smart materials are applicable to pavement construction materials including: concrete, asphalt, aggregates, and pavement marking materials. Transportation and pavement infrastructure condition monitoring sensors are made to form a reliable, accurate, low-cost network which includes temperature sensors, strain gauges, pressure sensors, accelerometers, and moisture sensors.

## What the Researchers Did

In Project 0-5239, the feasibility of nanotechnology applications in transportation was evaluated. Researchers created tables to summarize the results of their evaluations of potential applications of innovative smart materials and sensors, along with their recommendations.

A demo system was also developed for monitoring the condition of a stop sign using nano sensors designed for transportation and pavement infrastructures.

## What They Found

Advances in science and technology have led to the creation of new materials with new properties. Potential products that may have immediate benefits for traffic and work zone signage include self-cleaning materials. An example of one of these innovative materials is the lotus effect surface. Typically, on a hydrophobic (water-repellent) easy-clean surface, particles of dirt are merely moved around by moving water. But on a lotus effect surface, dirt and grime is collected by water drops and rinses off.


## Research Performed by:

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**Project Completed:**
8-31-06

When evaluating potential sensors for transportation applications, researchers found that nano and Micro-Electromechanical System (MEMS) sensors can be embedded into highway or pavement structures during the construction process. With a scale of less than a micrometer, these sensors can be used in monitoring temperatures, measuring cracks, corrosion testing, and monitoring alkali-silica reaction and other related reactions in concrete, and for measuring the reliability of welding units in structural steel. MEMS strain gauges can be used to monitor pavement strain distribution. MEMS accelerometers can be used in road profilers or for pavement load condition monitoring.

In the stop sign demo, nano sensors including a magnetometer, accelerometer, and a wireless MEMS were used to monitor the condition of a stop sign. The monitoring included orientation change, tilt angle change, and existence. Researchers found that with this technology, if the stop sign is turned, tilted, or removed, the system will report these conditions to its maintenance office wirelessly.

## What This Means

There are many aspects of nanotechnologies that can be applied to transportation systems. However, successful nanotechnology application may need 5 or 10 years to be commercialized. Potential applications of nano products for TxDOT may include:

1) MEMS sensors: MEMS accelerometers can be used in a profiler to replace costly coil-type accelerometers; a MEMS accelerometer and a magnetometer can collect the rotation and tilt information and other conditions of traffic signs.

2) Radio Frequency (RF) tags: TxDOT can use RF tags for pavement on-site monitoring and materials inventory.

3) Smart materials such as self-cleaning and self-healing materials: The lotus effect surface can be used on signs and traffic control divices to keep them clean. Work on self-healing polymers is already underway. Researchers have developed a polymeric material with the ability to automatically heal cracks in concrete.

Sensors that are not based on nano technologies may also have great application potentials to TxDOT, such as fiber optical sensors and microwave weigh-in-motion (WIM) sensors.

TxDOT is in a good position for applying nano materials and sensors in Texas highways in the future to reduce maintenance costs, increase pavement lifespan, reduce crashes, and increase construction efficiency.

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