TITLE:	**Elevated Temperature Sensors for On-Line Critical Equipment Health Monitoring**

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INDUSTRIAL COLLABORATOR:	Saint-Gobain Ceramics
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Project Objective:

The objective of thus research program is to improve high temperature piezoelectric aluminum nitride (AlN) sensor technology to make it useful for instrumentation and health monitoring of current and future electrical power generation equipment and related applications. The sensor's practical use temperature range was extended from approximately 700°C to above 1000°C. Ultrasonic coupling to objects at very high temperatures was investigated and tailored for use with the sensor. The sensor is being demonstrated in a laboratory simulation of an application of health monitoring for power generation equipment.

For this work, the sensor is constructed as an ultrasonic transducer used to measure the thickness of a material or to look for the formation of cracks or voids in a material. Performed on-line at high temperature, a thickness measurement could be used to monitor the extent of corrosion damage in metallic or ceramic components. Ultrasonic waves may additionally be used to monitor bonds, such as that between a metal and a ceramic, as found in thermal and environmental barrier coatings commonly found in power generation equipment.

Accomplishments to Date:

The project began with the reestablishment of the ability to produce piezoelectric AlN films through a previously used CVD process. These films were historically deposited on tungsten carbide substrates. In order to improve the oxidation resistance at high temperature and increase the bandwidth of the ultrasonic pulse generated by the films, alternative substrates were investigated. Titanium metal was the first alternative substrate. Deposition on titanium was achieved after some experimentation, but the resulting films failed during thermal excursions, likely due to thermal expansion. The films on titanium did, however, demonstrate that using a substrate material with an acoustic impedance close to that of AlN would generate a wide bandwidth pulse.

Many other substrate materials were considered and rejected, with silicon carbide (SiC) selected as the next candidate substrate material. Deposition on SiC was achieved immediately, but difficulties were encountered with substrate conductivity and failure of AlN films due to thermal cycling. After trying a number of different SiC materials, a successful substrate was found using a porous silicon carbide that provided electrical conductivity, film adhesion, a high bandwidth ultrasonic pulse, and attenuation of echoes internal to the substrate.

A concurrent effort to investigate ultrasonic coupling at elevated temperature settled on metal foil coupling as the best method for this sensor; experimentation verified the functionality of foil coupling. An ultrasonic sensor was designed using the AlN films and metal foil coupling for use in health monitoring. Laboratory demonstration of the sensor was attempted in several applications, including monitoring the thickness of a gasifier refractory block and a metal component simulating a heat exchanger or process piping.

Future Work:

Remaining experimental work on this project consists of some additional optimization of film deposition on SiC, and further testing of the resulting ultrasonic sensor. Future work in this area will likely include additional sensor development for other industrial applications and for immersion testing.

Papers and Conference Presentations:

Frede, Michael, “Coupling for High Temperature Ultrasonic Testing”, Poster Presentation, University of Dayton Stander Symposium, April 2005.
Frede, Michael, “Coupling for High Temperature Ultrasonic Testing”, Honors Thesis, University of Dayton School of Engineering, May 2005.
Sebastian, James, “Contact Ultrasonic Transducer for Ultrahigh Temperature Testing”, To be presented at Review of Progress in Quantitative Nondestructive Evaluation, August, 2005 and published in conference proceedings.
Sebastian, James, and Frede, Michael. “Metal Foil Ultrasonic Coupling for High Temperature Testing”, To be presented at Review of Progress in Quantitative Nondestructive Evaluation, August, 2005 and published in conference proceedings.
Sebastian, James, “Contact Ultrasonic Transducer for High Temperature Equipment Health Monitoring”, To be submitted for publication in an as-yet undetermined journal.

Students Supported:

1. Matthew Pacyna, undergraduate student in the department of Electrical Engineering, University of Dayton.
2. Michael Frede, undergraduate student in the department of Mechanical Engineering, University of Dayton. Michael researched high temperature ultrasonic coupling in support of the program in fulfillment of the requirements for his senior Honors Thesis.