# Providing Efficient Power Through Advanced Gas Turbines

## New Ceramic Materials Are a Spin-Off of DOE-Sponsored Research

Transportation FOR THE 21ST CENTURY

ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

## Background

In the early 1970s, the predecessor to the Department of Energy (DOE) began sponsoring the development of advanced gas turbines as a power source for automobiles. A crucial challenge was the synthesis of strong and fracture-resistant ceramic materials capable of performing at high operating temperatures and stresses to increase the efficiency and reduce the emissions of the turbine system. Research at Oak Ridge National Laboratory and the National Aeronautics and Space Administration, with heavy investment by industry, led to new ceramic materials and production processes and advanced turbine designs that significantly improved the performance, emissions, and durability of small gas turbines.

In the late 1990s, it was decided that turbines were not viable as a near-term option for passenger vehicles because of their moderate part load efficiency and the high cost of manufacturing the ceramics. However, the advances made in ceramic materials under DOE's transportation-related research program have been incorporated into a variety of small auxiliary power units (APUs) and catalytic converters for automobiles, and are slowly being incorporated into the next generation of high-efficiency, low-emission microturbines as well as larger turbines for stationary power generation.

## The Technology

Gas turbines are smaller, lighter, have fewer moving parts, and operate more smoothly and quietly than conventional internal combustion engines. Gasoline, natural gas, diesel, ethanol, sour gas, or used oil can be burned in the turbine, converting the fuel's chemical fuel to mechanical energy. Heat from the exhaust is captured and returned to the system to improve engine efficiency.

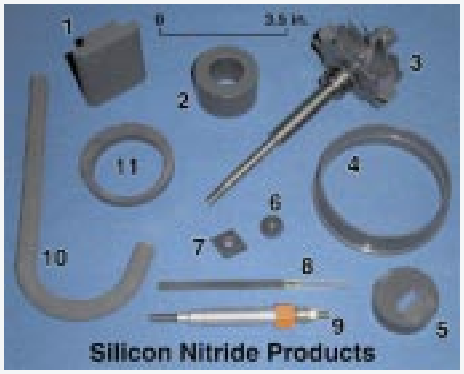
AlliedSignal Engines (now Honeywell) and Allison (now Rolls Royce) adapted ceramic technologies to build advanced automotive gas turbines that could run at temperatures of up to 2500$^{o}$F (1370$^{o}$C). New turbines with ceramics are more efficient than all-metal gas turbines and cleaner than metal turbines or diesel engines (see Benefits).

## Commercialization

The strong, fracture-resistant silicon nitride ceramics developed for the automotive gas turbine have been successfully commercialized for a variety of applications. Since 1996, silicon nitride oil seals fabricated by Honeywell and Kyocera Industrial Ceramics have been installed in 7,000 production engines with more than 6 million accumulated flight hours, and gerotor rings for APUs, provided exclusively by Honeywell, have been used on Boeing and Airbus aircraft since 1992. Kyocera has sold over 3 million silicon nitride cam-roller followers for large diesel engines for on-highway trucks. (See photo of applications, courtesy of Kyocera.) Both companies are working with microturbine and APU manufacturers to develop a new generation of advanced engines that incorporate silicon nitride hot-section components for cleaner, more efficient operation, at higher temperatures.

## Benefits

- **Ceramic turbines can achieve 30-40% greater efficiency than all metal turbines**
- **In 2010: If high temperature ceramics were incorporated throughout gas turbines in the electricity generation sector, then 1.4 Quads of energy could be saved annually**
- **Excellent wear characteristics extend maintenance intervals and reduce operating costs**




*Silicon nitride products, produced by Kyocera (K), Honeywell (H), and others. (1) Paper industry wear part (K); (2) diesel engine cam roller follower (K); (3) automotive turbocharger rotor (K); (4) turbofan engine oil seal (H and K); (5) diesel engine precombustion chamber (K); (6) ball bearing (Norton, Toshiba, and others); (7) cutting tool bit; (8) gas furnace igniter (K); (9) diesel engine glow plug (K); (10) aluminum processing fixture (K); (11) gerotor ring (H)*

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