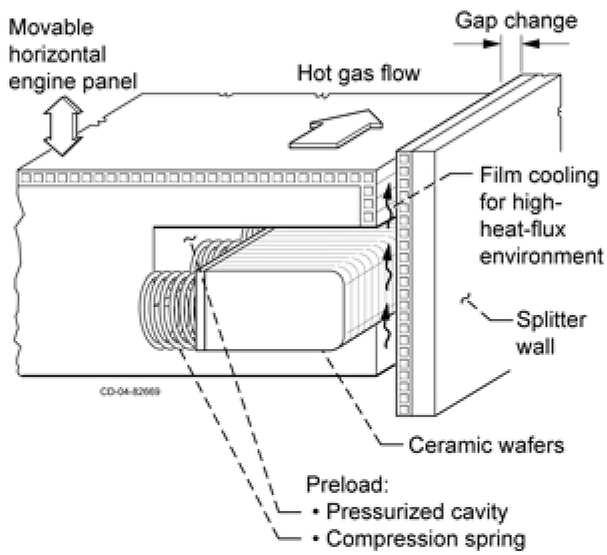
Advanced Ceramic Wafer Seals Demonstrated at 2000 °F

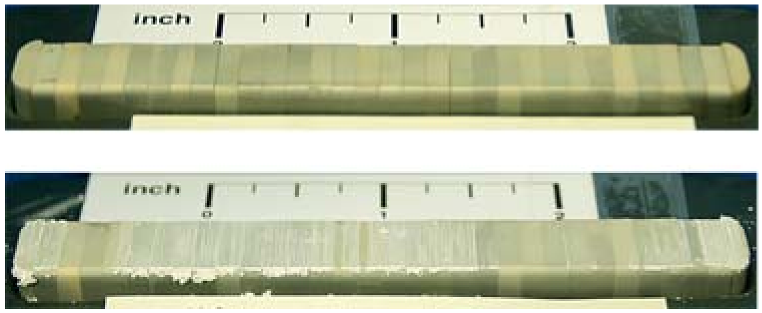
Durable, high-temperature sliding seals are required in advanced hypersonic engines and around movable control surfaces on future vehicles. These seals must operate at temperatures of 2000 to 2500 °F, limit hot gas flow, remain resilient for multiple cycles, and resist scrubbing damage against rough surfaces. Current seal designs do not meet these demanding requirements, so the NASA Glenn Research Center is developing advanced seals and preload devices to overcome these shortfalls. An advanced ceramic wafer seal design and two silicon nitride compression spring designs were evaluated in a series of compression, scrub, and flow tests.



Ceramic wafer seal with compression springs as preload devices.
Long description of figure 1. Drawing showing movable horizontal engine panel, hot gas flow, gap change, film cooling for high-heat-flux environment, splitter wall, ceramic wafers, and preload (pressurized cavity and compression spring).

The seals evaluated in this study, which were originally developed during the National Aerospace Plane program, are composed of a series of thin ceramic wafers installed in a channel on a movable panel and preloaded from behind to keep them in contact with the opposing sealing surface (see the preceding figure). The wafers were made of monolithic silicon nitride (Honeywell AS800, Honeywell International, Morris Township, NJ) and were 0.5 in. wide, 0.92 in. tall, and 0.125 in. thick. Commercially available silicon nitride compression springs were evaluated as preload devices to ensure sealing contact with the opposing sealing surfaces.

The silicon nitride wafer seals were proven to be quite robust and wear-resistant. They survived 2000 in. (50.8 m) of scrubbing at 2000 °F against a silicon carbide rub surface with no chips or signs of damage (see the following photographs). None of the wafers were chipped or broken, and the weight of each wafer set was almost identical before and after testing. The wafer seals were excellent at blocking flow even after 1000 scrub cycles at 2000 °F. Flow rates measured for the wafers before and after scrubbing were almost identical and were up to 32 times lower than those recorded for the best braided-rope-seal flow blockers.



Silicon nitride wafer seals. Top: Before 2000 °F scrub test. Bottom: After 2000 °F scrub test.

Silicon nitride compression springs showed promise conceptually as seal preload devices to help maintain seal resiliency. After repeated loading at temperatures up to 2200 °F, the springs showed excellent resiliency and little hysteresis.

This study demonstrated the excellent performance of a new, advanced ceramic wafer seal design at 2000 °F. Additional development is planned to demonstrate the performance of this seal design at temperatures greater than 2500 °F.

Bibliography

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