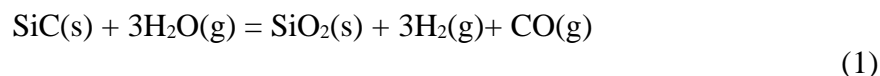


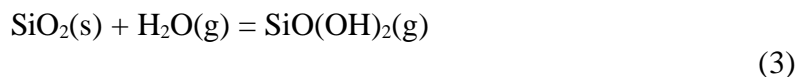
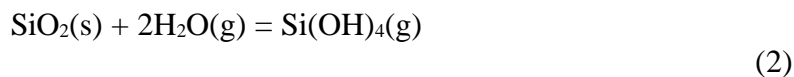
Volatile Reaction Products From Silicon-Based Ceramics in Combustion Environments Identified

Silicon-based ceramics and composites are prime candidates for use as components in the hot sections of advanced aircraft engines. These materials must have long-term durability in the combustion environment. Because water vapor is always present as a major product of combustion in the engine environment, its effect on the durability of silicon-based ceramics must be understood. In combustion environments, silicon-based ceramics react with water vapor to form a surface silica (SiO_2) scale. This SiO_2 scale, in turn, has been found to react with water vapor to form volatile hydroxides. Studies to date have focused on how water vapor reacts with high-purity silicon carbide (SiC) and SiO_2 in model combustion environments.

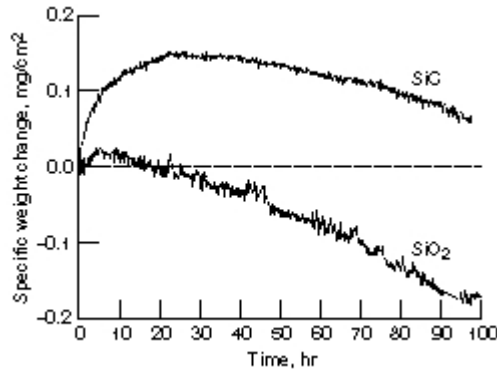
Because the combustion environment in advanced aircraft engines is expected to contain about 10-percent water vapor at 10-atm total pressure, the durability of SiC and SiO_2 in gas mixtures containing 0.1- to 1-atm water vapor is of interest. The reactions of SiC and SiO_2 with water vapor were monitored by measuring weight changes of sample coupons in a 0.5-atm water vapor/0.5-atm oxygen gas mixture with thermogravimetric analysis (ref. 1). SiC initially exhibited a weight gain due to SiO_2 formation:



At longer durations, a weight loss attributed to the volatility of SiO_2 in water vapor became apparent:



By testing SiO_2 (rather than SiC) in water vapor, a linear weight loss uncomplicated by the oxidation reaction (1) can be observed by thermogravimetric analysis.



Weight change kinetics for SiC and SiO₂ in 0.5 atm H₂O/0.5 atm O₂ at a temperature of 1200 °C and a velocity of 4.4 cm/sec.

The identities of the volatile species were established by using a specialized mass spectrometer that samples reactions at 1-atm total pressure (ref. 2). SiO₂ samples with large surface areas were exposed to water vapor/oxygen mixtures at high temperatures. Molecules with masses corresponding to both Si(OH)₄ and SiO(OH)₂ were identified.

Because SiO₂ is volatile in combustion environments, it no longer provides protection for SiC. Consumption of SiC thus occurs at more rapid rates in water-vapor-containing environments. The consumption rate of SiC increases with water vapor pressure as well as gas velocity. This is a concern when SiC is applied in the high-pressure, high-velocity aircraft engine environment. Current efforts are focused on coatings for SiC that prevent volatility of the surface SiO₂.

References

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2. Opila, E.J.; Fox, D.S.; and Jacobson, N.S.: Mass Spectrometric Identification of Si-O-H(g) Species From the Reaction of Silica With Water Vapor at Atmospheric Pressure. Submitted to J. Am. Ceram. Soc.

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