Active Oxidation of SiC
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Abstract
The high temperature oxidation of silicon carbide occurs in either a passive or active modes, depending on temperature and oxygen potential. Passive oxidation forms a stable oxide scale, whereas active oxidation causes pitting on the surface. The transition between these two modes is reversible and is often accompanied by the formation of gas byproducts like CO. This paper focuses on the passive regime, where the oxide scale is stable and the reaction is governed by mass transfer through the oxide scale. The passive regime is characterized by a decrease in oxygen potential, which promotes the formation of a thermally stable oxide scale that protects the substrate from further oxidation. Conversely, the active regime is characterized by an increase in oxygen potential, which leads to the formation of a less stable oxide scale that is easily broken down. The passive regime is further divided into two sub-regimes: the initial passive regime and the steady-state passive regime. The initial passive regime is characterized by a rapid decrease in oxygen potential, while the steady-state passive regime is characterized by a more gradual decrease in oxygen potential.

Passive/Active Oxidation of SiC

Critical issues:
- Transitions: active → passive
- Rates of active oxidation
- Unexplored areas: Focus of this study
- Hypotheses for SiC: active to passive and passive to active
- Breakdown of passive film

Pre-oxidation studies:
- SiC films grown on SiC in a clean environment [16]
- Microstructural examination
- PE-SEM (Hitachi S4700)

Summary and Conclusions
- Active oxidation of SiC:
  - SiC(g) + 1/2 O₂(g) → SiO₂(g) + CO(g)
- Unexplored area is the difference between the active-passive and passive-active transition for SiC
- Active-to-passive transition:
  - Attain sufficient PO₂ to establish the SiO₂/SiO₂ equilibrium
- Passive-to-active transition:
  - Scale-substrate reactions and SiO₂ product removal 'pulls' reaction
  - SiC(s) + 2SiO₂(s) → 3SiO(g) + CO(g)
- Examine pre-oxidized SiC to understand breakdown of SiO₂ scale

Theories of Active/Passive Transitions

Wagner: Active-to-Passive Transitions for Silicon [2]
Oxygen strikes a bare Si surface, gradually increases PO₂
- SiC → SiO₂ + CO
- Pre-oxidation
- PO₂ = 10 atm
- Passive oxide film forms
- Breakdown of passive film until PO₂ reaches 1 atm
- Active oxidation begins

References