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IRRADIATION BEHAVIOR OF PYROLYTIC SILICON CARBIDE

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Fuel particles for the High-Temperature Gas-Cooled Reactor (HTGR) contain a layer of pyrolytic silicon carbide to act as a miniature pressure vessel and primary fission-product barrier. Optimization of the SiC with respect to fuel performance involves four areas of study. (a) Characterization of as-deposited SiC coatings,[1] (b) thermodynamics and kinetics of chemical reactions between SiC and fission products,[2] (c) irradiation behavior of SiC in the absence of fission products, and (d) combined effects of irradiation and fission products. This paper reports the behavior of SiC deposited on inert microspheres and irradiated to fast-neutron fluences typical of HTGR fuel at end-of-life.

EXPERIMENTAL

Silicon carbide was deposited on carbon microspheres in a fluidized bed by the decomposition of methyltrichlorosilane (CH_3SiCl_3) in an excess of hydrogen.[3] The coated microspheres were irradiated to fast neutron fluences up to 8.8 $\times 10^{25}$ n/m^2 (E > 29 fJ) in the High Flux Isotope Reactor at temperatures from 950 to 1350°C. After irradiation, the SiC layers were removed from the particles and prepared for TEM by standard techniques.[4]

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RESULTS

As-deposited pyrolytic silicon carbide, Fig. 1, contains a high stacking fault density that generally increases with increasing coating rate.[1] Small cavities are sometimes present, frequently arranged in circumferential bands. These cavities are postulated to arise during fluctuations or local interruptions in the coating process.[5]

Irradiation at 1050°C and below produces small (~50Å) defect clusters (Fig. 2) which frequently lie along the remains of stacking faults. A defect-free region approximately 100Å wide exists along grain boundaries. Irradiation at higher temperatures (1150°C) produces voids (Fig. 3) that are typically 50Å in diameter. The voids lie parallel to remnant stacking faults in some grains but are distributed randomly in others. The foregoing observations are in substantial agreement with the work of Price[6] who used pyrolytic SiC disks rather than actual coated particles.

The influence of process variables on irradiation behavior can be summarized as follows. (1) A relatively high initial stacking fault density tends to inhibit void formation, suggesting that stacking faults, like grain boundaries, form a sink for point defects. (2) Any cavities initially present in the SiC are not "healed" during irradiation, so a low-density coating remains inferior to a high-density coating.

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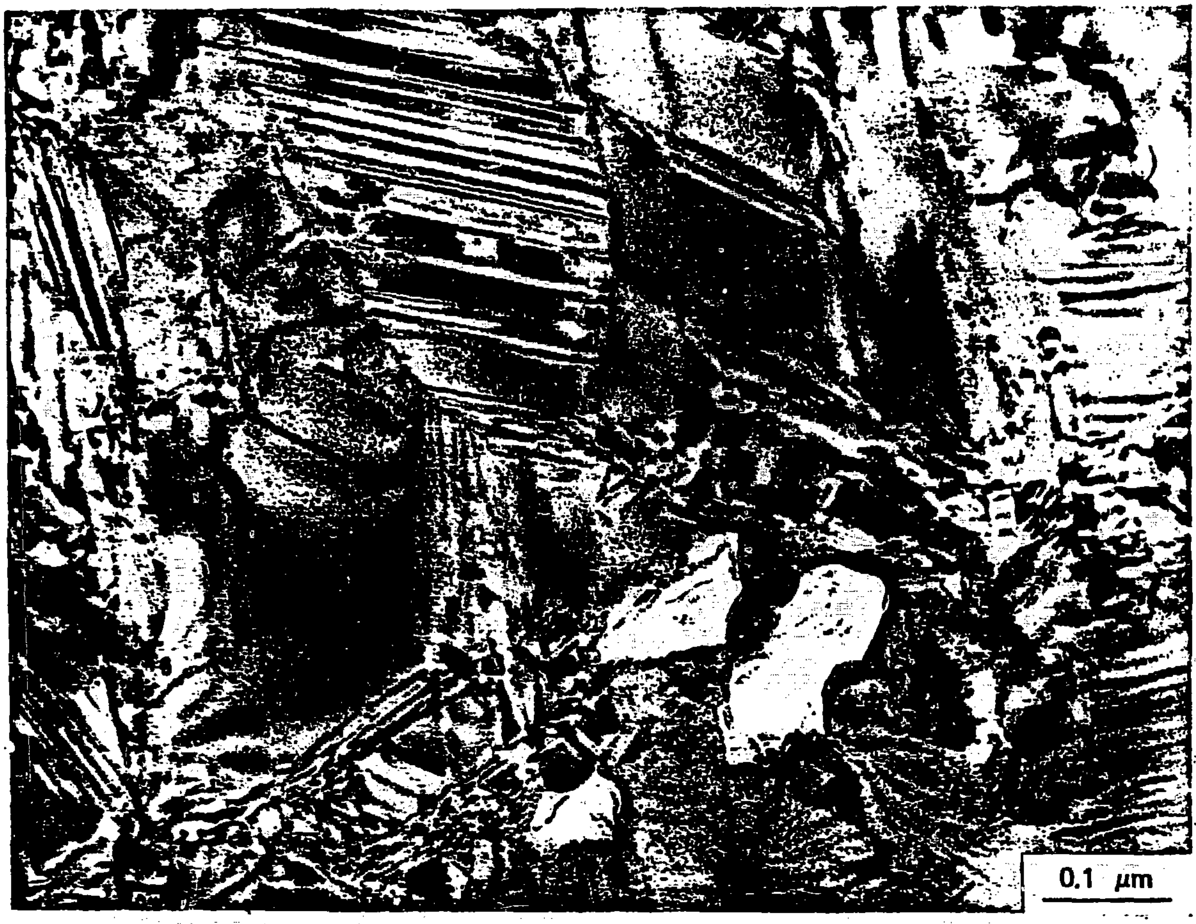
Fig. 1. Pyrolytic β-SiC, as deposited. Growth direction is upward. Note stacking faults and small cavities.

Fig. 2. Damage clusters in SiC irradiated at 1050°C to 7.3×10^{25} n/m^2.

Fig. 3. Voids in SiC irradiated at 1150°C to 7.6×10^{25} n/m^2.



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