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A MODEL TO DESCRIBE NEUTRON-INDUCED DIMENSIONAL CHANGES IN PYROLYTIC CARBON*

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ABSTRACT

A model has been developed that describes the dimensional behavior of pyrolytic carbon during irradiation by fast neutrons at the range 500° to 1100°C for exposures to $\sim 3 \times 10^{21}$nvt. The model uses crystallite averaging methods to describe the anisotropic distortion of the bulk in terms of its preferred orientation and the shape change of the individual crystallites. The densification, a simple first-order rate process, was assumed to be independent of the shape change and was superimposed isotropically on the shape change. The validity of the approach has been checked by comparing the predictions of the model with the dimensional changes observed in the twelve carbons irradiated at 680°, 710°, 810°, and 980°C to neutron exposures of 1.7, 2.2, 2.0, and 1.4 x 10^{21} nvt (E > 0.18 Mev), respectively.

Strain rates calculated from the model are used to estimate the suitability of various carbon structures for use as coatings on an unyielding support. For example, when a creep constant of 1×10^{-27}(nvt-psi)$^{-1}$ at 1200°C is used, the model predicts that a carbon with a BAF of 1.2 and an L_c in the range 120 Å to 155 Å would not fail due to neutron induced dimensional changes if its original density were greater than 2.0 g/cm^3. Similarly, carbons with the same crystallite size but with BAF = 1.0 would not fail under the same conditions if their original densities were greater than 1.7 g/cm^3.

Results from the carbons irradiated in the temperature range 500° to 1000°C show that the densification constant k_d for carbons with the L_c parameters in the range 24 Å to 45 Å is independent of temperature and equal to 3.3×10^{-22}(nvt)$^{-1}$. When L_c is relatively large (155 Å to 175 Å), k_d is also independent of temperature and equal to 1.1×10^{-22}(nvt)$^{-1}$. The value of k_d increases with temperature for carbons with intermediate values of L_c. The average crystallite growth rates, $\ln(1 + \Delta X_c/X_c)$ per 10^{21} nvt, measured in the present work are consistent with those reported earlier for lower and higher irradiation temperatures.

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