

DIMENSIONAL-CHANGE THEORY*

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ABSTRACT

The successful interpretation of dimensional changes, occurring in artificial graphites during neutron irradiation, is somewhat dependent on a valid analysis of the thermal expansion behavior of the material; the analysis of thermal expansion is in turn dependent on accurate knowledge of the crystallite lattice expansion behavior. Additional measurements⁽¹⁻³⁾ of the crystal lattice dimensions, as a function of temperature, have been reported since the lattice expansion coefficients were calculated by Riley⁽⁴⁾. A review and analysis of the published specific heat and crystal lattice measurements was made to improve the lattice expansion coefficients. The results of recent specific heat measurements^(5,6) are in reasonable agreement with the Debye temperatures⁽⁷⁾ used by Riley. The results of this analysis, and suggested lattice expansion coefficients, are reported.

An analysis of the thermal expansion behavior of both non-graphitic carbons and highly-crystalline graphites was made using the resultant lattice coefficients. The behavior of these materials is shown to be consistent with an invariant accommodation coefficient⁽⁸⁾ at temperatures below 1200°C. Therefore, the thermal expansion behavior does not provide a clue as to the amount of non-graphitic carbon, in artificial graphites, which could effect the radiation induced dimensional changes.

The interpretation of observed radiation-induced dimensional changes of artificial graphites is dependent on the assumed variation of crystallite dimensional-change rates and ratios of rates. Observed dimensional changes are compared with predicted behavior under the assumptions that at constant dose: (1) $(dX_c/dX_a) = \text{a constant}$ with $(dX_c - dX_a) = \text{a function of crystal size}$, and (2) $(dX_c/dX_a) = \text{a function of crystal size}$ with $(dX_c - dX_a) = \text{a constant}$, for both the single-phase and two-phase models. The data are shown to be best represented by the two-phase model, using the second set of assumptions.

- (1) Kellett E. A. and Richards B. P., J. Nucl. Mater. **12**, 184 (1964).
- (2) Stewart E. G., Cook B. P. and Kellett E. A., Nature **187**, 1015 (1960).
- (3) Yang K. T., Proceedings of the Fifth Conference on Carbon, Vol. 1, p. 492, Pergamon Press (1962).
- (4) Riley D. P., Proc. Phys. Soc. (Lond.) **57**, 486 (1945).
- (5) Jacobs C. J. and Parks G. S., J. Am. Chem. Soc. **56**, 1513 (1934).
- (6) De Sorbo W. and Tyler W. W., J. Chem. Phys. **21**, 1660 (1953).
- (7) Magnus A., Ann. Physik **70**, 303 (1923).
- (8) Morgan W. C., J. Nucl. Mater., (to be published).

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