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NASA TECH BRIEF

Tensile Creep-Rate of Pyrolytic Carbon

Pyrolytic carbon, also called pyrolytic graphite, has high strength at high temperature and is of considerable interest to industry. This material is deposited from thermally decomposed methane on a hot substrate at 1900-2300°C in a very pure form having near-theoretical density with layer planes approximately parallel to the substrate. Although the as-deposited structure has disordered layer stacking, it graphitizes quite completely under the influence of high-temperature thermal and mechanical treatment. Pyrolytic carbon in fundamental studies serves as a model material representative of the broad class of graphitizing carbons and graphites.

The parallel-to-substrate tensile creep behavior of an as-deposited (2200°C), substrate-nucleated, pyrolytic carbon was investigated over the temperature range 2500-2900°C and the stress range 5000-30,000 psi under deadweight loading. A stress-change technique was combined with a graphical-interpolation analysis to obtain data on the stress σ and temperature T dependence of the creep rate $\dot{\epsilon}$ over broad strain ϵ and stress or temperature ranges on individual specimens. These data were used to determine the stress exponent n and the activation energy ΔH in the empirical expression $\dot{\epsilon} = A\,\sigma^n \exp(-\Delta H/RT)$.

Two distinct deformation regimes were confirmed. After 1-2% gage elongation, an increase in ϵ indicated a change in deformation mechanism. In the same range, n dropped from an initial value of $\sim$ 4 to 1.5 $\pm$ 0.4, where it remained to at least 30% elongation independent of T and σ. In agreement with other results on deformation and graphitization of graphitizing carbons and graphite, $\Delta H = 250 \pm 40$ kcal/mole.

During the first 8% elongation, several changes occurred in structure and properties. A density increase of $\sim$ 2% and a large increase in Young's modulus were produced by the graphitization and preferred orientation increase (reported elsewhere) that occur in this range. The reduction in area showed that, aside from the graphitization volume decrease, the deformation occurred at constant volume to at least 30% elongation. After the early anomaly, $\dot{\epsilon}$ decreased regularly with increasing ϵ. Creep recovery was small, and appeared to decrease with increasing preferred orientation.

The first stage of deformation was dominated by breakdown of the as-deposited structure, evidently involving dislocation glide and climb. Among various mechanisms considered for the second-stage deformation, which occurs in highly oriented, well-graphitized material, self-diffusion mass transport was most consistent with the observations.

Note:

The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference:
NASA-CR-103846 (N69-33446), Tensile Creep-Rate Studies on Pyrolytic Carbon

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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