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Letters

Mechanical Behaviour of Polycrystalline TaC

The behaviour of tantalum carbide subjected to compressive loading has been investigated at temperatures above 1200 °C *in vacuo*. Previously, Kelly and Rowcliffe [1] had reported a ductile-brittle transition at ~ 1750 °C for polycrystalline TaC. In their study employing four point bend tests, they noted further that even at 2000 °C only small permanent strains (~ 0.1%) could be achieved prior to failure. An increase in the ductile-brittle point with increase in carbon content was reported by Johansen and Cleary [2] with a temperature range of 1750° to 1925° for C:Ta ratios of 0.90 to 0.981. The present study indicates that significant plastic deformation is achieved at temperatures of 1280 °C and above employing three decades of strain rates from 5×10^{-2} to 5×10^{-4} min^{-1}.

The material tested had a C:Ta ratio of 0.95 : 1, an average grain size of 13 μm, and was ~ 93% of theoretical density. The stock from which test samples were obtained was fabricated by vacuum hot pressing [3] in the absence of binder materials. Characterisation of the starting powder (identified as batch 1) and the hot pressed material has been reported previously [3]. In that study, grain boundary segregation of oxygen impurities was noted to occur after 2400 °C vacuum heat treatment. Room temperature tensile strength and Young's modulus have also been determined in identical materials and found to be 35000 psi and 39×16^6 psi respectively [4].

At temperatures below 1280 °C at the highest strain rate (5×10^{-2} min^{-1}), this material exhibited brittle failure; however, at 1280 °C and above, plastic deformation occurred, with permanent strains > 5% being achieved. The yield points of this material exhibited increasingly ductile characteristics at the higher temperatures ($T \geqslant 1640$ °C), while the onset of plastic flow was indicated by small deviations below 1640 °C. The yield stresses were depressed over the entire temperature range, and deformations up to 40% were achieved above 1640 °C. The mechanical data were analysed in terms of the relationship:

$$\sigma^n_{\mathrm{yld}} = A\,\dot{\epsilon}\,\exp\,(Q/RT)\,.$$

where $\dot{\epsilon}$ is the strain rate, Q is the apparent activation energy, T is the absolute temperature, n is the stress exponent, A is an empirical constant, R is the gas constant and σ_{yld} is the yield stress. Plotting in terms of $\ln\sigma_{\mathrm{yld}}$ versus $1/T$ at constant strain rates yields parallel, linear fits of these data (fig. 1). Slope changes occur at 1455 °C ($0.43T_{\mathrm{m}}$) at the lowest strain rate and at 1640 °C ($0.47T_{\mathrm{m}}$) for a strain rate of 5×10^{-3} min^{-1}. The apparent activation energies were determined to be 96 Kcal/mole and 90 Kcal/mole for the high and low temperatures ranges, respectively, based on stress exponents, n, of 4.5 and 13.3 computed for these same regions from $\ln\dot{\epsilon}$-$\ln\sigma_{\mathrm{yld}}$ relationships at constant temperatures. The activation energy values are consistent with those reported for self diffusion of carbon in TaC (85 Kcal/mole [5] or 98 Kcal/mole [6]). Steinitz suggests that diffusion of tantalum controlled creep rates in his observations on TaC and reported an activation energy of ~ 170 Kcal/mole [7].

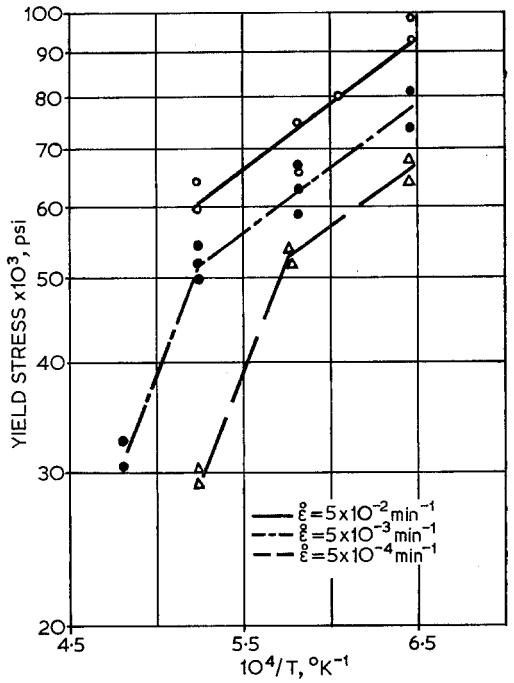

Figure 1 Yield stress as a function of temperature for polycrystalline TaC.

The results of this study reveal that ductile behaviour can be accomplished in polycrystalline TaC deformed at strain rates $\leqslant 5 \times 10^{-2}$ min^{-1} at 1280°C and above. Analyses of the thermomechanical data suggest that deformation occurs in part by dislocation motion controlled by carbon diffusion in contrast to the expected slower diffusing tantalum species; possibly as a result of the effects of chemistry or structural defects (dislocations or grain boundaries).

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PAUL F. BECHER*
North Carolina State University
Raleigh, North Carolina 27607

Low Temperature Crazing in Amorphous Polymers

The phenomenon of crazing in amorphous glassy polymers has been the subject of extensive study for several years [1–3]. The importance of crazes as sites of subsequent crack nucleation and propagation is well established [4–6]. In this capacity, craze morphology is an important parameter of the fracture behaviour. In another publication [6] the morphology of low temperature (ca. 78° K) crazes in poly(methyl methacrylate) is reported, with particular emphasis on the relation of craze morphology to crack nucleation. The important craze parameter in that respect is the surface step resulting from the generation and growth of crazes within the material. The present note is concerned with the general characterisics of low temperature crazes. The observations in PMMA are presented in more detail and some new observations of crazing at low temperatures in polycarbonate and polysulfone are presented.

Tensile specimens of poly(methyl methacrylate) (PMMA) (type II UVA), polycarbonate (PC) (Lexan), and polysulfone (PSF) were tested to fracture over the temperature range 333 to 78° K. At the lower temperatures PMMA fractures in

*The writer was a research associate in the Department of Engineering Research at the time this research was undertaken. He is now associated with the Ceramics Section, Chemistry Division, Naval Research Laboratory, Washington, D.C.