## COMMUNICATIONS

ates of about 10atures, other than eated vegetable or <sup>°</sup>K during a test. ecrease in ductility isition metals were definitely ductile" wing a yield point eld stress. For tests erienced in deciding e" or brittle. There egory. As we have stic deformation is ig. 1, are the upper stress were 53, 57.  $10^{-4}$ ,  $10^{-3}$ ,  $2 \times 10^{-3}$ ,

## r, on strain rate, $\dot{\epsilon}$ , in

irreversible changes  $\geq$  5 strain rates and lter irreversibly the ngsten. Hereafter no ressurized specimens. sintered (American) to reveal any effect. acks, away from the cks appeared to be predominantly interom ~20  $\mu$  to ~150  $\mu$ .

rom ductile to brittle  $nm^{-2}$  for strain rates  $m \sim 377^{\circ}$  to  $\sim 465^{\circ}$  K.

## SHORT COMMUNICATIONS

 $\sigma_{\rm Y} = E \dot{\varepsilon}^{\rm F}$ 

have done for molybdenum, assume relationships between stress and temperature<sup>5</sup> and strain rate<sup>8</sup>, respectively, of the form:

$$\sigma_{\rm Y} = A - BT \tag{1}$$

and

where A and B are constant at a given strain rate and E and F are constant at a given temperature. B is approximately equal to 0.3 kg mm<sup>-2</sup> °K<sup>-1</sup> for our material at all strain rates in the transition region and E and F have been evaluated for sintered tungsten at 473°K to be ~68 kg mm<sup>-2</sup> and ~0.09, respectively<sup>8</sup>. If we also



of a curved surface.

Fig. 2. Non-propagating surface crack in a recrystallized sintered tungsten specimen which cleaved at  $442^{\circ}$ K at a strain rate of  $5 \times 10^{-3}$  sec<sup>-1</sup> after 0.6% plastic deformation. Note that the crack follows grain boundaries along AB, AC, CDEF, FH, FG and is transgranular only along the segment G1. (In order to avoid etch-pitting, Murakami's reagent, which is a relatively poor etchant for tungsten, was employed.)

assume that (in the transition region) F is a constant, that the variation of E with temperature is given by eqn. (1), and make use of the identity:

$$\left(\frac{\partial\sigma}{\partial\dot{\varepsilon}}\right)_{T}\left(\frac{\partial T}{\partial\sigma}\right)_{\dot{\varepsilon}}\left(\frac{\partial\dot{\varepsilon}}{\partial T}\right)_{\sigma} = -\mathbf{I}$$
(3)

we derive for the relationship between T and  $\dot{\varepsilon}$ , for constant  $\sigma$  the expression:

 $\exp(-\dot{\varepsilon}^{0.09}) = K(E_0 - 0.3 T_{\rm T}) \tag{4}$ 

where K and  $E_0$  are constants. Figure I shows  $T_T$  plotted against  $\exp(-\dot{\epsilon}^{0.09})$  and it is seen that, although not as good for molybdenum<sup>4</sup>, there is a fair agreement between the data and the model.

The constant stress at the transition temperature suggests that this is a critical stress for some mechanism in the fracture process. It appears that the transition coincides with a change in the critical stage in this process, a hypothesis supported by the observation of microcracks in ductile but not in brittle specimens. If the cracks observed in the ductile region are of the type that cause fracture, crack

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