Effect of Hydrogen on the Deformation Characteristics of Alpha-Titanium

IT is well known that when iodide titanium containing more than 10 p.p.m. by weight of hydrogen is slowly cooled from 300° C. to room temperature, a second phase, titanium hydride, is precipitated in the alpha-titanium matrix.

X-ray and microscopical studies on single crystals have revealed that the precipitate is in the form of platelets, which lie mainly along the {10Ī0} slip planes. It is therefore natural to associate the precipitation with dislocations on the {10Ī0} system, especially as preferential precipitation occurs in regions of high plastic strain. If it is assumed that a {10Ī0} dislocation can dissociate as postulated by Churchman[1], the stacking fault structure associated with this dissociation requires only small additional movements of the titanium atoms to arrange these as the titanium atoms in either of the published structures for titanium hydride[2-5].

Evidence that hydrogen atoms do segregate around dislocations is provided by the observation of a very rapid strain ageing phenomenon in titanium during tensile experiments at 250° C. Calculations reveal that of the common impurities only hydrogen could diffuse at a fast enough rate to explain this effect. Experiments were carried out on both single crystals and polycrystalline titanium, which had previously been hydrogenated, the oxygen and nitrogen content being less than 0·01 weight per cent.

Little or no strain age-hardening was observed, and the work-hardening was of a parabolic nature with no significant increase in flow stress due to the presence of hydrogen. This differentiates the present deformation characteristics from those caused by 0·1 weight per cent oxygen plus nitrogen, where there is a very low linear rate of work hardening with an increased flow stress[6]. This difference suggests there is some fairly weak barrier to dislocation movement in titanium containing only low amounts of oxygen and nitrogen. Examination of the possible dislocations in the hexagonal lattice shows that two dissociated {10Ī0} dislocations on intersecting planes can combine to form a stable barrier of the Cottrell–Lomer type[7,8], which could hinder subsequent slip.

Embrittlement under impact-testing conditions occurs by the propagation of cracks which are associated with the hydride platelets. These cracks are caused by interference of the hydride phase with subsequent slip and twinning processes.

The above results will shortly be published in greater detail elsewhere.

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Occurrence of Beryllium Oxide in Polycrystalline Beryllium

SLOMAN[1] has claimed to have found, using optical microscopy in conjunction with chemical analysis, that a beryllium oxide/beryllium eutectic forms at grain boundaries in vacuum-cast beryllium containing 0·3 per cent oxide by weight. By contrast, other workers[2] have since been unable to detect such oxide, either in the grain boundaries or present as inclusions in metal of comparable purity. It is still generally agreed, however, that the brittleness of beryllium is probably associated with some impurity, and our current results support the original claims by Sloman.

Our beryllium specimens were fabricated from electrolytic flake beryllium which had been vacuum-cast (~ 1,400° C.). The ingots were extruded at about 1,000° C. to form both rod and tube of about 1 in. diameter and by analysis were found to contain approximately 0·25 per cent beryllium oxide by weight. Our electron-diffraction study shows that specimens prepared from four different batches of such beryllium contain variable amounts of the oxide, which is probably concentrated at grain boundaries : it is clearly in the form of relatively large crystals (greater than 500 A. in diameter). It has been shown[3] that beryllium oxide is crystalline when formed or heated at temperatures above about 280° C., and develops as relatively large crystals (greater than about 500 A. in diameter) when the metal is heated in air above 600° C. for half an hour or more. The beryllium oxide in the present case must therefore have been formed at, or subjected to, temperatures in excess of 600° C., probably above 800° C., during the electrolytic preparation, vacuum casting or extrusion.

The beryllium oxide is distributed throughout the material, as the following example shows. A 1-in. rod was turned down to 1 cm. diameter, and flat surfaces of transverse and longitudinal sections were prepared by grinding, followed by abrasion on emery papers down to grade 0000, then on fine (3μ) diamond powder. The final distorted surface layer was removed by electropolishing[4], which further smoothed the surface and showed the grain size to be about 40μ. Etching the surface in 10 per cent aqueous sulphuric acid for 30 sec. dissolved the metal preferentially at about 100 A. thickness per sec., but a beryllium oxide surface produced by heating another such sample of the metal in air (for example, at 400° C. for half an hour) was passive in the solution. Fig. 1, obtained by electron diffraction after etching the metal, shows arcs due to the beryllium (which we found has a
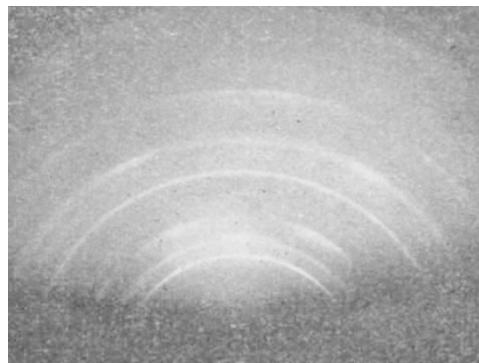

Fig. 1