

LETTERS TO THE EDITORS

PHYSICS

Coesite as an Inclusion in G.E.C. Synthetic Diamonds

IN the course of X-ray diffraction work on synthetic diamonds¹, many specimens were found to contain polycrystalline inclusions. A sample of coesite² made at the National Physical Laboratory, and kindly given to us by Sir Gordon Sutherland, has enabled us to identify it as the most prominent of the inclusions encountered (see, for example, ref. 1, Plate X, Figs. 1, 2).

This result is of interest for two reasons. In the first place, coesite has recently been identified in the Meteor Crater in Arizona³, where its presence is taken as evidence of the occurrence of an impact shock-wave of sufficient intensity to result in the production of crypto-crystalline diamond⁴, a possibility which has actually been demonstrated by de Carli and Jamieson⁵. One specimen in which coesite was found was actually the first synthetic diamond we ever examined, being a group of parallel black cubes which was selected from a batch in the G.E.C. Laboratories in Schenectady because of its superficial resemblance to cliftonite, the cubic graphite found in meteorites⁶. However, no graphite was detected in this specimen.

The second reason is that geologists have long suspected that reported inclusions of quartz in natural diamond were in reality *intrusions*, as quartz could scarcely be expected under the conditions likely to prevail during the genesis of diamond⁷. The identification of coesite strongly supports this point of view, since it indicates that if crystalline SiO₂ were present at all, it would almost certainly have been the high-pressure form. Some X-ray photographs of natural diamonds indicate the possible presence of coesite. A search for further specimens is in progress. If substantiated, this would represent the first natural occurrence of coesite except in meteor craters.

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¹ Lonsdale, K., Milledge, H. J., and Nave, E., *Mineral. Mag.*, **32**, 185 (1959).

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³ Chao, E. C. T., Shoemaker, E. M., and Madsen, B. M., *Science*, **132**, 220 (1960).

⁴ Lipschutz, M. E., and Anders, E., *Report EFINS-60-32* (University of Chicago, 1960).

⁵ de Carli, P. S., and Jamieson, J. C., *Tech. Rep.* 001-61, *Poulter Laboratories, Stanford Research Institute, Calif., U.S.A.*

⁶ Grenville-Wells, H. J., *Mineral. Mag.*, **29**, 803 (1952).

⁷ Williams, A. F., *The Genesis of the Diamond*, **2**, 423 (1932).

Thermal Diffusion of Oxygen and Nitrogen in Zirconium

THE diffusion of oxygen in zirconium under the influence of an electric field has already been studied qualitatively¹. Before beginning a further investigation of this phenomenon, it seemed worth while to find out whether a diffusion of the 'Ludwig Soret-type' occurred. If, under the influence of a temperature gradient, oxygen were indeed to diffuse preferentially in the direction of increasing or decreasing

temperature, such an effect would be superimposed on the diffusion under the influence of an electric field if resistance heating were applied on the zirconium wire or sheet. The reason for this is that when the oxygen moves to the anode, the concentration of oxygen in that region rises, the electrical resistance increases locally and thus a temperature gradient develops along the wire or sheet. Darken and Oriani² have found a thermal diffusion of carbon and nitrogen in iron under the influence of a temperature gradient. They could show that both nitrogen and carbon diffuse to the region of the highest temperature. In order to evaluate such an effect in the case of oxygen in zirconium, we tried several experimental methods. The most reproducible results were obtained in the following circumstances.

As the hardness of zirconium and of tantalum is very sensitive to small amounts of oxygen (or nitrogen)³, we used measurements of the hardness to determine the oxygen content. We carried out our experiments with ribbons of zirconium (free of hafnium, brand I.C.I. and Hereaus) first 140 μ thick and 6 mm. broad, later 200 μ thick, 6 mm. broad and in both cases 70 mm. long. An amount of oxygen was measured by volume and pressure and then absorbed in the zirconium by subjecting the strip to resistance heating (a.c.) at about 1,200° C. The solution was homogenized by subsequent heating at 1,350° C. during 4 hr. in a high vacuum. At various sites on the strip the homogeneity was checked with hardness measurements.

It proved very difficult to operate a furnace (to obtain a temperature gradient) in a vacuum of about 10⁻⁷ mm. mercury, without producing contaminating gases. Zirconium readily absorbs these gases. Therefore, resistance-heating (with a.c.) was applied in the experiments on thermal diffusion. The temperature gradient was realized by cutting away part of the ribbon so as to decrease its width towards one end, or so that the width diminished from both ends towards the centre (Fig. 1). In cases where the sheet was too brittle (more than 5 atm. per cent oxygen) to be cut, part of the material in the middle was etched away. After the gradient heating, several micro-hardness tests were made on each of a number of distances from one of the ends of the ribbon. Good reproducibility was obtained in the tests at constant distance from the end.

It was found that the oxygen moves in the direction of the lower temperature. Strips of zirconium with 1 and 2 at. per cent oxygen subjected to heating with a temperature gradient of 1,100–1,700° C. over a length of 50 mm. gave a decrease of the hardness (or oxygen content) on the site which had been at



Fig. 1. Strip of zirconium with 6 at. per cent oxygen, after gradient-heating. The thinnest part is ductile and bent, the thick parts remain brittle and one end is broken