

(Nuffield, 1945), but no Sn was reported. At Dachang, China, another cassiterite-sulphide deposit, andorite in a much restricted occurrence has a composition of $\text{Ag}_{0.96}\text{Pb}_{1.27}\text{Sb}_{3.03}\text{S}_6$ containing no tin (Huang, 1985). It appears that in these deposits the Sn present in the ore-forming environment formed tin minerals at relatively high temperatures, while andorite is a product of late-stage processes at lower temperatures. Recent analyses of andorite from various occurrences (Borodaev *et al.*, 1971; Birch, 1981; Makovicky and Mumme, 1983 and Moelo, 1983) all show an absence of Sn.

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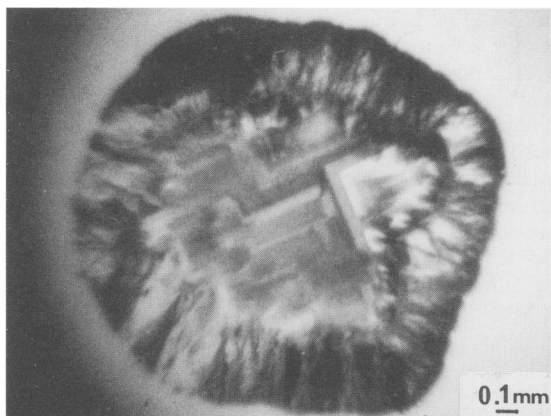
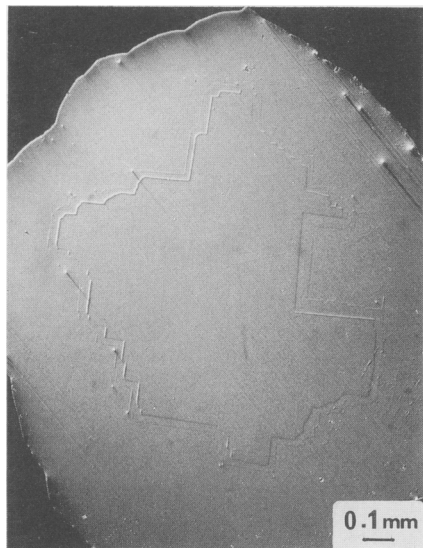
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An unusual form of coated diamond

SOME naturally occurring diamonds have an outer layer which is somewhat opaque and coloured. These diamonds are known in the trade as coated diamonds, and are of some interest as their unprepossessing exterior may conceal a core of good quality diamond (Bruton, 1970; Copeland, 1960; Custers, 1950; Lonsdale and Milledge, 1965; Orlov, 1977). Generally they are easily recognized by their lack of transparency, apparently arising from the presence of some impurities. Other methods of inspection reveal fundamental differences in the structure of core and coat. X-ray topographs commonly indicate the presence of patterns of structure in the core formed by growth on {111} planes, whereas the patterns in the coat are quite different, and suggestive of some form of radial growth (Kamiya and Lang, 1965; Machado *et al.*, 1985). Coated diamonds also show very characteristic behaviour when viewed in the cathodoluminescent mode (CL) of the SEM, the luminescence of coat and core differing greatly both in form and intensity.

We have recently examined seven natural colourless diamonds of gem quality from Zaire. They are of dodecahedral form and exhibit some vestigial {111} surfaces which permit a view into the interior of the stone. Visual and microscopic inspections of these diamonds gave no suggestion that the crystals were of other than uniform composition. However, on polishing an (001) surface on one of them (A52) for an experiment to be described elsewhere, a marked step was observed on the surface between the central and outer regions; see Fig. 1, an optical micrograph taken with Nomarski technique. The stone was then examined by X-ray topography and in the SEM. Fig. 2, a section topograph of this diamond shows a central pattern of growth typical of perhaps most diamonds, and an outer radial pattern similar to that observed in coated stones. Fig. 3 shows micrographs of the same diamond taken in the CL mode of the SEM with exposure chosen to bring out detail of the coat and core respectively. Note in particular the absence of linear growth lines in the coat and the indications



FIGS. 1 and 2. FIG. 1 (*left*). Polished (001) surface of diamond A52 viewed in optical microscope with Nomarski technique, showing step round the central region. FIG. 2 (*right*). X-ray section topograph of diamond shown in Fig. 1.

of some radial structure. All seven diamonds show similar optical and CL micrographs.

We have also examined the mechanical behaviour of the core and coat of two of the stones, A52 and A56. Measurements of the resistance to abrasion by diamond powder on a cast iron wheel (Wilks and Wilks, 1972, 1982) show that the abrasion resistance of the core is similar to that of typical colourless type I diamonds, whereas the lengths of the abrasions on the coat are at least 20% greater than those on the core. Another of the stones (A53) was

cleaved, and the micrograph of Fig. 4 shows that the slope of the cleavage surface changes as it passes from one region to the other.

The different growth patterns exhibited by the core and coat of a typical stone have been discussed by Kamiya and Lang (1965) in terms of an initial normal growth on {111} planes, interrupted at some stage by the presence of fine particles which caused the growth to change to a radial form. This approach accounts for the opacity of the coat, its different luminosity, and for the particles which are

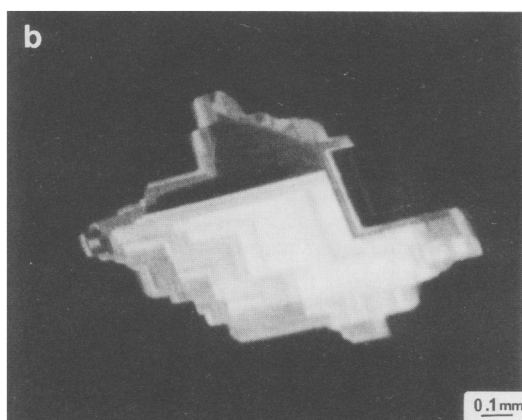
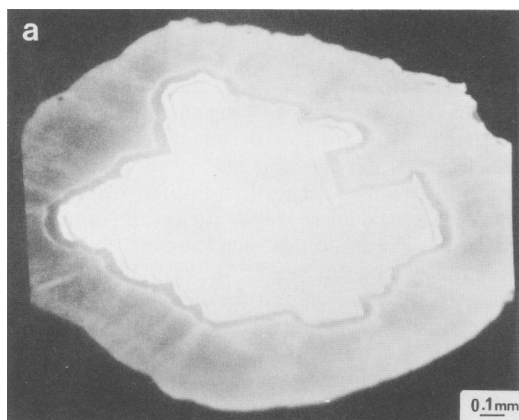
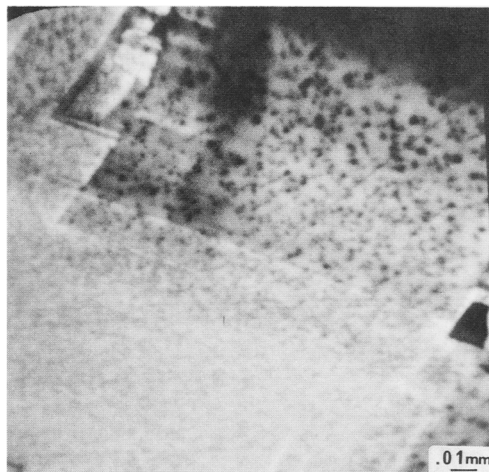
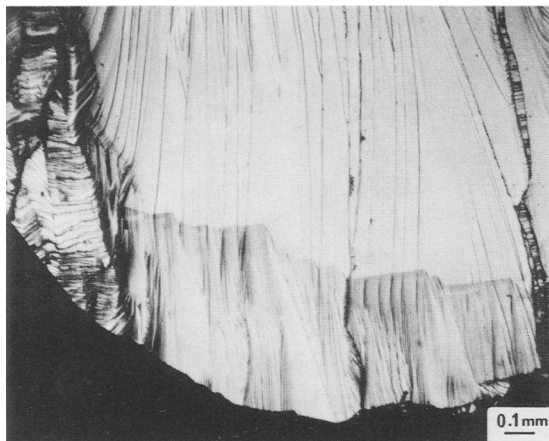


FIG. 3. Micrographs taken in CL mode of SEM of diamond in Fig. 1 with the exposure adjusted to show detail in (*a*) the coat (*b*) the core.



FIGS. 4 and 5. FIG. 4 (left). The cleaved surface of diamond A53 viewed in optical microscope with Nomarski technique. FIG. 5 (right). Micrograph taken in CL mode of SEM of diamond A52 showing detail of the core at higher magnification.

sometimes clearly visible in the coat. However, our present set of seven diamonds show no obvious sign of any difference in transparency between coat and core or any visible particles in either.

The above results suggest that the difference between coat and core in the present diamonds was not caused by the sudden appearance during growth of foreign particles but probably because of quite different growth conditions. A rather similar conclusion regarding the ordinary form of coated diamonds has been reached by Swart *et al.* (1983) who measured the infra-red absorption spectra of 47 coated diamonds. A strong $7.3 \mu\text{m}$ absorption line was observed in *all* the cores but never in the coat, and this result was taken to indicate that at some stage during its genesis the core had been at the high temperature needed to produce the platelets responsible for the absorption at $7.3 \mu\text{m}$ (Allen and Evans, 1981). In addition, Swart *et al.* observed differences in the isotopic concentrations of the carbon in the coat and core, again suggestive of quite different growth conditions.

A microspectrometer was used to examine the infra-red absorption of the diamond in Fig. 1 by passing a beam through different sections of the stone. As for the diamonds described by Swart *et al.*, a path entirely in the core showed a strong $7.3 \mu\text{m}$ absorption line. It was not possible to obtain a path completely in the coat but it was clear that the absorption at $7.3 \mu\text{m}$ in the coat was less than that in the core by a factor of over 10. We also observed that the core showed a greater coefficient of absorption than the coat over the whole range $7\text{--}10 \mu\text{m}$.

The cores both of the present seven diamonds

and of some normal coated stones show a luminescence in the SEM an order of magnitude greater than that of the coat. Unfortunately, it is difficult to relate the intensities to the concentration of impurities present, as these may either produce or quench luminescence (Davies, 1975). Cathodoluminescent micrographs at higher magnification revealed large numbers of micron-size particles in the cores, as shown for diamond A52 in Fig. 5. These are of irregular shape and appear dark, and are not readily identified with the large luminescent platelets sometimes associated with the $7.3 \mu\text{m}$ absorption line (Hanley *et al.*, 1977; Collins and Woods, 1982). It was also possible in four of the diamonds to observe the scattering of light in both coat and core from a beam passing through both, using an arrangement described previously (Wilks and Wilks, 1980). The beam was strongly scattered in the core, probably by the micron-size particles, but was invisible in its path through the coat.

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A simple attachment to Debye–Scherrer X-ray powder diffraction cameras to obtain powder patterns from single crystals

MANY methods of simulating X-ray powder patterns from single crystals have been published (e.g. Gordon, 1947; Switzer and Holmes, 1947; Matthews and McIntosh, 1949; Hiemstra, 1956; Gandolfi, 1964, 1967; Graeber and Jelinek, 1966; Corbett, 1972; Jenkins and Haas, 1973; Stern, 1977; Moss *et al.*, 1979; Koto *et al.*, 1984). They all provide for a random, or near random rotation of the investigated crystal. Notwithstanding the possibility of a non-random rotation, with as a consequence diffractograms that are not precise duplicates of powder patterns, the results are quite adequate for measurement and identification. In most designs the randomization of the crystal is effected by simultaneous rotation of the crystal around two inclined axes. Generally the primary axis is that of the camera itself and the secondary axis is that of the instrument. All these designs necessitate the purchase or fabrication of complicated and expensive special-purpose equipment. Moreover, these designs often require a careful and time-consuming centring procedure under a telescope which may be cumbersome in practice because it involves a simultaneous alignment of the crystal with respect to the two rotation axes.

Description. In our instrument (Figs. 1, 2, and 3)

the positioning of the sample is straightforward because the rotation around the primary axis can be adjusted by means of the original centring device on the powder diffraction camera. The unique features of this instrument are that (1) it is uncomplicated; (2) it is inexpensive to manufacture; (3) it can be used with only a minor adaptation in most commercially available Debye–Scherrer powder diffraction cameras; and (4) it allows for a very simple positioning of the sample in the X-ray beam.

The apparatus is machined out of aluminium in the shape of a saucer. In the centre of the saucer a steel cylinder has been inserted with a central channel drilled lengthwise through it. The diameter of the cylinder is chosen in such a way that it fits closely in the hollow axle of the powder diffraction camera. This rod forms in fact the primary rotation axis of the instrument. In the wall of the saucer a steel secondary rotation axle provided with ball bearings has been constructed. This axle makes an angle of 45° with the primary axis of the instrument and an angle of 90° with the side-wall of the saucer. One end of the secondary axle protruding outside the saucer is fitted with a supple rubber tip that can be brought into contact with the flat wall of the cylindrical powder diffraction camera. The other