
IDENTIFYING GEM-QUALITY SYNTHETIC DIAMONDS: AN UPDATE

By John Ilmari Koivula and Charles W. Fryer

The existence of gem-quality synthetic diamonds and their potential impact on the marketplace has long been a source of concern to gemologists and gem dealers the world over. While we do not know whether cuttable gem-quality diamonds have been synthesized in other nations, we do know that the General Electric Company has successfully synthesized cuttable gem-quality diamonds in the United States. Eight of these diamonds were studied in an attempt to determine means of identifying them using standard gemological tests. Sophisticated chemical and X-ray diffraction analyses and spectrophotometric and ferromagnetic studies were also performed. Distinctive inclusions, absence of strain in polarized light, electrical conductivity, and absence of both an absorption spectrum and a reaction to long-wave ultraviolet radiation were found to be useful indicators. Magnetism was also found to be a positive basis for separation but is not practical for the jeweler/gemologist.

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Rumors continue to circulate in the trade concerning the presence of gem-quality, round-brilliant-cut, synthetic* diamonds as large as one carat. In view of these rumors, and the subsequent concern about how to separate natural from actual synthetic diamonds, we decided to reexamine eight of the only *known* cuttable gem-quality synthetic diamonds, which were manufactured by General Electric Company in 1970 (figure 1) as a by-product of high-pressure/high-temperature research. Although the four largest of these stones had been studied by Robert Crowningshield in 1971, we felt that the current study would serve three purposes: (1) to bring the original work by Crowningshield (1971) back into focus, (2) to see if any new information could be discovered about these synthetics, and (3) to reveal any definitive tests that could positively separate these synthetic diamonds from their natural counterparts.

To this end, both standard gemological tests and more sophisticated research techniques were applied to the three faceted stones and five rough pieces. The results revealed that these synthetic stones can be identified even by conventional gemological techniques.

METHOD OF SYNTHESIS

Although the process used to produce gem-quality synthetic diamonds has been described elsewhere in the gemological literature (Nassau, 1978, 1980; Strong, 1982), a brief review is provided here as background for our study.

Time is perhaps the most important difference between the process used to grow the very small particles of synthetic diamond used for industrial grit and the one used by General Electric to grow the larger gem-quality syn-

**Important note: The term synthetic diamond as used in this article does not refer to cubic zirconia or any of the other common diamond simulants, but rather only to those manufactured stones that have all the chemical, physical, and optical properties that natural diamonds have.*



Figure 1. The eight gem-quality synthetic diamonds, manufactured by General Electric Company, that were examined for this study. Photo by Tino Hammid.

thetic diamond crystals that are suitable for faceting (figure 2). Whereas it takes only a matter of minutes to convert graphite into diamond grit, it takes at least a week to grow a single 5-mm gem-quality synthetic diamond crystal (i.e., which would cut an approximately $\frac{1}{2}$ -ct stone).

The diamonds were grown in a sophisticated high-pressure apparatus like the one illustrated in figure 3. The use of a metallic flux solvent (often called a catalyst) allows growth of diamond at much lower temperatures and pressures than would otherwise be required for diamond synthe-

sis. Microprobe analysis of the inclusions in the synthetic diamonds studied in this report indicates that they were probably grown using an iron solvent; traces of nickel and aluminum may have been part of the solvent, or may represent contamination in the growth apparatus. The metal melts and acts as a fluxing agent, allowing carbon atoms from the feed material to go into solution in the hot zone in the center of the growth vessel. Once in solution, the carbon atoms are then free to migrate toward the slightly cooler ends of the vessel, where a small natural or synthetic diamond seed crystal

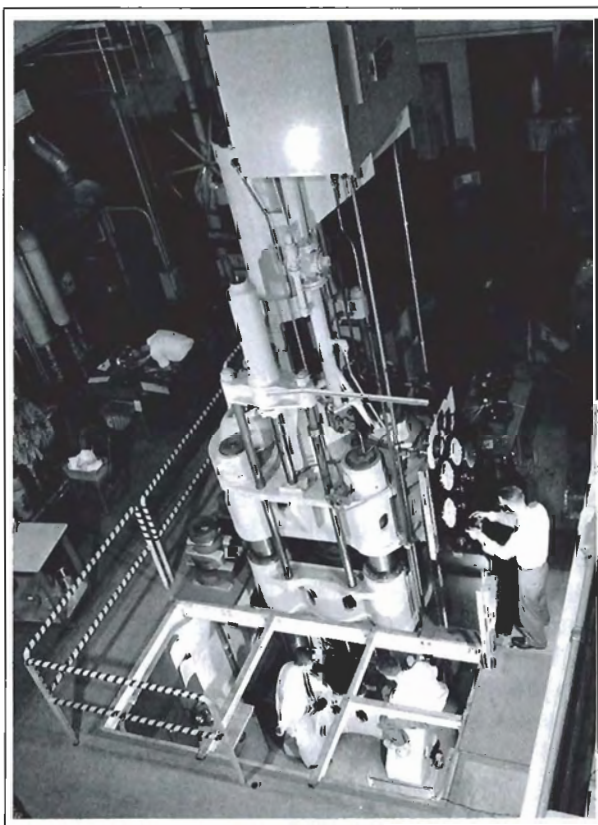


Figure 2. A selection of rough synthetic gem-quality diamond crystals grown by General Electric in 1970. Photo courtesy of General Electric.

has been implanted. The carbon atoms then deposit on the seed to produce a larger crystal (figure 4). The shape of the resulting crystal can be controlled by the orientation of the seed crystal in the cell. The addition of nitrogen will produce a yellow diamond; boron will produce a blue diamond. Figure 5 shows a blue synthetic diamond on its original growth site.

Synthetic diamond powder rather than graphite was used as the carbon source material for the large gem-quality synthetics because graphite has a lower density (2.27 grams/cm³) than diamond (3.54 grams/cm³) and thus occupies more volume per unit of weight. Therefore, when graphite is converted into diamond, there is an instantaneous loss of volume with a corresponding drop in pressure. This seriously slows the rate of diamond growth and makes control of the process much more difficult. Unless the press is specially programmed to maintain the pressure, or the temperature is increased to expand the cell contents to compensate for the volume loss, the internal pressure may decrease to the equilibrium point so that the impetus of the reaction is lost. This loss of volume and pressure in the cell can be avoided if diamond feed powder is used. Additional line drawings illustrating the interior of the pressure vessels used in synthetic gem diamond growth, together with further details, can be found in Nassau (1978, 1980) and Strong (1982).

Figure 3. An early photo of the 1000-ton hydraulic press at the G.E. Research Laboratory in Schenectady, New York. Photo courtesy of General Electric.



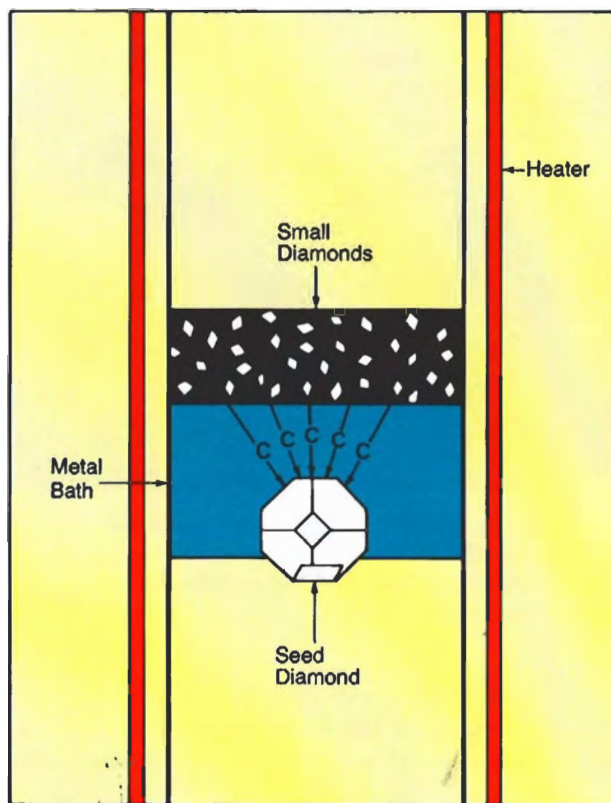


Figure 4. This diagram illustrates the method used to grow large gem-quality diamonds in a molten solvent catalyst metal. There is a temperature gradient between the hot upper portion of the cell, where the small feed diamonds are located, and the cooler lower portion, where the seed crystal is placed. The carbon atoms (c) move across this gradient and are deposited on the seed crystal.

DESCRIPTION OF THE SYNTHETIC DIAMONDS STUDIED

The eight synthetic diamonds examined in this study were among those manufactured in 1970 by the high-pressure diamond research laboratory of the General Electric Company. The three cut stones were faceted by Lazare Kaplan and Sons, Inc. of New York and donated together with a synthetic rough crystal to the National Museum of Natural History, Smithsonian Institution, in June 1971.

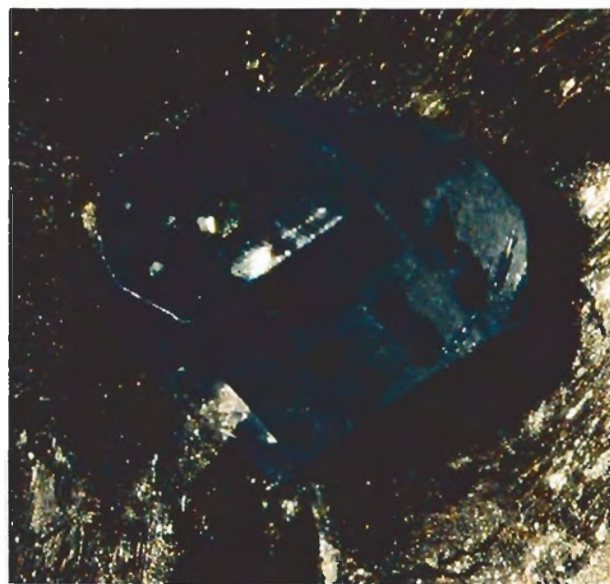
Dr. Peter Keller, of the Los Angeles County Museum of Natural History, obtained the four Smithsonian synthetic diamonds for this study through the kind offices of John Sampson White, of the Mineral Sciences Division of the Smithsonian

Institution. Dr. Kurt Nassau loaned us the four smaller rough crystals. All of the cut stones were round brilliants: one near-colorless, one a bright yellow, and one a grayish blue. The largest rough crystal was near-colorless with cube, octahedral, and dodecahedral faces; one of the cube faces had been polished. The four smaller crystals—one near-colorless, two bright yellow, and one grayish blue—were also examined. The colors and corresponding weights of these eight synthetic diamonds are provided in table 1. To the authors' knowledge, these are the only gem-quality synthetic diamonds that have ever been made available for gemological study. General Electric has never released any of the stones into the gem trade.

TESTING AND RESULTS

Ultraviolet Fluorescence and Phosphorescence. As previously reported by Crowningshield (1971) for the stones he studied, all eight of the G.E. synthetic diamonds we examined were completely inert to long-wave ultraviolet (366.0 nm) radiation. They differed, however, in their reaction to short-wave ultraviolet (253.7 nm) radiation. The near-colorless round brilliant showed a very strong yellow fluorescence with a very strong, very persistent phosphorescence of the same color. The yellow cut stone and yellow crystals were inert to the short-wave lamp. Both the grayish blue cut

Figure 5. A blue synthetic diamond crystal resting in the iron flux in which it grew. Photo courtesy of General Electric.



stone and the grayish blue crystal showed very strong fluorescence of a slightly greenish yellow color, again with a very strong, persistent phosphorescence of the same color. The near-colorless rough crystals glowed a strong whitish yellow with a strong, long-lasting phosphorescence of the same color. These results are outlined in table 1. The cruciform fluorescence patterning (figure 6) observed in short-wave ultraviolet light (first reported by Crowningshield, 1971) was readily apparent in the blue and near-colorless round brilliants, but only faintly visible in the largest uncut crystal.

Only blue type IIB natural diamonds phosphoresce after exposure to both short-wave and long-wave radiation. Therefore, the inert reaction to long-wave ultraviolet radiation, together with a strong to very strong short-wave fluorescence and phosphorescence in all but the inert yellow stone, is certainly a good indication of synthetic diamond.

X-Ray Fluorescence. Each of the eight synthetic diamonds was also checked individually with an



Figure 6. The cruciform fluorescence pattern as observed in the synthetic blue round brilliant when exposed to short-wave ultraviolet radiation. Magnified 6×.

X-ray fluorescence unit operating at 88 kV and 4 mA. The results of the X-ray fluorescence testing (again, see table 1) were identical with those ob-

TABLE 1. Gemological properties of eight cuttable gem-quality synthetic diamonds manufactured by General Electric Company.

| Shape | Color ^a | Weight (in ct) | Fluorescence and phosphorescence | | | Electrical conductivity | Specific gravity | |
|--------------------|--------------------------|-------------------|----------------------------------|-------------------------------|---------------------------------------|----------------------------|---------------------------------|----------------------------|
| | | | LWUV | SWUV and X-ray | Phosphor- escence | | Computed hydrostatic S.G. | Reaction in 3.5l liquid |
| Round brilliant | Near-colorless— GIA J | 0.305 | Inert | V. strong— yellow | V. strong— same color ^b | Conductive ^b | 3.49 | Floated |
| Round brilliant | Yellow— Fancy intense | 0.390 | Inert | Inert | None | Nonconductive | 3.54 | Sank slowly |
| Round brilliant | Grayish blue— Fancy | 0.310 | Inert | V. strong— greenish yellow | V. strong— same color | Conductive | 3.52 | Sank very slowly |
| Rough crystal | Near-colorless— GIA I | 0.735 | Inert | Strong— whitish yellow | Strong— same color ^b | Conductive ^b | 3.50 ^c | Sank very, very slowly |
| Rough crystal | Near-colorless | 0.200 | Inert | Strong— whitish yellow | Strong— same color ^b | Conductive ^b | — ^d | Sank very slowly |
| Rough crystal | Yellow— Fancy intense | 0.073 | Inert | Inert | None | Nonconductive | — ^d | Remained suspended |
| Rough crystal | Yellow— Fancy intense | 0.221 | Inert | Inert | None | Nonconductive | — ^d | Rose very slowly |
| Rough crystal | Grayish blue— Fancy | 0.157 | Inert | V. strong— greenish yellow | V. strong— same color | Conductive | — ^d | Remained suspended |

^aAccording to the GIA diamond-grading system.

^bSuggests synthetic origin.

^cIt is clear that a slight error in weighing occurred to result in a calculated S.G. of 3.50; in reality, the stone sank very, very slowly in a 3.51 liquid, indicating that the actual S.G. might be 3.515.

^dAccurate results could not be obtained because the stones were too small.

tained using short-wave ultraviolet radiation. The near-colorless and grayish blue stones all showed strong to very strong yellowish X-ray fluorescence with strong to very strong, and very persistent, phosphorescence; again, the yellow stones were inert to X-rays.

As Crowningshield (1971) mentioned, most, but not all, natural near-colorless diamonds show a whitish blue to blue fluorescence to X-rays and very limited, if any, phosphorescence. The color and strength of the X-ray fluorescence and phosphorescence exhibited by some of these near-colorless synthetics could certainly be used as a strong indication of synthetic origin.

Spectroscopic Examination. The synthetic diamonds were examined using a Beck prism spectroscope. None of the stones showed any signs of visible light absorption. The temperature of the stones was then lowered using an inverted can of the compressed gas chlorofluorocarbon (photographic duster), and the cooled stones were studied under the spectroscope. Even at the lower temperature, none of the stones examined showed any visible-light absorption spectrum. In most natural yellow stones in the cape series, including those of a near-colorless to pale yellow color, we expect to see at least a 4155 Å (415.5 nm) absorption line, with additional lines of the cape spectrum as the color deepens. The absence of these absorption lines in synthetic diamonds thus provides another test that can suggest the synthetic origin of a diamond. Because not all natural yellow diamonds are in the cape series, however, positive identification cannot be made on this basis. Still, we believe that given the known methods of gem-quality diamond synthesis, if a 4155 Å (415.5 nm) line or other lines from the cape series are visible in the hand spectroscope, then the stone being tested is most probably natural. An example of the absorption spectrum associated with natural cape series diamonds is shown in figure 7.

Spectrophotometry. The sample synthetics were next cryogenically cooled by means of a closed-

cycle helium refrigerator to 60°K and then examined with a Zeiss PMQ-3 UV-VIS spectrophotometer. The transmission spectra of the synthetics were studied in the visible-light range (410.0 nm to 700.0 nm). The spectral transmission curves (figure 8) provided by Dr. James Shigley confirmed the total lack of absorption bands that had been observed through the Beck hand spectroscope. Only the general regions of absorption causing the color of the colored ones was evident. Spectropho-

Figure 8. Spectrophotometric transmission curves obtained from each of the eight synthetic diamonds studied.

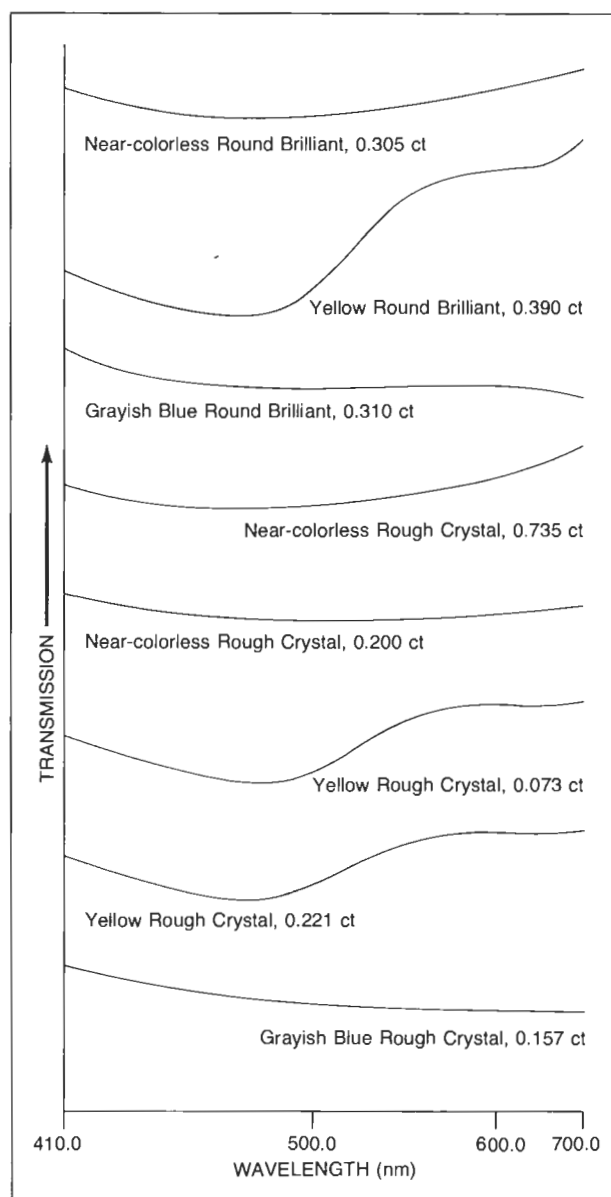
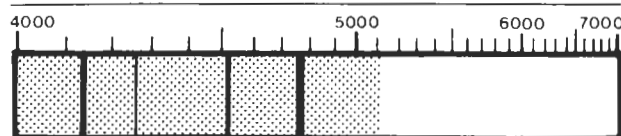


Figure 7. A representative absorption spectrum found in natural cape series diamonds.



tometry done in 1978 by Dr. George Rossman of the California Institute of Technology (pers. comm.) on one small yellow General Electric synthetic diamond crystal (R&D #2) revealed a "textbook-example nitrogen spectrum" with a strong 415.5-nm line. This spectrum may have originated from a natural diamond used as a seed. This particular stone was not available to the authors during this study, and no similar absorption characteristics were observed in any of the eight stones tested or in the other yellow synthetic stone (R&D #362) examined by Dr. Rossman.

Electrical Conductivity. The synthetic diamonds were tested for electrical conductivity using a conductometer. The results were the same as those reported by Crowningshield in 1971; that is, the yellow crystals and yellow cut stone did not conduct electricity but the blue and near-colorless crystals and cut stones did (again, see table 1).

Aluminum, beryllium, boron, and lithium can all readily enter a diamond's structure and any one of them will cause the diamond to become type IIB, electrically conductive (Nassau, 1980). However, only boron will produce a colored diamond (blue); the others will be near-colorless. The fact that small amounts of aluminum were found during semiquantitative analyses of the iron inclusions in the near-colorless G.E. synthetic diamonds suggests that some of this aluminum may have entered the diamonds' structure, making them conductive. A very low level of boron, not detectable by the microprobe, might also cause conductivity without color.

Natural type IIB diamonds encountered to date have been blue, grayish, or, rarely, completely colorless (GIA color grade D) or brownish. Since it is not common practice to test near-colorless diamonds for electrical conductivity, more research is needed in this area before one can state unequivocally that all natural near-colorless stones are nonconductors. However, no conductive natural near-colorless stones have thus far been reported. Consequently, on the basis of the stones tested thus far, the conductivity of a near-colorless diamond strongly suggests that the stone is synthetic.

Specific Gravity. The specific gravity for each of the largest synthetic diamonds was determined by the hydrostatic method using a Voland double-pan balance modified for specific-gravity determinations. The four smallest crystals were considered

to be too small to provide accurate results. The individual specific gravities of the four largest stones ranged from 3.49 to 3.54, with the average being 3.51. Since even these four stones were relatively small in size, a very slight error in weighing could cause a significant error in the final computed specific gravity. Therefore, a specially prepared heavy liquid was used to check the accuracy of the hydrostatically obtained specific gravities. Since a hydrostatic specific-gravity determination can be achieved with greater accuracy on a large stone, a 15.98-ct gemmy octahedron from GIA's reference collection (#11954) was selected. The specific gravity of this large diamond crystal was hydrostatically calculated to be 3.51. A liquid composed of Clerici's solution and distilled water was then mixed so that the large diamond crystal stayed suspended in it. All eight of the synthetic diamonds were then tested in this liquid. It is interesting to note that, as expected, those diamonds containing large inclusions of metallic iron (that is, the blue and yellow stones as well as the near-colorless rough crystals) all sank slowly in the liquid. Both the largest yellow crystal and the near-colorless faceted round brilliant, neither of which contained obvious iron inclusions, floated. Both the small yellow and small blue crystals remained suspended. Table 1 lists the results of this testing.

Microscopic Examination. The stones were examined with a Mark V Gemolite to determine the nature of the inclusions. The least included of the eight stones was the near-colorless round brilliant, followed in order by the three yellow ones, the grayish blue stone, and finally the two near-colorless rough crystals. All eight stones showed opaque, black, rod- to plate-shaped primary inclusions of the metallic flux (figures 9 and 10) in which the diamonds grew. Some inclusions in the blue faceted stone (figure 10) and the largest rough crystal broke the surface and so were ideally situated for chemical analysis. The primary flux inclusions observed in the rough crystals also showed a definite orientation parallel to the edges of the cube, octahedral, and dodecahedral faces. This is to be expected because primary flux inclusions are usually trapped by the formation of growth steps on the growing host.

All of the stones also contained clouds of tiny whitish pinpoint-sized inclusions (figure 11). The individual inclusions in these clouds were much

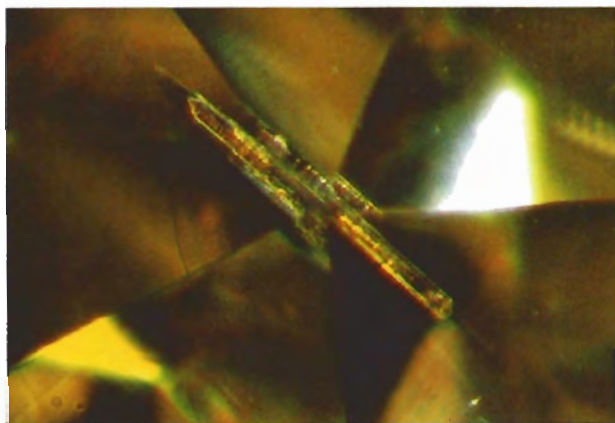


Figure 9. A rod-shaped primary flux inclusion in the faceted yellow synthetic General Electric diamond studied. Dark-field and oblique illumination, magnified 50 \times .

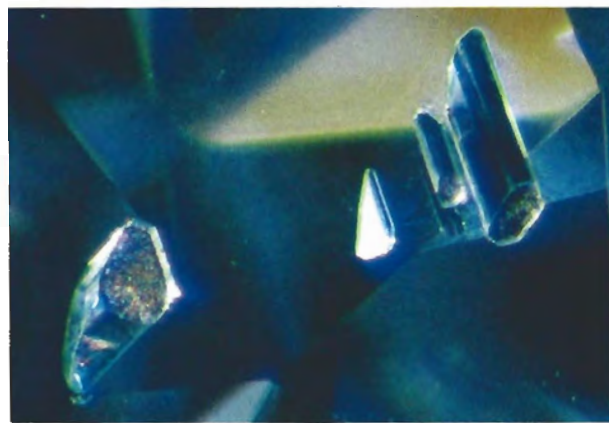


Figure 10. Large rod- and plate-shaped primary flux inclusions of metallic iron in the faceted blue synthetic diamond studied. Dark-field and oblique illumination, magnified 50 \times .

too small to be analyzed and therefore remain unidentified.

The largest of the two rough yellow crystals revealed some quite unique broom-like inclusions (figure 12) that pointed directly away from the

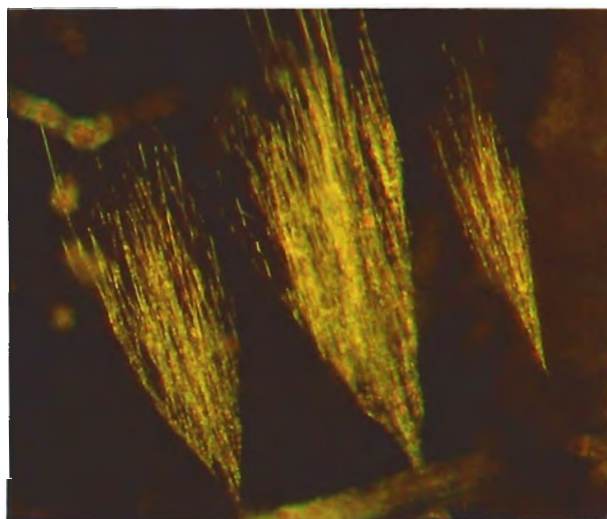
Figure 11. A cloud of tiny, whitish pinpoint inclusions in the faceted blue synthetic diamond. Dark-field and oblique illumination, magnified 50 \times .



cube face that was attached to the growth vessel where the original seed had been placed. In reflected, shadowed light, the square outline of the seed could also be seen centered on the cube face (figure 13).

Very distinct and obvious growth zoning was present in the yellow faceted stone, but none of the other seven synthetic diamonds we examined displayed this feature. However, color and growth zoning can also occur in blue synthetic stones, as shown in figure 14, which was provided by General Electric. The yellow was also the only cut stone to

Figure 12. Broom-like growth inclusions oriented perpendicular to the cube face of the seed. Dark-field and oblique illumination, magnified 50 \times .



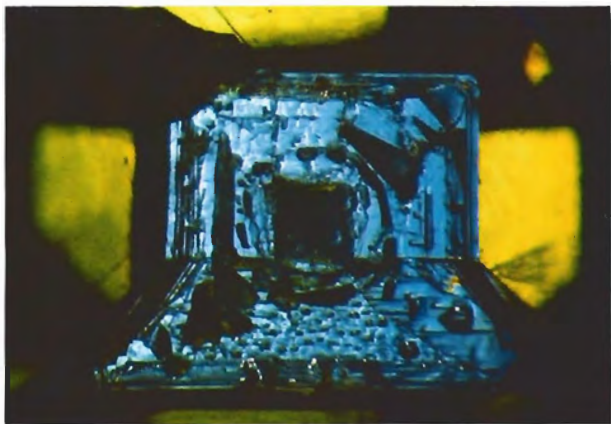


Figure 13. Surface tracing of the square-shaped seed crystal embedded in a cube face of the largest rough yellow crystal. Oblique illumination and shadowing, magnified 50 \times .

have a natural on its girdle, as pictured in figure 15. The surface features of the only rough crystals available to us were also quite interesting. Figure 16 illustrates the trigons found on one of the octahedral faces of the largest rough crystal. Striations were common to the dodecahedral faces, while cube faces generally displayed somewhat veined and striated geometric surfaces (figure 17).

Reaction in Polarized Light. In studying these synthetic diamonds with the polariscope, we observed no signs of internal strain, even in the yellow stone that contained obvious growth zoning. Small, faint fields of strain were visible under polarized light around some of the larger iron flux inclusions.

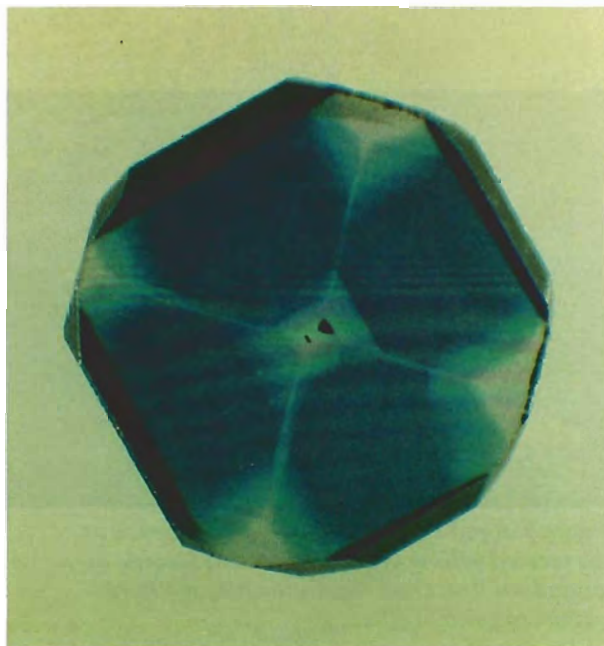


Figure 14. This sectioned, blue, boron-containing synthetic diamond crystal (5 mm across), produced by General Electric, shows cruciform color and growth zoning. Photo courtesy of General Electric.

These thin strain halos, appearing as gray, ghost-like zones, were difficult to resolve and visible only in certain directions. This is in direct contrast to what the gemologist would normally expect to see when examining natural diamonds under polarized light, as in figure 18. Although most natural diamonds show strain, some may be almost

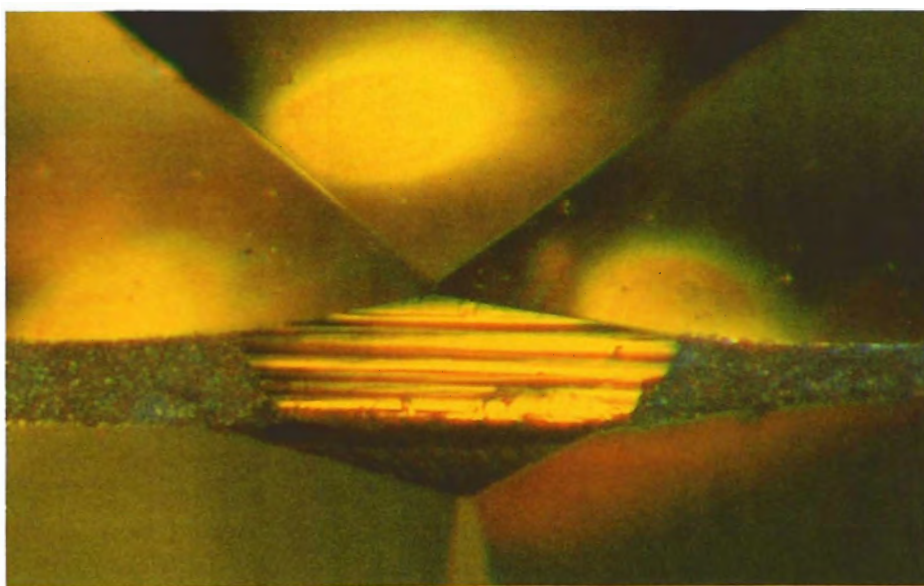


Figure 15. A striated natural on the girdle of the faceted yellow synthetic diamond. Dark-field and oblique illumination, magnified 50 \times .



Figure 16. A single large trigon aids in the identification of this octahedral face on the largest rough synthetic diamond crystal. Oblique illumination and shadowing, magnified 50 \times .

strain free. Therefore, the absence of strain only suggests synthetic origin but is not conclusive proof. A great deal of strain visible in a diamond under polarized light strongly suggests that the gem is natural.

X-Ray Diffraction Analysis. Some of the inclusions reached the surface of these synthetic diamonds and so provided the perfect opportunity for X-ray diffraction studies. After the inclusions were scraped, spindles were prepared from the scrapings

Figure 17. Veined and striated cube face surface on the largest yellow rough synthetic diamond crystal. Oblique illumination and shadowing, magnified 50 \times .

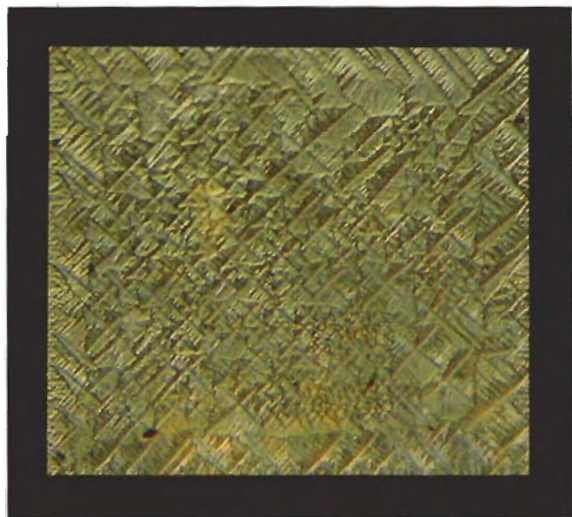


Figure 18. Strain effect in a natural diamond as observed in polarized light. No similar effect was observed in any of the synthetic diamonds. Magnified 50 \times .

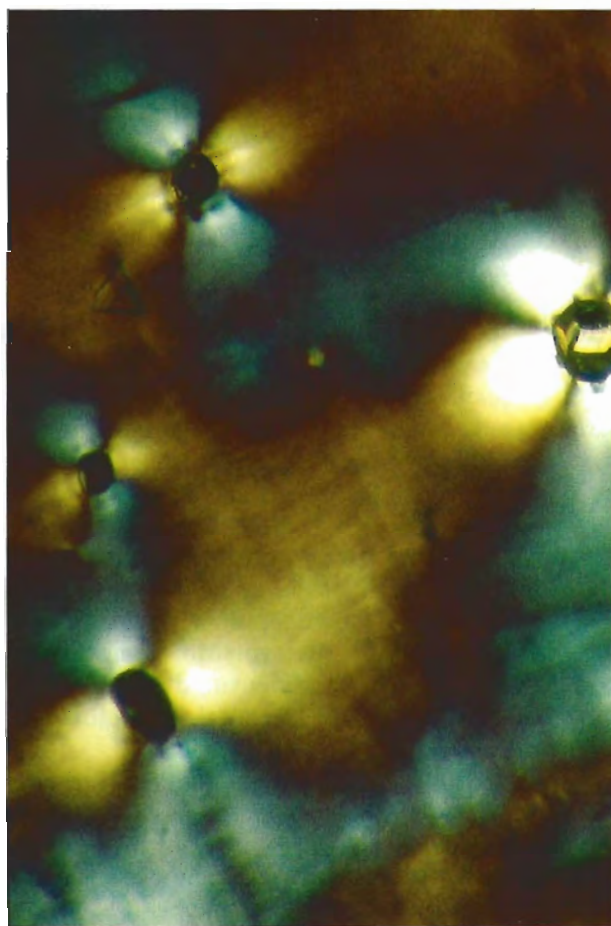
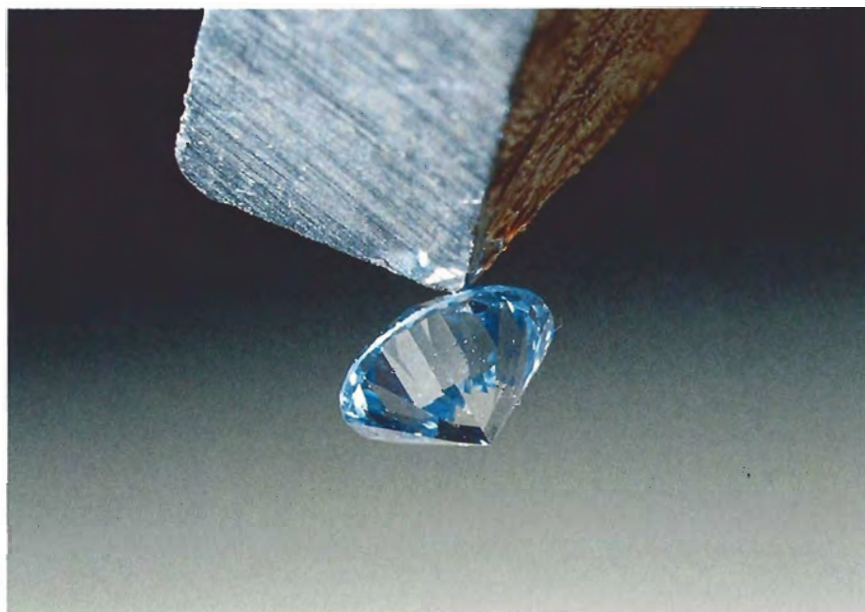


Figure 19. Synthetic blue diamond suspended from a pocket horseshoe magnet. The presence of elemental iron inclusions in the diamond causes this magnetic attraction.
Photo by Michael Havstad.



and run in a Debye-Scherrer camera on a Phillips X-ray generator unit for approximately 10 hours at 48 kV and 18 ma.

The patterns obtained were somewhat surprising because there were only two very broad, diffuse bands centered at approximately 2.03 and 1.86 Å. At first it was thought that plastic deformation had occurred in the sample as a result of the scraping, which is not an uncommon occurrence when samples are prepared from a metal. However, when other spindles were prepared and diffracted, these two diffuse bands were still the only pattern visible. A sample of meteoritic iron was then scraped and tested in the same manner, but the pattern obtained from this material showed the strong, clean, thin lines of crystalline iron. This strongly suggests that the pattern obtained on the synthetic diamond inclusions was not influenced by plastic deformation from the scraping procedure, but actually represented the pattern of the material. The band at 2.03 Å corresponds with the position of the strongest line in an iron diffraction pattern. The 1.86 Å band does not appear to line up with any identifiable pattern. More research is needed to explain the unidentified and unusual diffraction pattern obtained from these inclusions.

Semiquantitative Analysis of the Inclusions.

Those metallic inclusions that reached the surface of both the largest crystal and the grayish blue faceted stone were also prime candidates for semi-

quantitative chemical analysis. Testing with the microprobe by Carol Stockton of GIA determined that the inclusions consisted almost entirely of elemental iron (96.0%) with only small amounts of aluminum (2.8%) and nickel (1.3%) present. Since iron is a known metallic flux in General Electric's synthesis of diamond, the presence of elemental iron was not at all surprising. Independent chemical analyses by Dr. George Rossman also showed that the inclusions in these two stones were mostly iron with only a trace of nickel; he did not test for aluminum.

Magnetism. Since the dark primary inclusions were composed mainly of iron, we decided to test whether the synthetic diamonds would react to a pocket "horseshoe" type of magnet. To our knowledge, this method of testing had not been tried before. Those stones with obvious metallic inclusions were tested first. Figure 19 illustrates the reaction shown by the blue faceted synthetic stone. The largest near-colorless rough crystal and the smallest near-colorless crystal were both easily lifted by the magnet as well. This reaction has not yet been encountered in a natural diamond. Although the yellow faceted stone and the smallest yellow crystal reacted to the presence of the magnet, they could not be lifted. The near-colorless faceted stone, the largest yellow crystal, and the blue crystal showed no visible reaction to the magnet while resting on a table top. Although the

near-colorless faceted stone contained no eye-visible iron inclusions, we felt that since it was grown in the presence of the same molten iron flux it was likely that submicroscopic quantities of this flux might be dispersed inside it. If a more sensitive magnetic test could be devised, the presence of elemental iron impurities at all levels of concentration might be detected, possibly providing another practical method of separating natural from synthetic diamonds.

The next phase of magnetic testing involved using a very fine linen thread approximately one meter long. One end of the thread was hung from a support. A small wad of beeswax was attached to the loose end of the string and a diamond was pressed to the wax. However, the wax reacted to the magnet, so another method was needed. Next, a very small lead wire basket was constructed and was suspended from the thread. The four largest synthetics were then tested. In this basket, the large near-colorless crystal and the grayish blue and yellow round brilliants all reacted very obviously to the presence of the magnet. The near-colorless round brilliant showed only a slight reaction (the apparatus had to be shielded from air currents before any reaction at all was detected). The most sensitive means of testing available to us was found to be the reaction of the stones to a magnet when they were suspended in the specially prepared 3.51 specific-gravity liquid. The four smallest stones were noticeably attracted by the magnet, and even the near-colorless round brilliant reacted to the presence of the magnet under these conditions. Eight natural stones were also tested by this last method, but no attraction was observed.

In view of the above-noted reactions of the synthetics in a magnetic field, we felt that the strength of the magnetic attraction should be measured by more sophisticated methods to determine whether magnetism could indeed provide another test to separate synthetic from natural diamonds. The synthetic diamonds, together with a number of natural faceted diamonds for comparison, were turned over to Dr. George Rossman for further testing. Using a superconducting "SQUID" magnetometer, Dr. Rossman and Dr. Joseph Kirschvink examined each of the stones and found that without exception the synthetic diamonds could be separated from the natural gems on the basis of inherent magnetic properties.

Details of this magnetometer study are reported elsewhere in this issue (Rossman and Kirschvink, 1984).

CONCLUSION

Although General Electric maintains that the fundamental technology used to produce the stones reported on here has not changed significantly since 1970, there is always the possibility that the process that has been employed in the past to produce gem-quality diamond synthetics may be changed in the future. Perhaps a fluxing agent other than elemental iron will be used, or an entirely different process—resulting in a different product—will be developed. While there has been considerable speculation in the trade that other countries have begun to produce gem-quality synthetic diamonds, many researchers in the U.S. maintain that the large-scale production of gem-quality synthetic diamonds is still not financially feasible, since the cost of synthesis (a single one-carat rough stone ties up an extremely expensive piece of equipment, such as that illustrated in figure 3, for at least one week) far exceeds the cost of mining and processing natural diamonds (Dr. Kurt Nassau, pers. comm.). To date, the only *known* cuttable gem-quality synthetic diamonds are those produced by General Electric. From our study of eight of these synthetic diamonds, we feel that any cut synthetic diamonds manufactured by a process similar to that used by General Electric can be effectively separated from natural stones.

Perhaps the most unusual property of these synthetic diamonds is their reaction in a magnetic field. All eight of the synthetic stones we tested showed a reaction even to a pocket magnet under certain conditions, while no reaction has been observed in the natural diamonds tested so far. These inherent magnetic properties provide a means of conclusively identifying synthetic gem-quality diamonds manufactured by the G.E. process using iron as the solvent. However, the positive detection in all cases and accurate measurement of this property currently requires sophisticated equipment beyond the scope of the gemological laboratory. Although magnetic tests are not feasible for the present, there are a number of other procedures that can be carried out by the jeweler/gemologist to effectively separate natural from synthetic diamonds.

Specifically, the inclusions seen in these syn-

thetics do not resemble anything seen in natural stones. The rounded, opaque, metallic rod- or plate-shaped flux inclusions, together with the diffuse clouds of minute pinpoint inclusions, are indicative of synthetic origin.

The vast majority of natural diamonds show varying degrees of strain in polarized light. The synthetic stones we examined are remarkably strain-free. The complete absence of strain in polarized light could be considered a good indication of synthetic origin.

A near-colorless stone (without a bluish or grayish cast) that is darker than E on the GIA color-grading scale should not conduct electricity. If it does conduct, it is probably a synthetic.

Natural diamonds, other than type IIB which would have a tint of blue or gray, do not react to short-wave ultraviolet radiation without also reacting strongly to long-wave U.V. radiation. Therefore, diamonds that are near-colorless (not tinted blue or gray) that fluoresce and phosphoresce strongly to short-wave, but are inert to long-wave, U.V. radiation can be considered to be synthetic. There may also be a sector pattern to the fluorescence.

The vast majority of natural fancy yellow diamonds that do not show any absorption pattern in the spectroscope both fluoresce and phosphoresce to long-wave ultraviolet radiation. Conversely,

most natural fancy yellow diamonds that do not fluoresce will usually have a fairly strong cape spectrum, depending on the depth of color of the stone. Therefore, if a fancy yellow diamond shows neither an absorption spectrum nor a reaction to long-wave U.V. radiation, it is probably synthetic. A near-colorless stone, without a tint of blue, gray, or brown, that does not have a 415.5-nm line is also probably a synthetic.

Finally, diamonds that fluoresce strong yellow to X-radiation, with persistent strong yellow phosphorescence, are also probably synthetic. Most natural stones fluoresce blue to X-radiation. Very rarely, a natural stone might fluoresce red or orange to X-rays, but not yellow.

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