A NEW LASERING TECHNIQUE FOR DIAMOND

Shane F. McClure, John M. King, John I. Koivula, and Thomas M. Moses

A new laser treatment for diamonds, which typically does not have a surface-reaching drill hole, recently entered the trade. For a better understanding of this new technique, observations were made on several round-brilliant-cut diamonds before and after treatment. Diamonds with dark inclusions near the surface are favored for this new method, which causes small cleavages to develop or expand around an inclusion. Once the cleavage reaches the surface, it serves as a conduit for the solution that is used to bleach the dark inclusion. Irregular, wormhole-like channels are used to widen the cleavage to facilitate entry of the bleaching solution.

In February 2000, researchers at the GIA Gem Trade Laboratory first encountered what appeared to be a new laser treatment for diamonds. We had heard rumors of a lasering technique developed in Israel that did not show the typical surface-reaching drill hole, but we had not yet seen examples. Our first encounter was a diamond submitted to the laboratory for a grading report. While examining the stone, one of the graders noted a cleavage (or "feather"—for the purposes of this article, we will use these terms interchangeably) with some unusual dark lines in the center. Careful microscopic examination revealed oddly formed channels within the feather that were clearly not of natural origin (see, e.g., figure 1). Their appearance suggested that a laser had been used to expand or widen the feather. These unusual channels were observed in several other diamonds submitted to the laboratory shortly thereafter, and we were convinced that these stones had been treated by the new lasering process. We published two brief reports on our initial observations (GIA News, 2000; McClure et al., 2000).

While we were investigating the origin of this treatment, *Gems & Gemology* editors received correspondence on the subject from Yoichi Horikawa of the Central Gem Laboratory in Tokyo. He reported the introduction of a new type of diamond treatment that broadened cleavages with a laser beam and was specifically adapted to remove "carbon" from within them. He also reported that the process was called the "KM treatment," with the initials referring to *Kiduah Meyuhad*, which means "special drill" in Hebrew. Another new laser drilling technique, which forms a channel of parallel drill holes, has recently been reported (see GIA News, 2000; Guptill et al., 2000), but will not be addressed in this article.

With traditional laser drilling, a hole is drilled into a diamond until it reaches the dark inclusion (figure 2; Crowningshield, 1970). The resulting

ABOUT THE AUTHORS

Mr. McClure (smcclure@gia.edu) is director of West Coast Identification Services, and Mr. Koivula is chief research gemologist, at the GIA Gem Trade Laboratory, Carlsbad, California. Mr. King is laboratory projects officer, and Mr. Moses is vice president of Research and Identification, at the GIA Gem Trade Laboratory, New York.

Acknowledgments: GIA thanks De Beers for financial support of this research project.

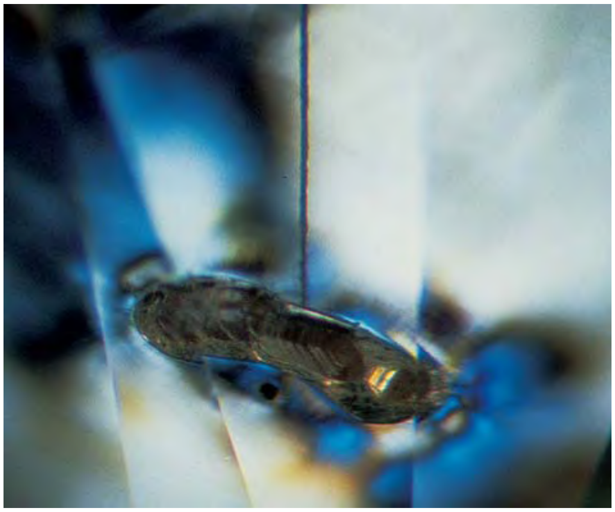
Gems & Gemology, Vol. 36, No. 2, pp. 138–146.

channel serves as a conduit for a strong acid (e.g., sulfuric or hydrochloric) to "bleach" the material or remove it altogether. The clarity grade may or may not be affected, but the resulting "white" appearance is generally considered more acceptable in the diamond trade than a dark spot that does not return any light (Pagel-Theisen, 1976). Since the early 1970s, laser drilling has been an accepted trade practice as long as it is disclosed.

In almost all of the approximately 40 to 50 diamonds we examined that appeared to be treated by this new process, we did not observe the surface-reaching drill hole that is normally associated with laser drilling. From our examination of these stones, we surmised that diamonds with shallow black or dark-appearing inclusions (such as various sulfides or graphite; see Koivula, 2000) with some type of associated tension fracture or cleavage were the most likely candidates for this procedure. One or more pulsed lasers focused on such an inclusion would produce sufficient heat to cause the inclusion to expand (and possibly even melt), and thus create enough stress to extend the cleavage to the surface. This now surface-reaching cleavage would provide an opening for the acids to enter the diamond and bleach or dissolve the inclusions. Note that it is not necessary to have a hole at the surface of a diamond to use a laser. The primary purpose of the hole is to allow entry of the bleaching solution, although it also allows the escape of gases created during the vaporization of the diamond. With this new treatment, the feather created by the laser permits entry of the solutions and allows any gases to vent.

Figure 1. The appearance within feathers of unnatural, irregular, wormhole-like channels provided the first clue that a new laser treatment had entered the market. Photomicrograph by Vincent Cracco; magnified 63×.

Figure 2. Traditional laser drilling usually leaves a straight, tube-like channel that extends from the surface of the stone to a dark inclusion. Photomicrograph by John I. Koivula; magnified 20×.



To further investigate this theory, and the procedure itself, we submitted a carefully selected group of nine diamonds for treatment by this new technique, and documented their appearance before and after lasering (table 1). We also examined and photographed approximately 25–30 diamonds seen in the laboratory that had been treated by this method.

TABLE 1. Color and clarity of the nine round-brilliant-cut diamonds before and after treatment.

Sample number	Weight (ct)	Color grade[a]	Clarity before treatment	Clarity after treatment
1	0.30	F	I_1	I_1
2	0.31	F	SI_2	I_1
3	0.33	F	SI_2	Not treated[b]
4	0.50	I	SI_1	SI_2
5	0.58	J	SI_2	SI_2
6	0.51	K	SI_2	I_1
7	0.36	N	I_1	Not treated[b]
8	0.39	N	I_1	Not treated[b]
9	0.31	O	SI_1	SI_1

[a]No change in color grade was noted following treatment.
[b]These three diamonds showed no evidence of treatment when they were returned.

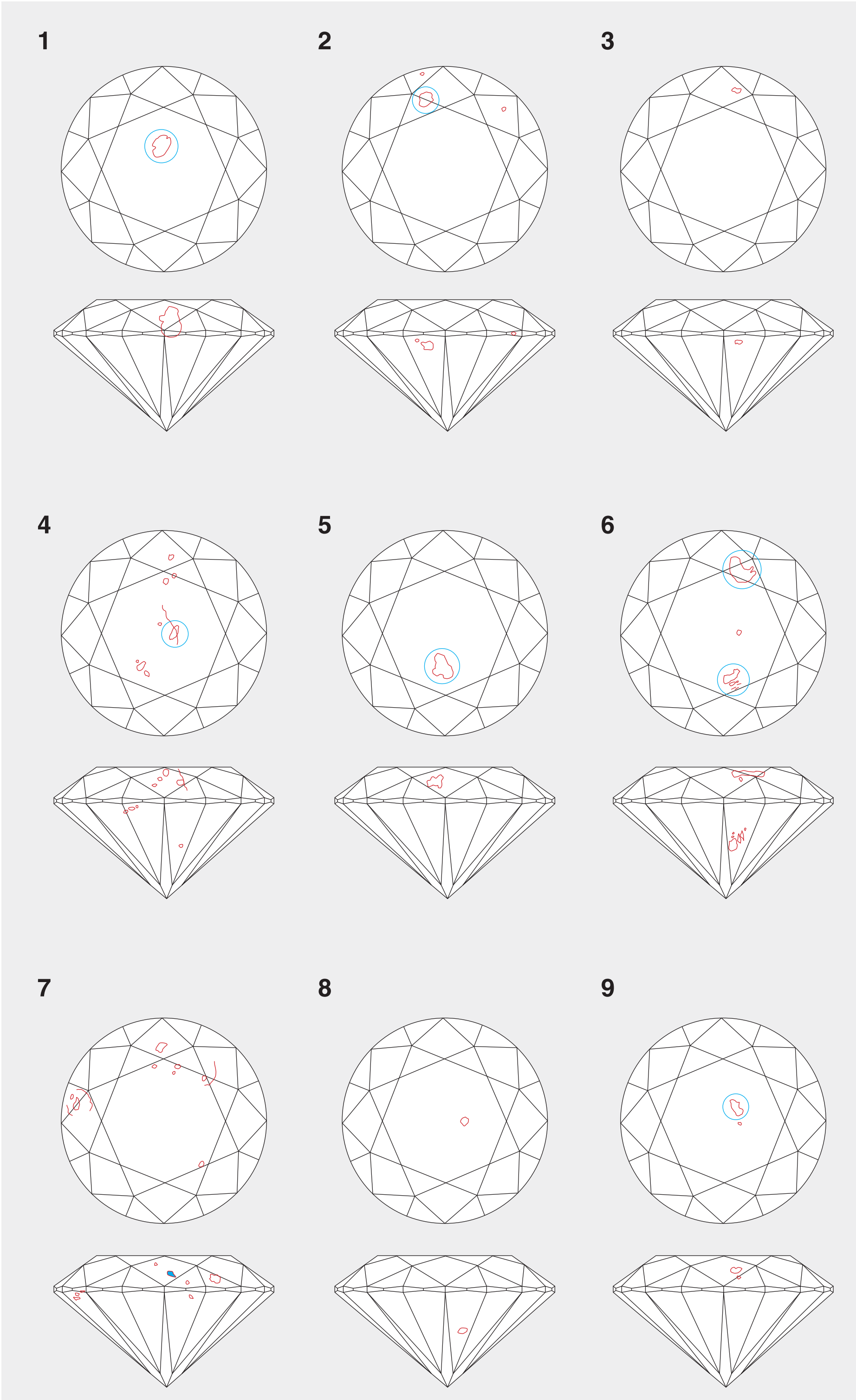


Figure 3. These plots were made on all nine diamonds in the test sample before laser treatment. Profile views are provided to illustrate the relative depth of inclusions within each stone. Note that when an included crystal is surrounded by a feather, it is plotted as one larger crystal. Following is a description of the key inclusions in each diamond and the treatment result. Those crystals that were affected by the treatment are circled in blue on the face-up view. (1) crystal with black feather—treatment created feather to surface of table; (2) crystal with black feather—treatment created feather to surface of pavilion; (3) black crystal with no feather—not treated; (4) crystal just under surface of table surrounded by black—treatment created small feather to surface of table, but several black crystals with no feathers were not treated; (5) two adjacent small crystals with black feathers—treatment created feathers to surface of table, but only one crystal was treated; (6) two large crystals with black feathers under crown and near pavilion—treatment created feathers to surface of crown and pavilion; (7) two small crystals with black feathers under bezel and edge of table, plus other crystals either not black or without feathers—not treated; (8) black crystal with no feather—not treated; (9) crystal with black feather—treatment created feather to surface of table. Plots by Joshua Cohn.

MATERIALS AND METHODS

All nine test diamonds were round brilliant cuts; they ranged from 0.30 to 0.58 ct. To test our hypothesis on the relevance of location in this process, we chose diamonds that had dark inclusions near the surface *and* deep within the stone (figure 3). Readily visible tension cracks were associated with some, but not all, of the dark inclusions. All of

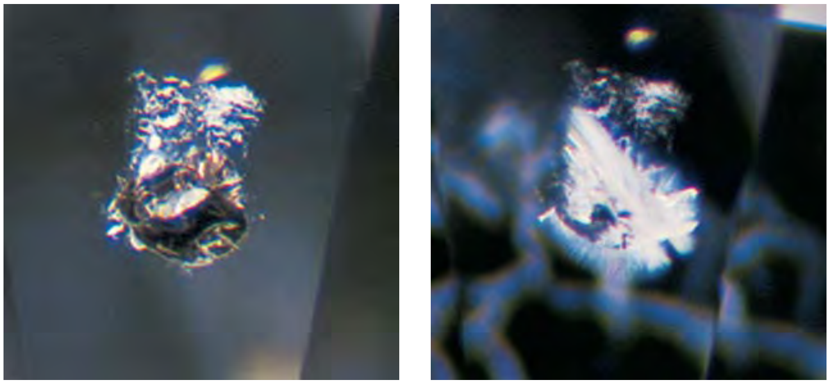


Figure 4. The first thing we noticed in those diamonds that did show evidence of treatment was the presence of new feathers leading from the inclusions to the surface of the stone. On the left we see a crystal surrounded by black feathers as it appeared before lasering in sample no. 2. After lasering (right), the inclusion is no longer black, but there is a bright new feather extending from the crystal to the surface. Photomicrographs by Shane F. McClure; magnified 40×.

these features were documented with photomicrographs, and the diamonds graded for color and clarity, before they were given to a third party to send out for treatment. On their return, the diamonds were once again photographed and graded. Our study of these samples mainly involved examination with a binocular microscope, under diverse lighting conditions, and photography with Nikon SMZ-10 photomicroscopes.

RESULTS

After the diamonds were returned, we examined them carefully, both face-up and in the table-to-culet position, using darkfield, brightfield, and fiber-optic illumination. We saw no evidence of treatment in three of the nine diamonds (nos. 3, 7, and 8 in figure 3 and table 1). Two of these three samples (nos. 3 and 8) contained a black crystal with no tension fractures that was located relatively deep within the stone. The third diamond (no. 7) contained two dark crystals with small tension fractures that were located near the surface of the crown. Five of the remaining stones had one treated inclusion, and the sixth (no. 6) had two, for a total of seven treated inclusions. One of these stones (no. 4) had several solid black inclusions—with no tension cracks—that were not treated. The black was completely removed from three of the treated inclusions (nos. 1, 4, and 5), and it was mostly removed from the remaining four.

One of the first features we noticed following treatment was the presence of new feathers (or extensions of preexisting feathers) at the treated inclusions (figure 4). In all six stones that showed evidence of treatment, mirror-like or transparent feathers were present where none had been before, connecting the original inclusion to the surface of the stone. These new feathers usually extended in directions unrelated to any preexisting feathers (figure 5). In two cases, several new feathers in different cleavage directions created a step-like progression to the surface of the diamond (figure 6).

All of the new feathers had irregular, unnatural-appearing channels similar to those we had noted

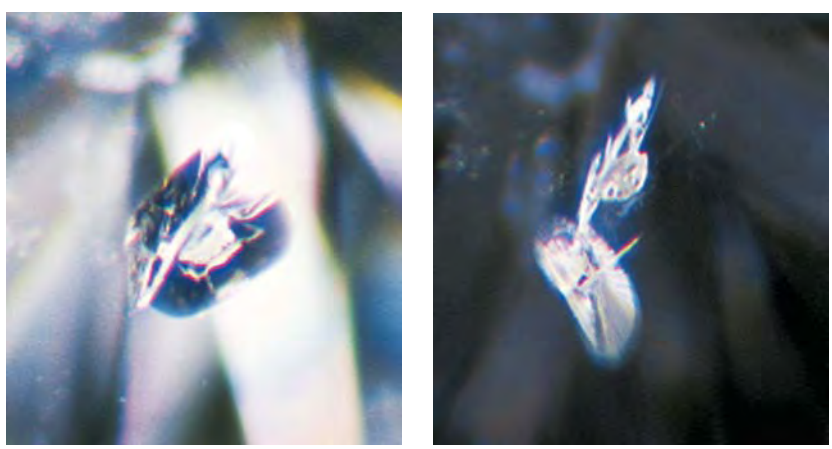
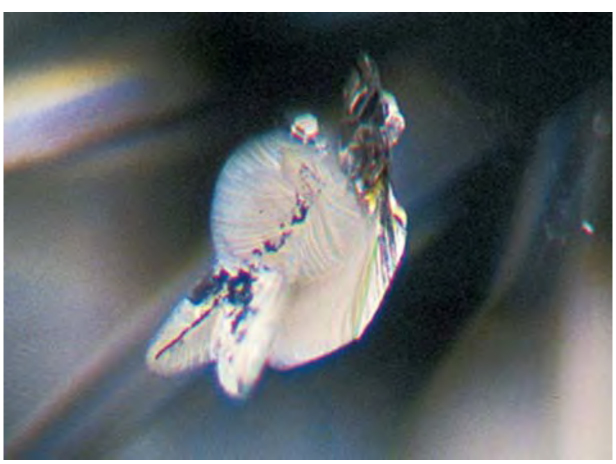


Figure 5. The most significant discovery in the treated diamonds is that some of the feathers created were new and not just extensions of preexisting feathers. The image on the left shows a black inclusion in sample no. 1 before treatment. After treatment (right), the black has been removed, but there is now a bright new feather extending from the tension crack around the crystal to the surface of the stone that is not an extension of the ones present before. Photomicrographs by Shane F. McClure; magnified 40×.

Figure 6. This treatment may be used to produce tiny cleavages that form a step-like progression from the inclusion to the surface of the diamond. In this way, the treater can take the shortest route to the surface, even if that route does not correspond to a cleavage direction. (Note that the single feature is duplicated here in a facet reflection.) Photomicrograph by Shane F. McClure; magnified 40×.

in the treated stones that had been submitted to the laboratory. These channels were usually present along the center of the feathers (figure 7). They ranged from fairly straight single lines to very convoluted multiple channels that resembled wormholes (see figures 1 and 8). They tended to be much narrower than the channels left by the traditional drilling procedure and appeared dark when viewed in transmitted light (figure 9). This typically black appearance in transmitted light often made them easier to find, since the reflective nature of the feathers sometimes made the channels difficult to see in darkfield (compare figure 9 to figure 6).

Figure 7. The treated samples (here, no. 5) always had channels—some straight and some irregular—down the middle of the new feathers; in some areas, these channels appeared black. Photomicrograph by Shane F. McClure; magnified 40×.



Four of the seven treated inclusions in the test diamonds had holes at the surface that were related to the treatment. These holes were located in the center of the induced feathers where they broke the surface of the stone. They were smaller and more irregular in shape than traditional laser drill holes, and appeared to be caused by the channels reaching the surface.

The appearance of most of the inclusions changed dramatically with the laser treatment, in that they no longer were dark or black (figure 10), although four inclusions were not completely bleached out and still had some minor black areas. One stone (no. 5) had two black inclusions (small

Figure 8. The wormhole-like channels took on a variety of appearances in these treated diamonds. These channels lead from the feather on the surface to a group of crystals and accompanying feathers. Note that the large crystal on the upper right has not been treated. Photomicrograph by Vincent Cracco; magnified 63×.

Figure 9. Most of the laser channels appeared dark in transmitted light. In some cases, such as with the step-like series of cleavages in figure 6, this was the best way to see them. Photomicrograph by Shane F. McClure; magnified 40×.

crystals with tension feathers) adjacent to each other under the table. After treatment, it appeared that the induced feather had reached only one of the inclusions, so that one was now colorless and the inclusion next to it was still black (figure 11).

One stone (no. 4) had a rectangular cavity in the center of the table—not present before treatment—where a piece of diamond had come out (figure 12). The lasering extended from the inclusion to the bottom of this cavity.

DISCUSSION

We believe that the three diamonds that did not show any evidence of enhancement (nos. 3, 7, and 8) were deemed unsuitable for this process because of the absence of tension cracks or because the dark inclusion was too deep within the host (again, see figure 3). It is possible that the one stone (no. 7) that had two small dark crystals with small tension cracks was not treated because these inclusions had minimal effect on the overall clarity of the stone. This would support our theory that the treatment works best on dark inclusions near the surface, as

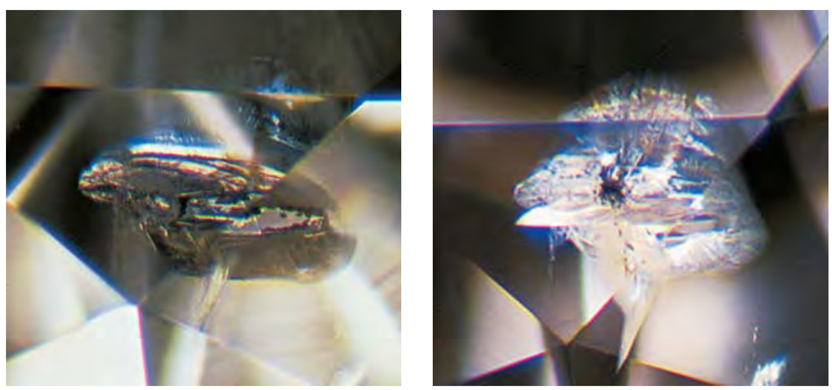


Figure 10. The new laser technique dramatically improved the appearance of most of the treated inclusions by removing the black coloration as seen here in sample no. 6. The view before treatment is on the left. Photomicrographs by Shane F. McClure; magnified 40×.

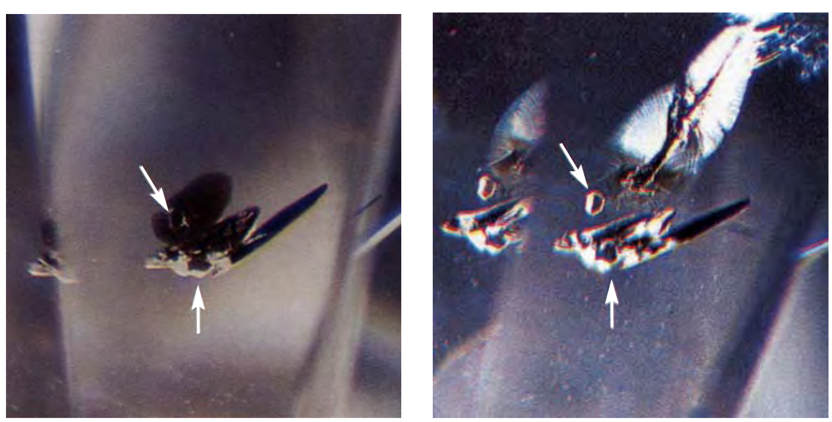


Figure 11. Before treatment (left), this diamond (sample no. 5) had two included crystals, both surrounded by dark feathers, that were adjacent to each other. After treatment (right), the feather at the top is no longer dark and the crystal is now clearly visible. However, the treatment did not reach the second inclusion, so it remains unchanged. Note the large, bright feather leading to the surface that was created by the treatment. Photomicrographs by Shane F. McClure; magnified 40×.

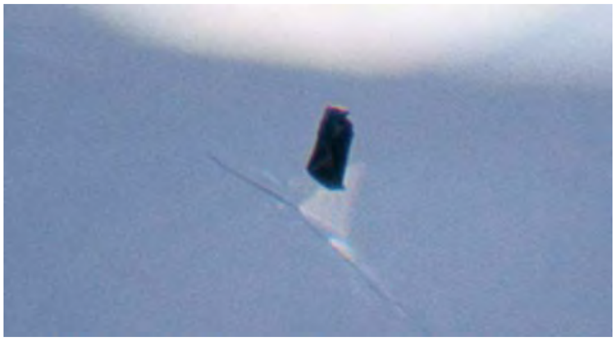


Figure 12. This cavity, which appears black in reflected light, was not present before the diamond (sample no. 4) was treated, which suggests that there is some risk involved in using this new technique. Photomicrograph by Shane F. McClure; magnified 40×.

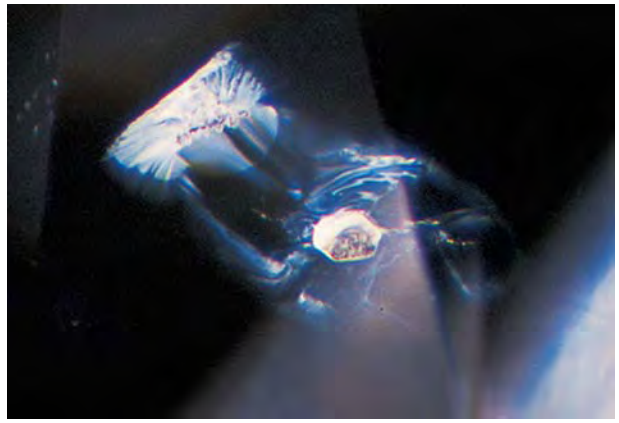


Figure 13. The new laser treatment has extended the feather surrounding the crystal in this stone to reach the surface. The preexisting feather is very transparent in this photo, while the new portion is much more reflective. Photomicrograph by Shane F. McClure; magnified 40×.

was the case with the remaining six diamonds. Inducing a surface-reaching feather from a deep inclusion would probably result in a clarity feature that was more noticeable than the original inclusion. One of the inclusions treated in our test sample (no. 6) was located deep in the diamond, but a feather was induced to the surface of the pavilion, allowing the inclusion to be bleached.

The most significant discovery from our sample diamonds was that the new treatment process not only extends existing feathers (figure 13), but it also creates entirely new ones. The presence of a step-like pattern in some of the treated feathers suggests that the treatment process is very controllable. By inducing small cleavages in this step-like pattern, the treaters seem to be able to join the inclusion to the surface by the most direct path, even if that path does not correspond to a cleavage direction of the diamond.

It appears that the wormhole-like channels were

Figure 14. It appears that the channels, shown here in the center of the bright area, serve to widen the feathers, thus allowing penetration of the acids used to bleach the inclusions. This is evidenced by the higher visibility of the areas immediately surrounding the channels. Photomicrograph by Vincent Cracco; magnified 63×.

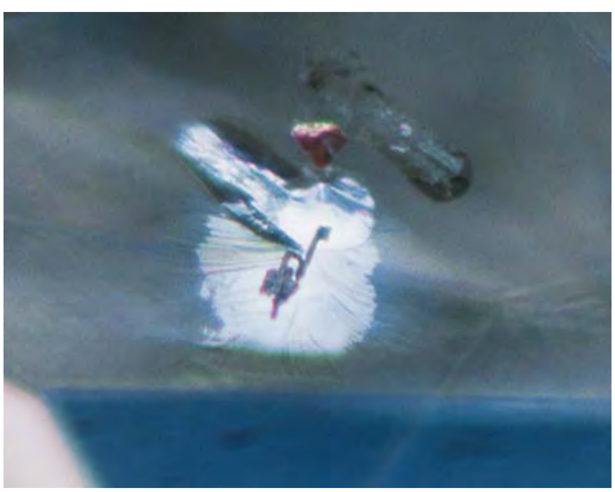


Figure 15. Several large feathers were present around an included crystal in this diamond when it was subjected to bleaching. Remnants of black material are still present in several of the feathers. Photomicrograph by Shane F. McClure; magnified 40×.

being used to widen parts of the induced feathers; this is evident in the microscope as areas of higher visibility within the feathers that immediately surround the channels (figure 14). This is undoubtedly being done to allow easier penetration of the acids used to bleach the inclusions. Nevertheless, the treatment was not always successful at removing all of the black material (figure 15). This may have been because the lasering was inadequate, or because the materials being removed respond differently to the bleaching process. For example, sulfides are easily attacked by acids, while graphite is not. The size of the inclusion does not appear to be a problem, however, as we have seen diamonds in which large crystals were dissolved with this technique (figure 16).

When we examined the new laser-treated diamonds that were submitted directly to the laboratory, we felt that one advantage to this treatment might be the lack of a hole at the surface to accept contaminants such as dirt or grease. Yet four of the treated inclusions in the test stones had holes that reached the surface. This inconsistency could be because the stones in our test sample were relatively small. Most of the diamonds treated in this fashion that have come through the laboratory have weighed between 1 and 2 ct.

Clearly the cavity in sample 4 was caused by the treatment, which indicates that there is some risk involved in this new technique. It is reasonable to assume that a treatment that involves controlled cracking of a stone could result in such undesired breakage. In fact, as table 1 shows, three of the six samples dropped one clarity grade after treatment because of the new clarity characteristics (e.g., feathers, cavity) created by the treatment.

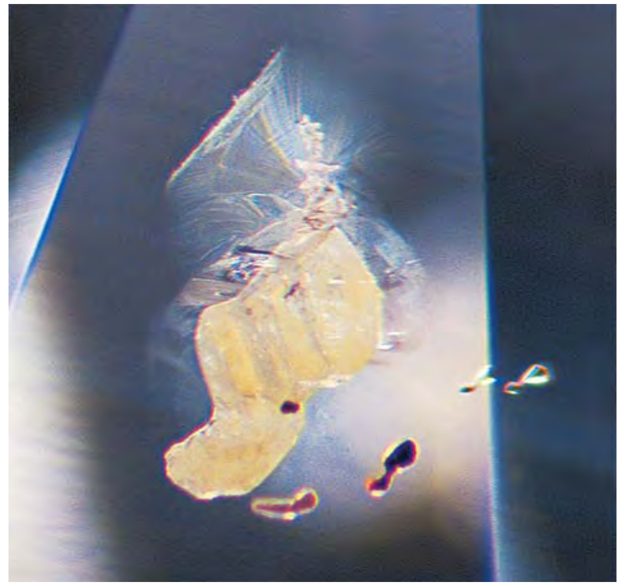


Figure 16. The original large crystal in this diamond was completely dissolved by the treatment. The induced feather created to reach the crystal is seen just above the inclusion. Note that there are several small crystals around the remnant of the larger one that are still black, because no feathers were induced to reach them. Photomicrograph by John I. Koivula; magnified 30×.

Detection. Identification of this treatment, as with traditional laser treatments, is entirely dependent on a thorough microscopic examination. The diamond must be examined both face-up and in the table-to-culet position using a variety of lighting conditions: darkfield, brightfield, and fiber-optic illumination. Look for the presence of one or more of a number of features in making the identification. The treatment may appear as a mirror-like or transparent feather that extends from an inclusion to the surface of the stone, usually at an angle completely different from the direction of the preexisting internal cleavage. Note that these feathers are often transparent and may not be visible in certain

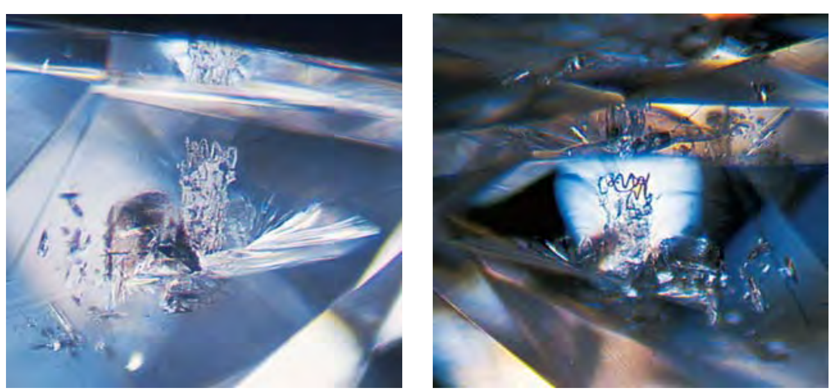


Figure 17. The use of different lighting conditions and various viewing angles is important in detecting this treatment. The wormhole-like channels are clearly seen in the photo on the left, but not the induced feather in which they are contained. By varying the position of the stone, light can be made to reflect off the feather, so that it is easily seen (right). Photomicrographs by Shane F. McClure; magnified 40×.

Figure 18. The internal channels became very difficult to see when light was reflected off the host feather, as is the case with the top half of the feather shown here. Note, though, that the widening of the feather is clearly visible. Photomicrograph by Shane F. McClure; magnified 40×.

lighting conditions (figure 17). The cracks themselves are not unknown in untreated diamonds, but their positioning makes them suspect.

There are usually one or more small channels in the center of the cleavage plane that may be relatively straight or very convoluted and often resemble wormholes. These channels may appear black or white in darkfield illumination, but are usually dark in brightfield. Often they are not visible when light is reflecting off the surface of the host feather, which indicates that they are completely contained within the feather (figure 18). Such channels are not seen in untreated diamonds. In some instances, however, the channels are so convoluted that they may be difficult to recognize (again, see figure 8). The treatment also may appear as a series of small step-like cleavages that are close together and have a very unnatural appearance. Typically, they are connected by numerous wormhole-like channels that are best seen in transmitted light (again, see figure 9).

This treatment was very difficult to detect in some diamonds, both in our study sample and in those that came through the lab. This was usually because the distance between the inclusion and the surface of the stone was short, so the features generated by the laser were small and difficult to discern. Also, if an inclusion is very close to the surface of a faceted diamond, then the number of effective viewing angles is greatly reduced, which further increases the difficulty of detecting the treatment.

Laboratory Reporting on Laser Drilling. GIA has disclosed laser drilling on its diamond grading reports since first documenting the process in 1970 (Crowningshield, 1970). To draw attention to its presence, "laser drill hole" is listed first in the key to symbols on GIA's Diamond Grading and Diamond Dossier reports. In those cases where lasering techniques do not result in surface-reaching drill holes, the GIA Gem Trade Laboratory discloses the treatment in the "Comments" section of its reports with the statement "Internal laser drilling is present."

CONCLUSION

This new lasering technique eliminates the drill channel associated with traditional laser drilling by opening or expanding a cleavage to the surface of the diamond to accommodate entrance of a bleaching solution. The resulting feather has a more "natural" appearance than the traditional laser drill channel. Identification of this new laser treatment requires careful microscopic examination with a variety of lighting techniques. It can be recognized by the presence of transparent, mirror-like feathers that contain unnatural-looking irregular channels and connect internal inclusions to the surface of the stone. Regardless of the technique involved, it is critical to the integrity of the diamond industry that treatments such as this be properly disclosed at every level from treater to final consumer.

REFERENCES

Crowningshield G.R. (1970) Laser beams in gemology. *Gems & Gemology*, Vol. 13, No. 7, pp. 224–225.

GIA News (2000) GIA identified new laser drilling treatment. www.gia.edu/news, posted April 14.

Guptill M., Quinn E.P., Tashey T.E. (2000) Laser-drilling in diamonds: A new technique. *Professional Gemologist*, Vol. 3, No. 1, p. 8.

Koivula J.I. (2000) *The Microworld of Diamonds: A Visual Reference Guide.* Gemworld International, Northbrook, IL, 157 pp.

McClure S.F., Koivula J.I., Moses T.M. (2000) Detecting new laser drilling techniques. *Rapaport Diamond Report*, Vol. 23, No. 16, May 5, pp. 1 et passim.

Pagel-Theisen V. (1976) On lased diamonds. *Börsen Bulletin*, September.