A VISUAL GUIDE TO THE IDENTIFICATION OF FILLED DIAMONDS

By Shane F. McClure and Robert C. Kammerling

A microscope with various types of lighting is the most practical and reliable method to detect fracture filling in diamonds. All of the filled diamonds examined to date have shown flash effects in a variety of colors. Also seen in some stones are evidence of flow structure, trapped bubbles, incomplete filling at the surface, crackled texture, an apparent color to the filler, cloudy filled areas, and surface residue. This article is accompanied by a chart that illustrates the various features seen in filled diamonds, plus features observed in unfilled fractures with which they might be confused.

Today, the ability to identify fracture-filled diamonds is critical for anyone involved in buying and selling diamonds, or in appraising, manufacturing, or repairing diamond-set jewelry. Two research projects conducted by staff members of the GIA Gem Trade Laboratory and GIA Research (Koivula et al., 1989; Kammerling et al., 1994) showed that careful examination with a binocular microscope is both the most practical and the most reliable method of detecting this treatment. Nevertheless, we continue to see and hear of cases where the treatment was detected too late: after a jewelry repair or cleaning procedure had damaged the filling in a stone (see, for example, figure 1).

Although the various reports published to date are, collectively, quite comprehensive in their presentation of the diagnostic features, we recognized the need to place the key information in a visual format that could be readily referenced by the jeweler/gemologist when actually examining diamonds under magnification. The accompanying chart has been produced with this practical application in mind. The following discussion briefly reviews both the important microscopic techniques to use and the key identifying features of this treatment, as illustrated on the chart. Also examined are those features seen in some untreated fractures that might be mistaken for features typical of filled stones.

ABOUT THE AUTHORS

Mr. McClure is supervisor of Identification Services, and Mr. Kammerling is vice president of Research & Development, GIA Gem Trade Laboratory, Santa Monica, California.

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PREPARATION FOR USING THE CHART

The first step in using the chart to identify fracture filling in diamonds is to familiarize yourself with the suite of diagnostic features. Study the illustrations on the chart and, if available, those in published articles. If possible, borrow known filled diamonds from your suppliers or colleagues, so you can examine them first-hand. It is important to recognize that the filling procedure is effective in disguising a variety of inclusion features, such as fractures (figures 2 and 3) and knots (figure 4). We also recommend that you acquaint yourself with the microscopic features of *unfilled* diamonds that might be confused with those in filled stones; the most com-

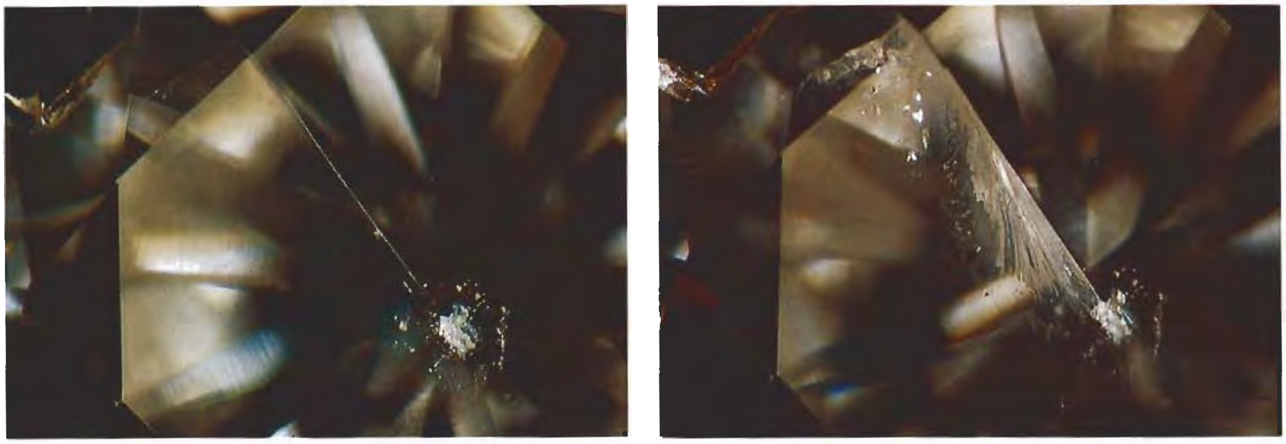


Figure 1. The change in appearance of this filled diamond before (left) and after (right) a prong-retipping experiment graphically illustrates what a jeweler might face should fracture filling not be detected before direct heat is used to perform a simple jewelry repair procedure. Photomicrographs by Shane F. McClure; magnified 32×.

mon of these are illustrated on the chart. The misidentification of an unfilled diamond as filled can also have serious consequences.

Next, review the various microscope lighting techniques that might be called on to detect one or more types of features. The methods we have found most useful include—in addition to standard darkfield lighting—fiber-optic illumination, polarized light, and the shadowing technique (as illustrated at the bottom of the chart). For additional information on lighting techniques, see Koivula, 1982a and b; Koivula et al., 1989; Koivula and Kammerling,1990; Hurlbut and Kammerling, 1991; Scarratt, 1992; Kammerling and McClure, 1993; and Kammerling et al., 1994.

TECHNIQUES FOR EXAMINING DIAMONDS FOR EVIDENCE OF FRACTURE FILLING

Begin your examination for potential fracture filling essentially the same way you would begin examining the diamond for standard diamond clarity grading, that is, with the microscope set at relatively low magnification (10×) in conjunction with standard darkfield illumination. At any stage of the examination, you can increase the magnification to resolve a particular feature further.

First hold the diamond at the girdle—in a stoneholder or tweezers if it is unmounted—in its face-up position, so you are looking through the table and crown facets. Rock the stone back and forth slowly while you look for evidence of filling. The movement is important, as some features—such as flash effects—are seen only at certain angles. Next, turn the stone over, so you are looking through the pavilion facets, and continue the examination. Finally, check the diamond while you are holding it table-to-culet. Remember that a careful, methodical examination not only helps you minimize the possibility of overlooking evidence of fracture filling, but it also helps you document the *extent* of treatment in stones where multiple breaks have been filled.

Note that although the microscope is set up for darkfield illumination, secondary reflections from facets can produce localized areas of brightfield illumination. It is therefore important to look, for example, for those flash-effect colors seen in brightfield as well as those seen in darkfield. Furthermore, experience has shown that filled breaks often may be positioned such that some portions of the break show darkfield flash-effect colors (the background is dark) while other portions show brightfield flash-effect colors (the background is light). Additional lighting methods, such as fiber-optic illumination, can be called on as required.

Testing mounted diamonds can be especially challenging. For example, prongs may cover a portion of a stone where a filled fracture breaks the surface. Mountings can also restrict the angles of observation. This is an important consideration, as the most reliable diagnostic feature of filled diamonds—the flash effect—is seen

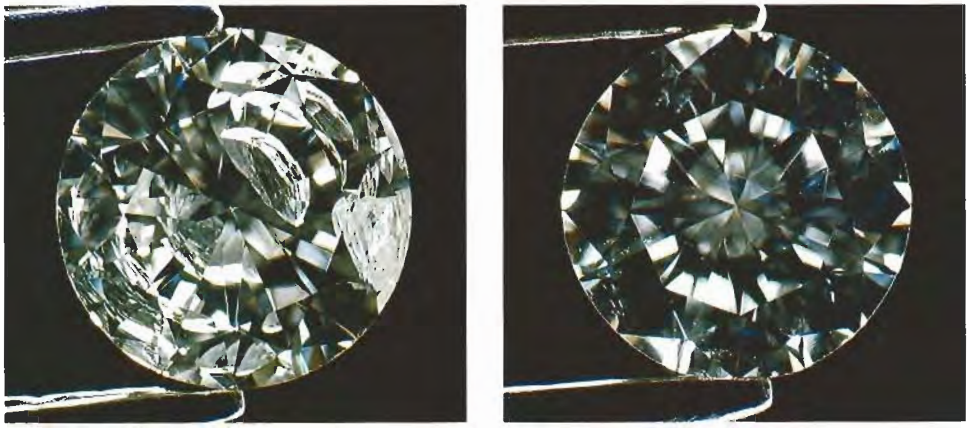


Figure 2. All commercial filling procedures investigated by the authors are very effective in improving the face-up appearance of diamonds. This is readily apparent in these photos of a 0.20-ct diamond with large, highly visible reflective fractures before filling (left) that are considerably less visible after filling (right). Photomicrographs by Shane F. McClure.

only within a narrow range of viewing angles. When testing mounted stones, it is therefore critical to view them carefully and in as many directions as possible. With jewelry-set diamonds, the use of supplemental lighting techniques—fiber-optic illumination in particular—can take on added importance (and may allow you to see a reflected flash effect; see "Flash Effects," below).

An additional test that may be used on both mounted and unmounted stones is the application of water. Orient the stone under the microscope so that the surface exposure of the suspect fracture is clearly visible. While looking at the fracture, pass a small, wet brush across its entry point. If water enters the fracture (seen as a brief reduction in the relief of the fracture), then the fracture is probably not filled. Although it is not always easy to see the water flow into the fracture, with a little patience you can see (in the fracture) the movement of the water and gas bubbles as the fluid evaporates rather rapidly in response to the heat generated by the light source. Note that the failure of water to enter the break does not necessarily mean that it is filled, as some unfilled fractures will not receive water in this way.

DIAGNOSTIC FEATURES: A REVIEW

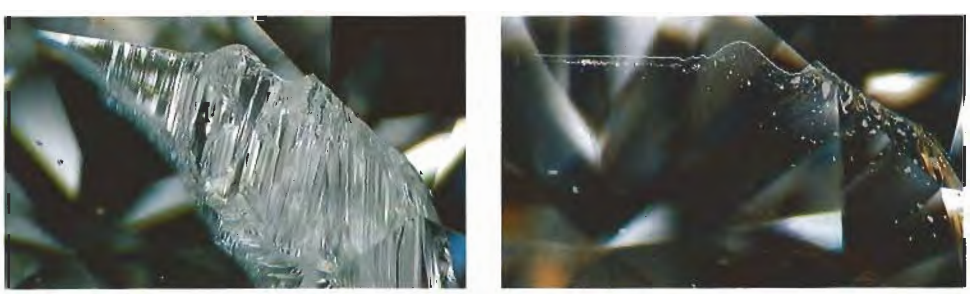
Following is a brief review of diagnostic features that have been documented to date in fracture-filled diamonds from one or more commercial treaters. All are illustrated on the accompanying chart. As with other gem identification procedures, always look for more than one feature for confirmation before reaching a final conclusion.

Flash Effects. To date, we have seen flash-effect colors in every diamond known to be filled that we have examined. This is the most consistently encountered diagnostic feature of fracture-filled diamonds.

In *darkfield illumination*, the most commonly encountered colors are yellowish orange and violet to purple to pink. Less commonly, a pinkish orange darkfield flash effect may be seen. Rarely, yellow, blue, green, and red may be visible against a dark background.

In *brightfield illumination*, the most frequently seen flash-effect colors have been blue to bluish green, and green to yellow, which correspond to the complementary colors (opposite on the color wheel) of those seen in darkfield. Violet has also been seen in some atypical samples.

Figure 3. This reflective feather is easily seen without magnification before filling (left), but only small, unfilled areas near the surface are visible after filling (right). Photomicrographs by Shane F. McClure; magnified 40×.



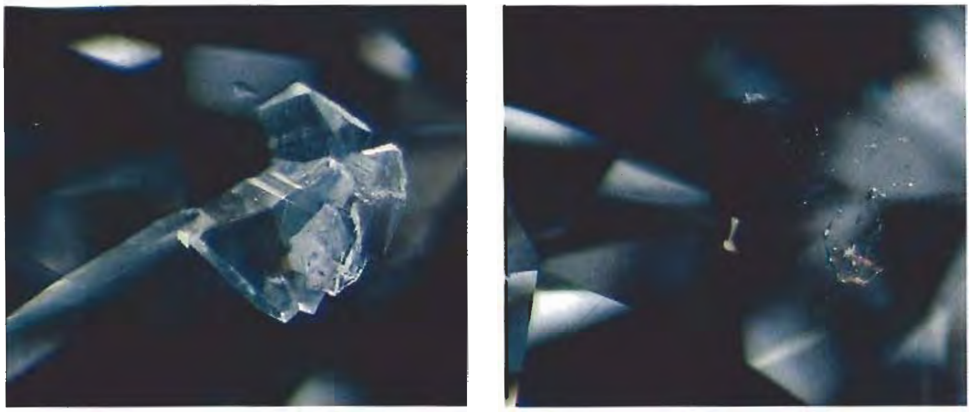


Figure 4. The interfaces around this knot are quite apparent before filling (left), but the knot is barely visible after filling (right). Photomicrographs by John I. Koivula; magnified 20×.

In both darkfield and brightfield illumination, a filled break may exhibit one color in one area and another color in another area—or even multiple colors—at a single angle of observation. When a single-color flash effect is encountered, it is often violet in darkfield. In addition (again, in both darkfield and brightfield), the flash color may change in all or part of the filled break as the stone is rocked back and forth very slightly.

Recently, in several isolated diamonds, we noted a "reversal" of the flash-effect colors normally observed in darkfield and brightfield illumination. In these instances, the colors observed in darkfield were blue to green, whereas those seen in brightfield were yellow, orange, and/or pink.

Flash-effect colors may also vary in intensity. In some treated stones, the flash colors are quite intense and easily seen using standard darkfield illumination (some may even be noted without magnification). In other stones, though, the flash colors may be quite subtle and require fiber-optic illumination to detect. In our experience, the darkfield flash color is similar in intensity to the corresponding brightfield flash color in any given filled diamond. Another point to keep in mind is that flash colors may be seen indirectly, that is, as reflections within the diamond. In fact, the reflection of a flash color is often seen before the filled fracture is located.

The feature of some unfilled breaks that is most likely to be confused with a flash effect is thin-film iridescence. Although thin-film iridescence usually appears as a multi-colored rainbow-like effect, occasionally only a few colors are apparent. These few colors are generally restricted to yellow and orange or blue and purple. Also, no complementary colors will be seen when the fracture is viewed in brightfield. One reliable method to distinguish iridescence from flash effect is by the viewing angle: Iridescent colors in unfilled breaks are generally best seen at a viewing angle roughly perpendicular to the plane of the break, whereas flash effects are usually detected when the stone is viewed almost parallel (edge-on) to the break. Polarized light may also prove useful in making the distinction: Iridescent fracture colors will shift in position as the polarizer is rotated, whereas flash-effect colors will only turn darker and more vivid (i.e., they do not shift hue laterally as the polarizer is rotated).

Occasionally, surface-reaching breaks in untreated diamonds contain an orangy brown staining of naturally occurring iron compounds that might be mistaken for an orange flash effect. Such staining, however, should be visible through a broad range of viewing angles, whereas the similarly hued flash effect can be seen only within a very narrow range of viewing angles.

Although not encountered very frequently, a natural radiation stain in a feather might also be confused with an orange flash effect. However, like iron compound staining, and unlike flash effects, radiation stains should also be visible in many directions of observation. In addition, you should be able to see the radiation stain extending from the break into the stone.

Flow Structure. A filled break may look as if a glassy substance has flowed into it. This is an appearance unlike anything seen in unfilled breaks.

Trapped Bubbles. These voids in the filling substance—areas of incomplete filling—may be fairly large and noticeably flat, or they may be small and occur in groups in an overall "fingerprint" pattern. Trapped bubbles are highly reflective in darkfield illumination, with those that are relatively large and flat producing mirror-like reflections. These bright inclusions are often the first indication that a fracture has been filled.

Incomplete Filling at the Surface. These areas are usually extremely shallow and generally look like fine, white scratches or "ribbons" in darkfield illumination. They may result from a partial removal of the filling during cleaning of the diamond.

Crackled Texture. Cracks in the filling material, producing a web-like texture reminiscent of mud cracks in a dry lake bed, are encountered relatively infrequently in filled diamonds. This feature is usually associated with areas of fairly thick filler. Such crackled areas have also been noted in filler within laser drill holes.

In some filled breaks, we have detected extremely fine, nearly parallel whitish lines that may be minute fractures within the filler. This is a very subtle feature and one that we have only been able to see using intense fiber-optic illumination.

Apparent Color of Filler. In relatively thick areas of filler, a light brown to brownish yellow or orangy yellow color may be detected. This "body color" of the filling substance used by at least one treatment firm may also be seen in filled cavities and in laser drill holes.

Cloudy Filled Areas. These are areas of reduced transparency that resemble white clouds in the filler.

Surface Residue. To date we have noted two features that appear to be residue from the filling process: (1) cloudy markings around the entry points of some filled breaks, and (2) an essentially colorless substance at the surface. This should not be confused with "burn" marks on the surface of a diamond, which result from excessive heat when the diamond was on the polishing wheel. Such burn marks usually cover larger areas, are not associated with fractures, and cannot be removed without repolishing. Note, however, that burn marks can be seen on filled as well as unfilled diamonds.

THE JEWELER'S RESPONSIBILITY

A point often reinforced in the trade press is that it is the responsibility of jewelry professionals to disclose gemstone treatments at every step in the distribution pipeline (see, e.g., Diamond, 1994). There is no excuse for avoiding this responsibility with fracture-filled diamonds, as the treatment can be detected using the basic microscopy techniques and looking for the features described and illustrated in this brief report and the accompanying chart. It is important to remember that, because the treatment is less than permanent, the unwary may only discover that a diamond is filled by damaging the filler while retipping prongs on a ring, or by merely leaving a filled stone for an extended period of time in an ultrasonic cleaner.

Equally important is the risk of misidentifying an untreated diamond as fracture filled. Such a mistake may not only hurt your relationship with your customer or with your customer's supplier, but it might also expose you to financial liability or damage your reputation in the community. It is, therefore, critical that you know the potentially confusing features of unfilled diamonds as well as the characteristics of their treated counterparts.

CONCLUSION

Magnification is the most valuable and practical means of detecting diagnostic features in filled diamonds. Keep in mind, however, that there are also microscopic features in *unfilled* diamonds with which these can be confused. Flash effects are the most diagnostic feature of filled diamonds; yet they can be confused with thin-film iridescence, iron compound–based staining, and even natural radiation stains in unfilled diamonds. The key to making the distinction is to consider such critical subtleties as the angles of observation in which the effects are visible. Additional clues that a fracture is *not* filled include high relief and a feathery appearance. Gas bubbles in the filler, representing areas of incomplete filling, are also diagnostic of filling; yet minute gas bubbles could conceivably be confused with pinpoint inclusions if only the inclusions themselves were considered. The key to making these distinctions is to become thoroughly familiar with *all* of the features seen in filled diamonds, as well as with those features in unfilled breaks with which they might be confused.

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Footnote: Additional (laminated) copies of this chart may be purchased from the GIA Bookstore, 1660 Stewart Street, Santa Monica, CA 90404. To order, call toll-free (800) 421-7250 ext. 282; outside the U.S., call (310) 829-2991 ext. 282; Fax (310) 449-1161.