CHAPTER 7

CLARITY ENHANCEMENTS

The clarity or *purity* of a diamond — the relative or apparent severity of flaws within the stone — has, like the other "four Cs", a strong bearing on the evaluation of a diamond's worth. The most common flaws or *inclusions* seen in diamond are fractures (commonly called *feathers* due to their feathery whitish appearance), and solid foreign crystals within the diamond; such as garnet, diopside, or even other diamonds. The size, color, and position of inclusions can reduce the value of a diamond, especially when other gemological characteristics are good. Those who prepare diamonds for sale sometimes choose to reduce the visual impact of inclusions through one or more of a variety of treatments.

Laser drilling

The combustibility of diamond has allowed the development of laser drilling techniques which, on a microscopic scale, are able to selectively target and either remove or significantly reduce the visibility of crystal or iron oxide-stained fracture inclusions. Diamonds have been laser-drilled since at latest the mid-1980s. Laser drilling is often followed by glass infilling.

An inclusion in a gem (usually of some other gem material) shows up as an imperfection. In this treatment, a microscopic channel is drilled to the imperfection and an acid is injected into the foreign material to bleach it and make it less visible. The inclusion becomes less apparent but it is still present.

Laser drilling is controversial within the jewelry industry, and not all jewelers believe the treatment needs to be disclosed. However, a laser-drilled diamond has a lower value than one of similar appearance that has not been laser-drilled. The drilling process involves the use of an infrared laser (wavelength about 1060 nm) to bore very fine holes (less than 0.2 millimeters or 0.005 inches in diameter) into a diamond to create a route of access to an inclusion. Because diamond is transparent to the wavelength of the laser beam, a coating of amorphous carbon or other energy-absorbent substance is applied to the surface of the diamond to initiate the drilling process. The laser then burns a narrow tube to the inclusion. Once the included crystal has been reached by the drill, the diamond is immersed in sulfuric acid to dissolve the crystal or iron oxide staining. This process is not effective for inclusions which are diamonds themselves, as diamond is not soluble in sulfuric acid.

Several inclusions can be thus removed from the same diamond, and under microscopic inspection the fine bore holes are readily detectable. They are whitish and more or less straight, but may change direction slightly, and are often described as having a "wrinkled" appearance. In reflected light, the surface-reaching holes can be seen as dark circles breaching the diamond's facets. The diamond material removed during the drilling process is destroyed, and is often replaced with glass infilling, using the fracture filling techniques described below (Fig. 7.1).

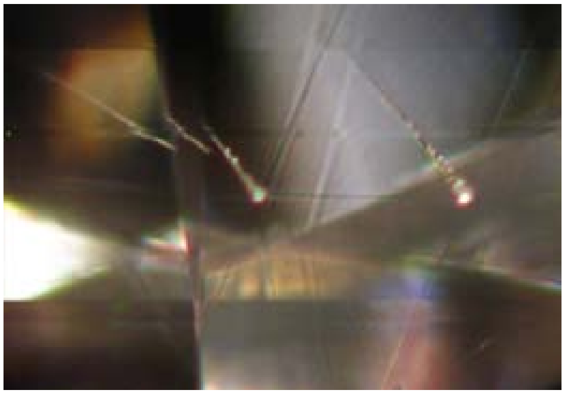

Fig. 7.1 Photograph showing fracture filled diamond by laser drilling.

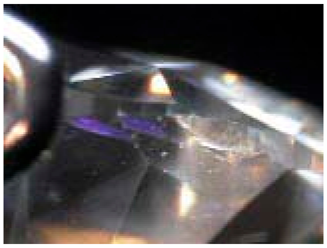

Fig. 7.2 A Photograph showing the flash effect is more predominant in the gemstone which is untreated.

Fig. 7.2 B Photograph showing the flash effect is negligible in the gemstone which is treated by lesser drill method.

Fracture filling

Around the same time as the laser drilling technique was developed, research began on the *fracture filling* of diamonds to better conceal their flaws. The glass filling of diamond often follows the laser drilling and acid-etching of inclusions, though if the fractures are surface-reaching, no drilling may be required. This process, which involves the use of specially-formulated glasses with a refractive index approximating that of diamond, The glass present in fracture-filled diamonds can usually be detected by a trained gemologist under the microscope: the most obvious signs apart from the surface-reaching bore holes and fractures associated with drilled diamonds are air bubbles and flow lines within the glass, which are features never seen in untreated diamond. More dramatic is the so-called "flash effect", which refers to the bright flashes of color seen when a fracture-filled diamond is rotated; the color of these flashes ranges from an electric blue or purple to an orange or yellow, depending on lighting conditions (light field and dark field, respectively). The flashes are best seen with the field of view nearly parallel to the filled fracture's plane (Fig. 7.2 A & B). In strongly colored diamonds the flash effect may be missed if examination is less than thorough, as the stone's body color will conceal one or more of the flash colors. For example, in brown-tinted "champagne" diamonds, the orange-yellow flashes are concealed, leaving only the blue-purple flashes to be seen. One last but important feature of fracture-filled diamonds is the color of the glass itself: it is often a yellowish to brownish, and along with being highly visible in transmitted light, it can significantly impact the overall color of the diamond. Indeed, it is not unusual for a diamond to fall an entire color grade after fracture-filling (Fig. 7.3). For this reason fracture-filling is normally only applied to stones whose size is large enough to justify the treatment: however, stones as small as 0.02 carats (4 mg) have been fracture-filled.

Fig. 7.3 Photograph showing Diamond before fracture filled.

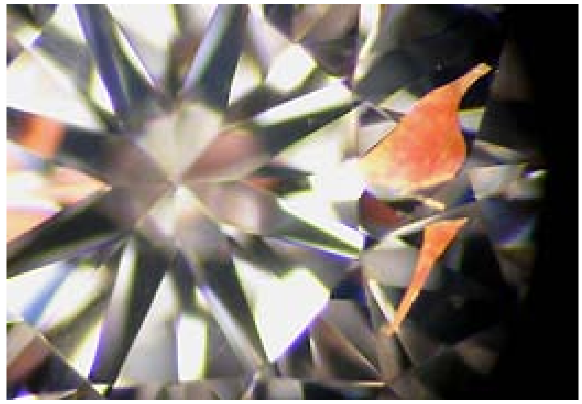

Fig. 7.4 Photograph showing diamond after fracture filled.

The fracture-filling of diamond is a controversial treatment within the industry and increasingly among the public as well due to its radical and impermanent nature. The filling glass melts at such a low temperature that it easily "sweats" out of a diamond under the heat of a jeweler's torch; thus routine jewelry repair can lead to a complete degradation of clarity or in some cases shattering, especially if the jeweler is not aware of the treatment (Fig. 7.4). Similarly, a fracture-filled diamond placed in an ultrasonic cleaner may not survive intact. Yehuda diamonds are however given a warranty, which allows owners of their diamonds to return them for retreatment following any degradation of the glass filling.

Emerald

Emerald has the longest history of fracture filling, due to its popularity and its tendency to be highly included and fractured. Natural oils have traditionally been used for fillings, such as Canada balsam, cedarwood oil, mineral oil, cooking oil, and even motor oil! Cleaning the stone and heat can remove these oils. Recently synthetic resins have been used, such as Opticon, which is more permanent than the natural oils. Treated surfaces are best detected with magnification, in reflected light; dark-field illumination is best for internal break fillings. A flash effect, blue (indicates epoxy resin), orange-yellow (probably epoxy resin), or yellow (sometimes the residue left after the filling has come out), can confirm the presence of resin. Flattened gas bubbles can be trapped in the filling material, slight colored outline of the fracture, and/or areas of low relief can be clues to fracture filling.

Diamonds

Fracture filling, or clarity enhanced diamond, effects the clarity grading of diamonds and is a concern in the trade. The process was begun in the 1980s and is a method of filling cracks with a glass-like substance to improve the overall appearance. The filling material is stable with routine cleaning, but not at temperatures and conditions needed for jewelry repair. The fillings might up the clarity grade but have been slightly yellow, lowering the color rating. Sometimes laser drill holes were made to reach an internal fracture in order to fill it, or introducing a fracture that was not originally there! Detection of fracture fillings in diamond include: an orange flash or blue or green flash interference effect with dark-field illumination; a melted or flow structure in filled breaks; flattened trapped gas bubbles in the filling material (fingerprint pattern); crackled texture in the filling resembling cracks on a dry riverbed (Hurlbut and Kammerling, 1991).

Other Material

Opal can dehydrate producing surface crazing. These breaks can be concealed with oil or wax. Chatoyant tourmaline has parallel tubes creating the phenomenon, that can fill with debris from the fashioning process or from wear. The stone can be cleaned with acid and then tubes filled with wax or Opticon resin. Another filling enhancement introduced in the 1980s was filling cavities and pits on the surface of ruby, sapphire, and emerald. These fillings were not oils or waxes, but a glassy material that served to conceal the cavity and also add weight to the reported carat of the stone.

Lead Glass Filled / Repaired Rubies

This treatment refers to the “ Lead Glass” definition as many different formulas can be used: Pure lead oxide, lead oxides mixed with silica or fluxes like borax can be encountered. Temperatures, parameters and result can be very different. The most suitable rubies for repair are stones with color potential and that are rich in fissures.

It is a multi step treatment involving simple heating and the use of different lead rich compounds to fill the fissures and cavities of the stones. If most of the “repaired” stones seen were large size stones, stones less than 1 carat have also been treated this way.

The stones are performed to eliminate the matrix and other impurities that could disturb the treatment.

As you can see here, small and large stones are treated together and AIGS gemologists have seen many rubies less than 1 carat treated with lead glass. But many stones treated this way do not present fissures and as a result will not show diagnostic features of the treatment. Then the stones are "warmed" . In fact, this step is a heat treatment. This step is important to remove the impurities possibly present in the fissures that could create some problems when the glass is added. The heat treatment may also by itself improve the stone color.

Fig. 7.5 Photograph showing lead glass treated ruby.

This "warming" can be conducted at different temperatures from 900C to 1400C depending on the ruby type (Fig. 7.5). As 900C is not hot enough to melt some inclusions as rutile, many stones can still have an "unheated" aspect. But all stones are heated.

The stones are then mixed with some oxide powders and heated. The composition of the powder is mainly a mixture of silica and lead, but sodium, potassium, calcium and metallic oxides like vanadium or bismuth also enter in some glass composition (Fig. 7.6). It could be interesting to compare the glasses used here with those used for diamonds, but this

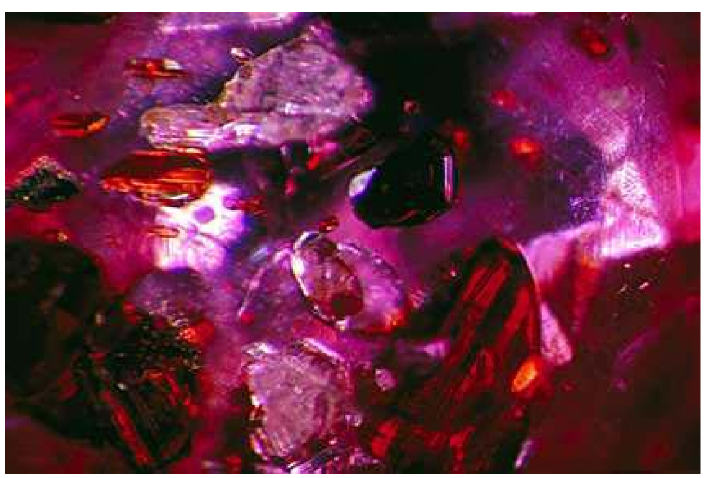

Fig. 7.6 Photograph showing Calcite inclusion in Burmish ruby.

would need further investigation. There are 2 main types of glass compositions used in this process at the moment but experimentations about new glasses are in process.

There is currently the “basic” formula which is a simple lead rich transparent glass. This formula is used for most of the best quality larger stones. This orange powder will turn into a yellowish to orange glass after heating as you can see in this used crucible. In this case, the heat treatment temperature is believed to be around 900 degrees Celsius in Chantaburi. But the treatment temperature can be much higher for other burners as other components are used in the composition of the glass.

The second formula also in corporates some other metallic oxides, in order to produce glass, optimizing the color and aspect of rubies. This formula is known in the market as the “popular” formula and is used on “iron stain” rich commercial quality stones. This formula is in fact a mix of many oxide powders that turns to a pink glass, after melting. With this formula, the treatment temperature is slightly higher nearing 1000 degrees Celsius. The powders are added to the stones with care along with some oil so they will cover them. The stones are then placed in crucibles and are then bring to the furnace. The powders will fuse during the heating process and turn into glass.

A well balanced glass composition is the key to achieving good transparency and fluidity so the glass will fill the entire fissure. The glass stability is also an important concern to create a durable product. New improved fillers will probably soon be tested and used in order to get better result. These stones are then heat treated with the glass powder under a controlled atmosphere using electric furnaces.

Identification of glass field ruby

Ultra violet : Examination of the stones using a standard SW and LW (short wave and long wave) fluorescent box did not give any diagnostic result.

Microscopic observation : By using a microscope and dark field illumination, one will be able to identify correctly the “repaired” rubies without any difficulty. This is on the basis of inclusion healed inclusion

The presence of lead is diagnostic that the stone has been treated with the lead glass technology because lead is never found in natural corundum. Lead was found in every stone that was tested and copper was also found in large filled cavities. Using dark field illumination, most lead-rich glass filled fissures will display blue/orange flashes as seen

Surface-reaching fissures/fractures: If the stone is examined in reflected light, minute hairline fissures can be observed breaking the surface of the stone. It is through these fissures that glass fillings are introduced. Glass-filled pits may also be observed in reflected light; these areas have a different quality of polish than the surrounding gem.

Gas bubbles: By following the path of the fissure and looking into the depths of the gem, glass fillings may be observed. These generally contain rounded gas bubble inclusions. If they are constricted to a smaller fissure, these gas bubbles can become elongated and "squashed" in appearance. As rubies do not have this kind of inclusion in nature, glass filling should be strongly suspected.

Flash effect: While the refractive index of the glass and the host ruby may be similar, their dispersion is different. Under magnification, the point of contact of these two substances (glass and ruby) within a fissure often leads to a "flash effect," an optical phenomenon that is manifested in a variety of different colors including violet, purple, blue and green. It can be observed flashing on and off when the gem is rocked and turned under magnification. If any or all of these clues are observed within the stone, it should be rejected as a natural untreated gem, or sent to a laboratory for additional tests. Labs can radiograph a gem, perform sophisticated spectroscopy, X-ray fluorescence analysis and other methods for positive identification of glass-filling treatment.

Dyeing

Dyeing is a treatment that alters the body color of a gem and has been done for thousands of years. For the dye to penetrate, fractures must exist. If the gem is not porous or fractured naturally, the opening for the dye to enter the stone is produced by "quench crackling," a heat-induced thermal shock, that creates a network of fractures The stability of dyed gems is dependent upon the type of dye, which varies from natural organic material to synthetic or precipitations of metallic salts.

Emerald and ruby is dyed using a colored oil, which fills in fractures and enhances the depth of color. To detect this enhancement, examine the stone in diffused transmitted lighting and look for color concentrated around fractures. Some green colored oils will fluoresce a greenish yellow.

Quartz

Colorless quartz can be *quench crackled* and placed in the dye simultaneously or after drying. Magnification can show the result of the quench crackling. Chalcedony, a cryptocrystalline quartz, has many varieties including agate, onyx, carnelian, chrysoprase, and pseudomorphs after bone and wood. The stone is simply soaked in a solution for penetration, then soaked in another solution to arrive at the desired color.

Chalcedony

Chacedony shows various colours in nature due to impurities. It is a natural green chalcedony colored by nickel, whereas the solution to dye chalcedony green has chromium oxide. This can be detected by spectroscopy or using the color filter (chromium colored will be red and nickel colored will remain green). Blue chalcedony is dyed with cobalt and again can be detected with the color filter, which will show red. Blackening is a technique using a sugar-acid chemical reaction that produces carbon to blacken the color (Matlins and Bonanno, 1997). The method is to soak the stone in a sugar solution, then in concentrated sulfuric acid. This treatment produces *black* opal and dyed black chalcedony, sold as black onyx. This treatment cannot presently be detected but because natural gem-quality black chalcedony is extremely rare, this dye treatment is the norm (Hurlbut and Kammerling, 1991). Jasper may be dyed blue to resemble lapis lazuli.

Green and lavender jadeite is routinely enhanced with dying inferior material. Green enhanced jadeite can be detected with spectroscopy. Lavender jadeite, created by dying white jadeite, has no conclusive tests to detect the enhancement although some fluoresces a strong orange with long-wave UV radiation. Nephrite has a more compact texture and is not dyed as often as jadeite.