

DIAMOND COLOR TREATMENTS AND IDENTIFICATION

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INTRODUCTION

A diamond's color - or lack of color- is one of the components that affect its value. The diamond industry has developed methods to turn yellow and brownish diamonds into the colorless and vivid fancy colors that the public and the market demands.

As a result, the diamond market has seen an ever increasing number of natural diamonds and diamonds types that have been subjected to some form of color changes through High Pressure High Temperature annealing or irradiation.

The synthesis of diamond at high pressures and high temperatures was first demonstrated by ASEA in Sweden in 1952 and at GE in 1955.

The awareness of the market to HPHT color treated diamonds started when General Electric and Lazare Kaplan, in early 1999 introduced a technology to process certain type IIa diamonds and to convert them from brownish colors to a much more marketable colorless range or pink color. As a result of the treatment, the color of a diamond can be improved by several color grades. General Electric is producing colorless diamonds, called Bellataire, from type IIa diamonds that are nitrogen-free.

Irradiation and HPHT treatment are the color enhancement methods that in recent years have been applied to change the color of natural diamonds as well as laboratory created diamonds. Experiments using irradiation to change diamond's color began in the early 1900s. The early process produced some good colors but left the gems strongly radioactive for years. Current methods though leave hardly any residual radioactivity. Irradiation produces green and blue colors, and additional treatments can create yellow, orange, and red colors.

The artificial irradiation of diamonds uses high-energy particles to create color centers in the atomic crystal lattice. The most common commercial irradiation treatments involve focusing a beam of accelerated particles (electrons or neutrons) at a diamond, which creates green and blue colors. By following irradiation with annealing via heating to around 800 °C, the green and blue colors can be changed to orange, pinks and reds.

The problem with irradiation is that although the colors are attractive, there is some question about their permanency and the health hazards. Irradiated diamonds are guaranteed to survive the normal, everyday wear and tear, but the color may change when the stone is exposed to high heat.

The more recent option for coloring diamonds, the HPHT treatment is more costly more than irradiation, but it produces colors that are stable even under intense heat and there are no health issues involved. A variety of tests have shown the HPHT color treatment to be permanent and irreversible. The HPHT treatment has therefore proven to be the primary color enhancement method.

How HPHT Works

Initially, General Electric and Lazare Kaplan utilized HPHT treatment to remove color from brown type IIa diamonds, resulting in colorless or near-colorless gems

From Brownish to Colorless



Before

After

When the diamond crystal is subjected to very high temperatures, the structure of the dislocations is modified, causing the brown coloration to be reduced. At these very high temperatures, diamonds will convert to graphite unless very high pressure is applied. This is done using the same kind of equipment as is used for diamond synthesis, e.g., the conventional "belt" presses developed by General Electric, the cubic or prismatic presses used by NovaTech or the BARS presses developed in Russia. Such equipment is complex and relatively expensive.

Typical HPHT conditions can be in excess of 2000°C and 60,000 atmospheres.

Less than 1 percent of natural diamonds are type II of adequate quality to be suitable for HPHT treatment. The HPHT color enhancement can also be suitable for converting brownish colored diamonds to fancy colored diamonds. Type IIb brownish diamonds can be enhanced to blue. HPHT can also change Type IaA/IaAB to yellow/orange or yellow-green.

From Brownish to Fancy Color



Before

After

HPHT color treated diamonds - IDENTIFICATION

Gemological laboratories today are required to be able test both whether a diamond is suitable for HPHT annealing, ie. Color improvement and whether a diamond has undergone color treatment.

Currently, the recognition of HPHT-treated diamonds involves the determination of various visual properties - such as color and features seen with magnification - as well as characterization by several spectroscopic techniques. HPHT-treated diamonds were introduced into the jewelry trade in the late 1990s, and despite progress in their recognition, their identification remains a challenge. While some detection methodologies have been established, the large number of diamonds requiring testing with sophisticated analytical instrumentation poses a logistical problem for some gemological laboratories.

HPHT will continue to be a controversial topic, with grading labs trying to perfect ways to detect the always-improving process so that consumers can receive full disclosure about the diamonds they purchase. The Federal Trade Commission recommends that HPHT is disclosed. It has become common practice for gemological laboratories to clearly indicate on diamond grading reports if the diamond is "HPHT annealed" or "artificially irradiated". At the Gemological Institute of America (GIA), diamonds are laser-inscribed with the words "HPHT PROCESSED" or "IRRADIATED" on the girdle.

Color treated HPHT diamonds are highly fluorescent and contain observable absorption characteristics as well as inclusions. The majority of color treated diamonds are type IIa diamonds, which are very rare in nature. They are almost free of nitrogen transparent in part of infrared and have irregular shapes.

Type IIa diamond is the rare type of diamond that can be transformed from brownish to colorless of a higher value — up to D in color — by HPHT treatment.

Thus, **the first step** to detect color treated diamonds is to determine whether the sample is type IIa. This can easily be done by using the SSEF Diamond Spotter, which is based on the transparency of these diamonds to short-wave ultraviolet radiation (SWUV).

The SSEF diamond spotter provides an inexpensive and convenient first test to determine whether it is *not* one of these rare types that are suitable for HPHT treatment, but if it *is* one of the rare types other infrared spectrometric tests must be performed.

The SSEF Diamond Spotter determines whether or not a diamond is one of the rare types that *could* be treated to produce colorless, near-colorless, pink and blue diamonds. It allows an easy separation into two groups of diamond types: type IaA, IaAB and Ib versus IIa, IIb and rare IaB. The technology is based on the fact that Type II diamonds are transparent to SWUV light, whereas the vast majority of Type I diamonds block SWUV light.

However, it does not determine whether the diamond has been HPHT treated or not.

By placing a diamond into the spotter and switching on the SWUV light source, the diamond will react by transmitting or absorbing the SWUV light, thus fluorescence or no fluorescence on the screen of the spotter

Green fluorescent light spot on the screen during testing with the SSEF diamond spotter identifies the diamond as type IIa or IIb or rare type IaB and at the same

provides indication that a colorless diamond may have been “decolorized” by HPHT treatment. Further analysis is required within a specialized gemological laboratory which is equipped with spectroscopic detection instruments.

If no fluorescence reaction shows on the screen in the SSEF diamond spotter, the diamond is of type Ia or Ib, which means that the colorless diamond has not been HPHT treated for decolonization.

A very similar screening device has most recently been introduced by the HRD. The technology used by the D-Screen is based on optical measurement by projecting shortwave UV radiation through the diamond.

Conclusive identification of HPHT treated diamonds requires low-temperature visible and photoluminescence spectroscopy, techniques normally available only in professional gemological laboratories.

Thus as the diamond is identified as a type that is suitable for HPHT color treatment, **the second step** is to look for subtle luminescence features related to N-V centers in the type IIa diamonds with a Raman spectrometer.

Conclusion

The real concern in the industry regards the possibility of undisclosed HPHT treated stones and the need for detection. Research in the detection methods are constantly under review to extend capabilities. Laboratories worldwide have therefore invested heavily in the equipment needed to handle detection hand in hand with professional staff that has the necessary knowledge to interpret the available data. The potential of fraud in the industry means that disclosure must be accompanied by a combination of means of identification. In the case of HPHT treated diamonds, this can reliably only be achieved by detailed spectroscopic examination at a fully equipped gemological laboratory.