Using the DTC DiamondView to Detect Irradiation-Induced Defects in a Brown Orange Diamond

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Fluorescence is an important property of diamonds, which have characteristic fluorescence colors and patterns depending on whether they are natural or synthetic, and treated or untreated. The De Beers DiamondView instrument is a very powerful tool for studying fluorescence in all sorts of diamonds. It uses very strong short-wave UV radiation with a wavelength slightly greater than the absorption edge of diamond to induce a fluorescence reaction in diamond. The instrument then captures relatively high-resolution, real-time images of diamond fluorescence.

Diamonds show large variations in their fluorescence patterns, which are closely correlated with crystal growth structure and orientation. Generally, however, fluorescence shows no correlation with the faceting of cut diamonds. Recently GIA's New York laboratory (as also reported in *Gems & Gemology*'s Lab Notes section) examined a diamond that displayed strikingly different fluorescence behavior between the table and pavilion facets, a clear indication that this diamond is artificially treated.

The 1.49 ct pear-shaped brilliant (figure 1) was color graded Fancy Deep brown-orange according to GIA's fancy color grading system. Viewed with the unaided eye, it appeared to have a homogeneous body color. But a strong zone of orange/brown color, visible just below the surface, followed the girdle facets around the entire stone (figure 2).

Figure 1. This 1.49 ct pear-shaped brilliant was graded Fancy Deep brown orange.

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Figure 2. A strong color zone was confined to a shallow area just below the surface along the girdle facets.

The brown-orange zoning along the stone's faceting is not a natural feature: It is indicative of irradiation. Irradiated stones typically show a strong zone of color at the culet and along the adjacent pavilion facets—termed the "umbrella effect"—as this area is often exposed to the strongest concentration of radioactive particle bombardment.

Infrared absorption spectroscopy revealed the diamond was type IaB, meaning that it contained number B centers composed of four nitrogen atoms surrounding a vacancy (Collins et al., 1986), with a moderate to high concentration of nitrogen. Brown grain lines, which are a typical feature of type IaB diamonds, were also observed.

A UV-visible absorption spectrum was collected using a custom-built high-resolution Avantes spectrometer equipped with four spectrometer channels and a powerful halogen light source. A strong absorption band at 595 nm was observed in the visible spectrum (figure 3). This band, rarely found in untreated yellow or brown diamonds, offered strong evidence that this diamond had been artificially irradiated to induce its brown-orange color.

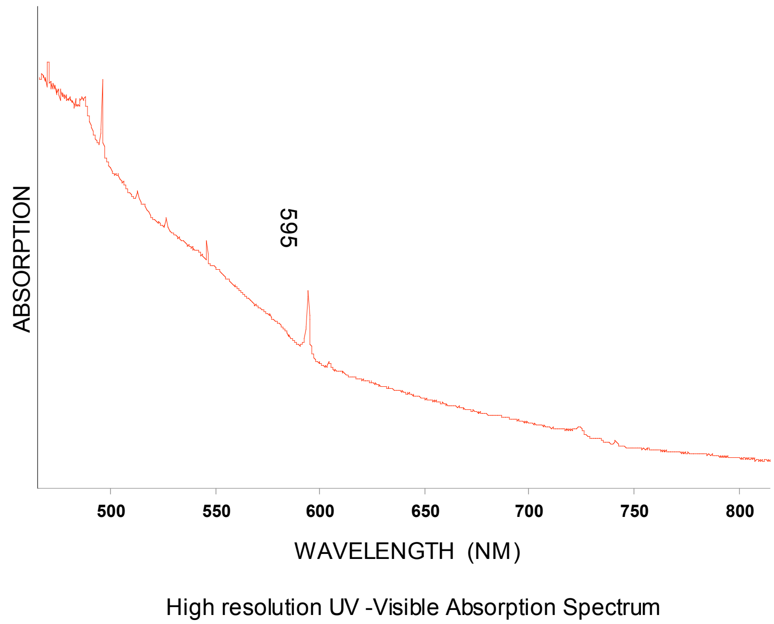

Figure 3. This high-resolution UV-visible absorption spectrum shows a strong absorption band at 595 nm.

During examination with the DiamondView instrument, the pavilion fluoresced strong blue, while the crown and girdle facets fluoresced strong green-yellow. A clear, sharp boundary separated the two zones of color (figure 4).

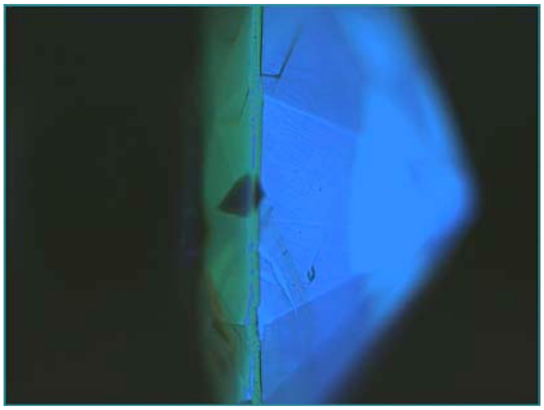

Figure 4. This DiamondView image shows the two distinct zones with different fluorescence colors.

The blue fluorescence is produced by the N3 defect (415 nm), which consists of a triangle of the three nearest-neighbor nitrogen atoms surrounding a vacancy.

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The strong green-yellow fluorescence is attributed to the H3 center (503 nm). The H3 center is a vacancy located at an A center aggregate of two nearest-neighbor nitrogen. It is typically observed in diamonds treated with irradiation and heating, but it is also responsible for natural green transmission seen in some types of diamond.

The contrasting fluorescence behavior between the pavilion facets and the table and crown facets is rarely observed in gem-quality diamonds and cannot be attributed to any natural growth process.

The observed combination of gemological and spectroscopic features strongly suggests that this diamond has been artificially irradiated and annealed. The DiamondView images indicate that the table and crown facets were exposed to the high-energy beam used during the irradiation process (figures 5 and 6), which induced the H3 defect predominantly in the table and crown facets.

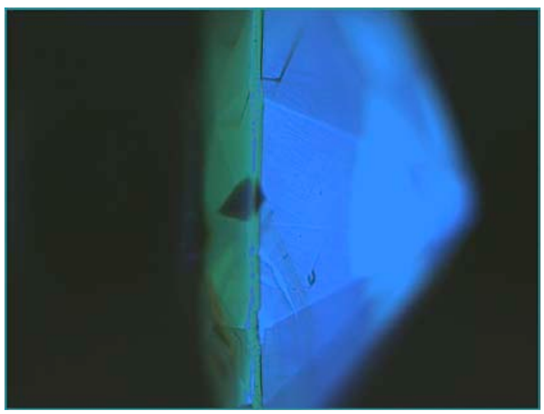

Figure 5. This DiamondView image shows the strong blue N3-inducedfluorescence of the pavilion facets and the contrasting H3-induced green-yellow fluorescence of the table and girdle facets.

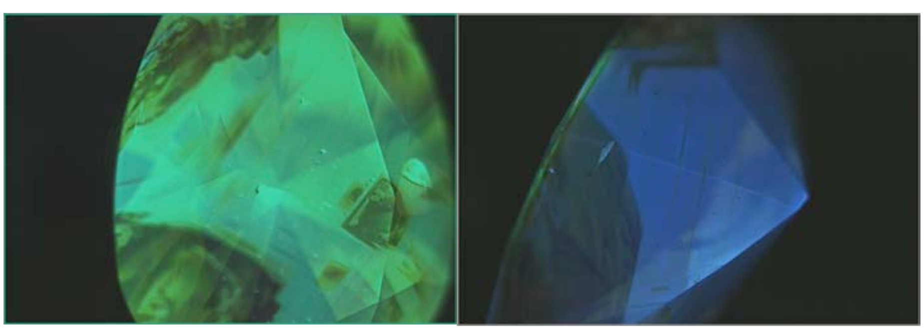

Figure 6. These DiamondView images show the yellow-green fluorescence of the table facets in contrast to the blue fluorescence of the pavilion facets. Note also the strong brown graining seen through the pavilion facets.

The H3 defect was also revealed by photoluminescence (PL) spectra taken on the table facet using 488 nm excitation (blue laser; figure 7).

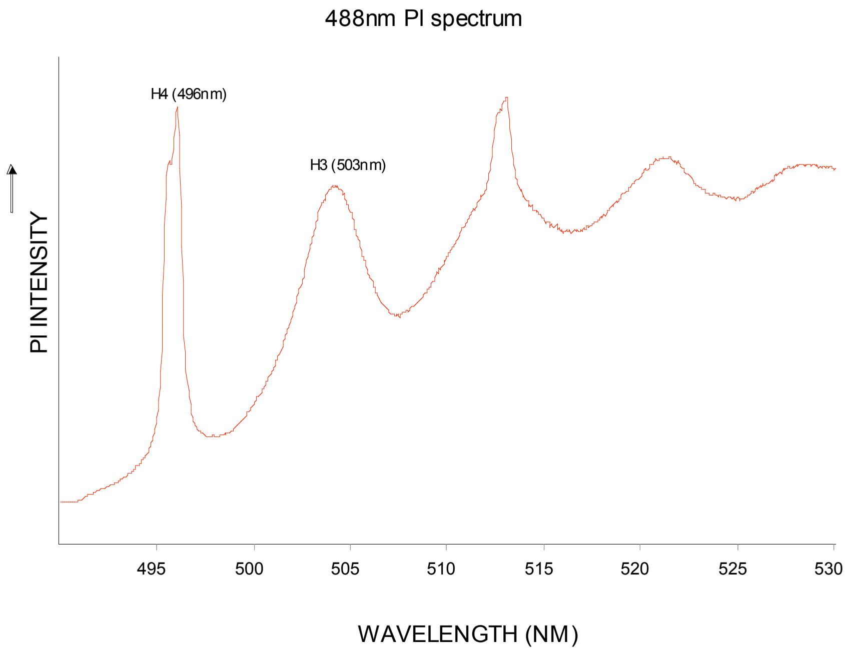

Figure 7. This 488 nm PL emission spectrum shows the H3 defect produced by irradiation.

This study demonstrated the power of the DeBeers DiamondView in rapid identification of laboratory-created defects and associated color zoning in diamonds.

The diamond in question received a GIA color grade of Fancy Deep Brown orange, with a statement of artificially irradiated color.

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