Identifying natural, treated and synthetic gem diamonds

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Correctly determining whether a gem diamond has been treated or grown in the laboratory is essential to insure integrity and stability in the jewelry industry as well as confidence among consumers. Gemological research undertaken over the past several decades has resulted in significant progress in developing practical diamond detection techniques and equipment. However, gem identification remains a challenge with new developments in diamond synthesis and treatment technologies. Efforts at GIA to develop identification criteria have required us to create an extensive database of information obtained from our examination of a vast number of gem diamonds using various non-destructive analytical techniques. This presentation will provide a current review of gem diamond identification.

Synthetic diamonds grown by the temperature-gradient technique at high pressures and temperatures (HPHT) are not often encountered today in the jewelry industry. Most synthetic diamond crystals are small (weighing less than 2 carats), cuboctahedral in shape, and yellow in color (blue and colorless synthetic diamonds are more difficult to grow as high-quality crystals). Some yellow synthetic diamonds are treated by post-growth irradiation and annealing to produce pink, red, or purple colors.

These HPHT-grown synthetic diamonds can often be distinguished from natural diamonds by one or more visual clues such as crystal shape, crystal surfaces features, internal color zoning patterns, growth banding (internal graining patterns), and ultraviolet luminescence reactions. In addition, they can contain opaque flux-metal inclusions (such as iron and nickel) from which they were grown (which sometimes cause the synthetic diamond to be attracted by a simple magnet). Non-destructive chemical analysis techniques can detect these flux metals even when large opaque metal inclusions are not present. In addition, optical centers involving nickel give rise to distinctive sharp absorption bands in the near-infrared and visible spectra.

Single-crystal brown or gray to near-colorless synthetic diamond crystals grown by the chemical vapor deposition (CVD) technique have just recently been produced in very limited
amounts in sizes (up to 1 carat) and qualities suitable for jewelry use. This material may occur as just a tabular crystal, or it may be a layer overgrowth on a natural or synthetic diamond substrate. Annealing at high pressure can often remove the brown color to produce a near-colorless synthetic diamond. Based upon our examination of a small number of samples, CVD-grown synthetic diamonds exhibit few of the diagnostic visual clues found in HPHT-grown synthetic diamonds. However, the material does display an unusual orangey-red luminescence when exposed to ultraviolet radiation with wavelengths shorter than 230 nm. In addition, several photoluminescence spectral features appear to be distinctive. Examination of this new diamond product is still underway to develop practical means of identification. CVD synthetic diamonds can be doped with boron during growth to produce a blue color, and can be treated by post-growth processes to produce additional colors.

Natural gem diamonds are sometimes treated to improve their clarity or color. A focused laser beam is used to bum an open channel from the surface of a polished diamond to a dark inclusion. Chemicals can then be introduced through this channel to lighten the appearance of the inclusion or to dissolve it. A newer technique employs one or more lasers to create or extend a surface-reaching fracture from a dark inclusion to again allow for chemicals to be introduced through the fracture to alter or remove the inclusion. The presence of large surface-reaching fractures can detract from the appearance of a faceted diamond and, in some instances, these fractures are filled with a glass with a high index of refraction. The presence of the glass filling these fractures hides their visibility.

Gem diamonds have been irradiated on a commercial basis to produce a range of colors (green and blue, and if then heated, yellow, orange, and red) since the 1950s. These treated-color diamonds can be detected by occasional color zoning that parallels the facet shape and unusual ultraviolet fluorescence, and by diagnostic features in their absorption spectra.

Recently, heating at high pressure (HPHT) has been used to remove the brown color from certain diamonds, and to change the colors of other diamonds. In some cases, evidence of this heating at very high temperatures is present in the form of heat damage to surfaces, as well as graphite formation along fractures and at inclusions. However, such visual clues are not always present, and identification of HPHT-treated diamonds requires the use of visible, infrared, and luminescence spectroscopy methods to check for distinctive spectral features. Diamonds whose colors have been changed by the HPHT method are increasing
in number. This treatment presents one of the most significant identification challenges at this time for gem-testing laboratories.

An additional identification challenge is represented today by diamonds that have been subjected to more than one treatment process (such as HPHT annealing followed by irradiation) to change their color. The combination of treatment processes can greatly complicate the gem identification procedure for colored diamonds because the features that are diagnostic of the treatment may be altered or removed by the processes. Current studies of these multi-treatment colored diamonds will help to develop identification criteria for this new material.