CURRENT RESEARCH ON DIAMONDS AT THE GEMOLOGICAL INSTITUTE OF AMERICA

Shigley, J.E.

GIA Research, Gemological Institute of America (GIA), 1660 Stewart Street, Santa Monica, CA 90404-4088, USA

By the time that diamonds enter the jewelry industry, their geological provenance is often unknown, and in most cases, it cannot easily be ascertained. As a consequence, it is usually not an important issue for most members of the jewelry trade. Gemological research on diamonds at GIA encompasses technical questions that arise from the particular needs of the jewelry industry. These questions typically revolve around several important issues, which include:

(1). what is its identity - is it a natural, synthetic, or laboratory-treated diamond?
(2). if it is faceted, what quality grade would the diamond receive on a laboratory grading report?
(3). how does the cutting style influence the diamond's appearance?

Gem diamond identification can present challenges for members of the jewelry trade for several reasons. First, the identity of any gemstone is closely related to its commercial value (which, for some natural gem diamonds, can be hundreds of thousands of dollars per carat). Second, while synthetic diamonds have so far posed little threat since they are not yet a commercial reality as gemstones, treated natural diamonds are regularly encountered in the trade. To maintain their business reputation, jewelers must (and want to) disclose identity information on the gem diamonds they sell. However, jewelers do not always have an understanding of the gemological means to identify certain treated and synthetic diamonds and other gem materials.

Establishing whether a gem diamond is a natural stone, a synthetic diamond (that is, one grown in a laboratory), or has been treated by some means (such as irradiation and heating) to alter its color or appearance, involves both basic and more advanced gemological testing equipment and procedures. The former includes examination with a microscope, photography of inclusions or other microscopic features, and documentation of basic properties such as ultraviolet fluorescence. At the GIA Research Department, the latter testing methods used for diamonds consist of visible, infrared, and luminescence spectroscopy, cathodoluminescence, energy-dispersive X-ray fluorescence (EDXRF) chemical analysis, and X-radiography. Because of the potential high

value of gemstones, all characterization techniques must be non-destructive. While some data on the gemological properties and identifying features of diamonds are available in the published literature, such information tends to be scattered, incomplete, and possibly incorrect. As a result, GIA researchers have systematically assembled a database of information, taken from both published sources and our own work, to support practical gem diamond identification.

Laboratory treatments are used to change either the appearance (i.e., clarity) or color of diamonds. Currently, the most widespread process is the one in which a transparent, glass-like material (with a high index of refraction (R.I.) similar to that of diamond) is injected into tiny surface-reaching fractures in a faceted diamond. The presence of this filler material makes the fractures much less visible. These so-called "fracture-filled" treated diamonds can be identified by the distinctive dispersion colors, displayed by the filled fractures, that can be seen using 10X magnification. The presence of this filler material, which often contains heavy elements such as Pb and Bi, can also quickly be confirmed by EDXRF chemical analysis or X-radiography of the diamond.

Treated-color diamonds (mostly, yellow, green, or blue) are also encountered. Depending upon the impurities present (mainly nitrogen), irradiation and sometimes heating can produce atomic-level defects known as color centers in the diamond. Such treated-color diamonds can often be recognized by their color, by an uneven color appearance that is related to their faceted shape, and more importantly, by specific absorption bands in their visible or infrared spectra.

Single-crystal synthetic diamonds, up to several carats in weight, are grown at high pressures and temperatures from a metal alloy flux. Over the past eight years, we have documented the distinctive gemological features of over 100 gem-quality synthetic diamonds produced by all major manufacturers. Synthetic diamonds can be recognized by features that result from the development of internal growth sectors that can contain differing impurity contents. For colored synthetic diamonds (mainly yellow; sometimes blue), these distinctive features include uneven color distribution, opaque inclusions of flux metal, and slight differences in R.I. within or between growth sectors. When these differences in R.I. can be seen in a diamond, they are described by gemologists as "graining"; in a synthetic diamond, they usually form an intersecting pattern of graining in the shape of a "funnel" or an "hourglass". These diagnostic features also include yellow to yellow-green fluorescence that is usually more intense to short-wave than to long-wave ultraviolet, and that exhibits a growth sector-related pattern. The visible and infrared spectra may display distinctive absorption bands, while chemical analysis will reveal traces of the flux metals (usually, Fe, Co, or Ni). Several synthetic diamonds with a red color due to irradiation and annealing treatment have also been reported. Colorless synthetic diamonds exhibit flux metal inclusions, unevenly distributed

yellow to green-yellow fluorescence to short-wave ultraviolet, and yellow phosphorescence that persists for as much as a minute or more once the ultraviolet lamp is turned off.

Faceted, natural gem diamonds are quality graded in terms of both their clarity and color under controlled lighting and viewing conditions. According to the GIA system, clarity grades are based on the visibility of inclusions or other features see under 10X magnification. The more common colorless-to-light yellow diamonds are color graded face-down, and are evaluated based on the relative absence of yellow color. Natural colored diamonds (i.e., pink, blue, green, intense yellow, etc.) are graded face-up depending on the relative presence of color.

Research at GIA on diamond grading has focused on issues related to color observation, such as the type of lighting, design of the viewing environment, and investigation of diamond color by visual comparison with various reference materials. In addition, efforts are currently underway to evaluate or develop instruments, such as colorimeters and spectrophotometers, that can be used for color measurement of faceted diamonds. One very important goal of these efforts is to relate visual and instrumentally measured color grades for a particular faceted diamond.

The cutting style affects the market value of a faceted diamond. We have been developing a computer graphics imaging program to model the interaction of light with a faceted diamond while taking into account all relevant physical factors. This imaging program will enable us to address questions dealing with diamond appearance and cutting style.

Diamond research at GIA is an ongoing effort to better understand the gemological properties of this most important gemstone. As diamond is the foundation of the international jewelry industry, its study continues to remain the basis of our research program as summarized here.