Synthetic Diamond Identification

Because of the contrasting conditions of natural and artificial formation, synthetic diamonds display several features which allow them to be gemologically distinguished from natural diamonds. These include visual characteristics such as color zoning, dark metallic inclusions, weak strain patterns and distinctive patterns and colors of ultraviolet fluorescence. Because they represent types of diamonds that are rare in nature, synthetic diamonds also possess additional features that can be detected with gemological instruments.

Decades of research, in addition to the use and development of advanced scientific instrumentation, enable GIA to accurately identify synthetic diamonds. GIA's Diamond Check™ and recent introduction of a fully automated Melee Analysis Service allow for fast and accurate separation of loose natural diamonds from loose synthetics and simulants. The challenge to develop a similar method for analysis of mounted stones is more complex due to coverage from metal settings.

Information on synthetic diamond identification has been published extensively in GIA's peer-reviewed *Gems & Gemology* over the last 30 years.

About GIA

Established in 1931, GIA has studied the scientific properties of gems, developing new methods of identifying natural, synthetic and treated gemstones. This research serves to protect all who buy and sell gems by ensuring accurate and unbiased standards for determining and describing gem quality. GIA research findings are incorporated into its educational programs, published in professional journals, used for developing practical instruments and tools and applied in grading and identification services every day.

To learn more about diamond identification and GIA laboratory services, and to view past issues of *Gems & Gemology*, visit **GIA.edu**

The World's Foremost Authority in Gemology™

Front cover image: Natural diamond (top), synthetic diamond (middle) and diamond simulant (bottom).

Distinguishing Natural Diamonds from Synthetic Diamonds and Diamond Simulants

GIA®

Knowing the Difference

Natural diamonds have long fascinated mankind with their unique physical and visual properties. Features such as exceptional hardness, durability, light reflectivity (brilliance) and dispersion (fire) distinguish them from other gems. The beauty and universal appeal of natural diamonds come at a price, as the recovery and fashioning of such rare gems are challenging. For decades, researchers have sought alternatives by creating less expensive "look-alikes" in the form of simulants and, more recently, "duplicates" with synthetic diamonds. Though such attempts by man to recreate the properties and structure of natural diamonds are nothing new, a rapid increase in synthetic diamond growth technology over the past decade has led to real concerns regarding their identification.

Fortunately, GIA has followed the developments of synthetic diamonds for more than 60 years. This continuum—combined with fundamental research on tens of millions of natural diamonds—allows GIA to accurately identify synthetic diamonds.

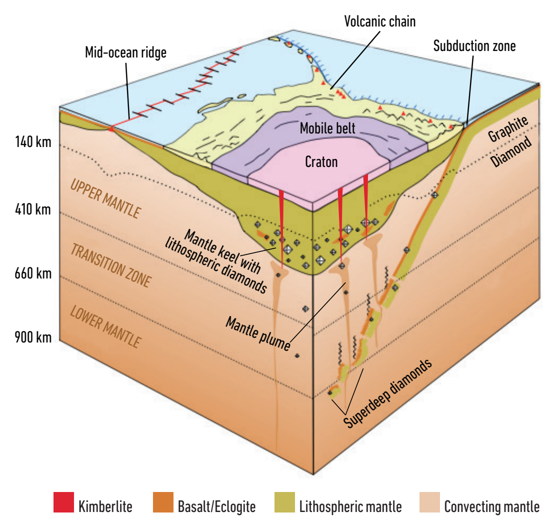
In order to protect yourself and your clients against misrepresentations and misconceptions surrounding natural diamonds, synthetic diamonds, and diamond simulants, it is important that you understand the differences among them and the means of their identification.

Unlike diamond simulants, which can be recognized by using standard gem testing, synthetic diamonds have essentially the same chemical composition and crystal structure as natural diamonds, but are made in laboratories—not grown in the earth. Because their optical and physical properties are nearly identical to natural diamonds', identifying synthetic diamonds is complex. However, because of their artificial growth environments, synthetic diamonds exhibit several diagnostic features that allow for their detection in gemological laboratories.

Natural Diamonds

Natural diamonds are a wonder of science, as they occur only when atoms of carbon are exposed to high pressures and temperatures about 100 miles (160 kilometers) below the earth's surface in what geologists call the upper mantle. Diamond crystals reside in these extreme mantle conditions for millions of years. The crystals that grow under these conditions have a unique structure we associate with natural diamonds.

Natural diamond crystals sometimes incorporate solid small inclusions of diamonds or other minerals into their structure as they grow. While mineral inclusions are often considered a negative clarity feature in a polished diamond, they are of tremendous value to geoscientists. Natural diamonds provide a way for these mineral inclusions to be preserved and brought to the earth's surface where they can be scientifically studied. Because certain inclusions contain radioactive elements that decay at a known rate, the minerals can also be used to calculate the age of diamond formation.



This block diagram depicts the basic relationship between a continental craton, its lithospheric mantle keel, and diamond stability regions in the keel and the convecting mantle. Under the right conditions of low oxidation, diamonds can form in the convecting mantle, the subducting slab, and in the majority of cases, in the mantle keel.

Courtesy: Steven B. Shirey, modified from R. Tappert and M.C. Tappert, Diamonds in Nature: A Guide to Rough Diamonds *(2011)*

Following their extended time in residence in the mantle, some diamonds are brought to the earth's surface by volcanic eruptions of kimberlite magma. Geologists believe that the diamonds are transported by the magma very quickly over the 100-mile distance (in just a week or more), so that the diamonds are not physically changed in the process and transformed to graphite. During this rapid upward journey, the diamond crystal can, however, break along cleavage directions, and undergo other changes that may affect, for example, its color.

A natural diamond is a gift from the earth. A cutter carefully examines the rough before polishing to a finished gem of optimal beauty.

Courtesy: Aftergut N. & Zonen. Antwerp, Belgium

Natural Diamond

Synthetic Diamonds

Although their use for jewelry purposes is a somewhat recent occurrence, **synthetic diamonds** have been produced for industrial applications since the 1950s. Unlike natural diamonds, synthetic diamonds are grown in laboratories, over a very short period of time – likely just two or three weeks (or less). A longer growth period results in larger crystals; however, steady environmental conditions must be maintained to ensure the formation of high-quality crystals. Currently, the production of synthetic diamonds in melee sizes is what is most encountered. The drastically shorter growth period of synthetic diamonds results in features that are of diagnostic value in separating them from natural diamonds.

Two artificial growth methods are used to create synthetic diamonds: HPHT and CVD. HPHT (high pressure/high temperature) synthesis, developed in the 1950s, uses high temperatures and pressures, a molten metal flux and a diamond seed to initiate crystal formation. The result is a distinctive crystal shape which is a combination of octahedral and cube faces and a flat base. The HPHT process more closely mirrors the conditions of natural diamond formation than CVD.

The CVD (chemical vapor deposition) method, which was mostly developed during the past decade, produces diamonds through the use of low pressures and high temperatures in a vacuum chamber. A carbon-containing gas such as methane is introduced into the chamber, and gas molecules break down there into the constituent atoms. The carbon atoms "rain" down onto flat diamond seed plates, resulting in a square-shaped, tabular synthetic diamond crystal.

Rough colorless HPHT synthetic crystals.

Synthetic Diamond

Diamond Simulants

Various materials have been used as imitations or substitutes for diamonds since ancient times. These materials, often referred to as **diamond simulants**, may grow naturally in the earth or artificially in a lab. Years ago, the colorless varieties of some colored stones (i.e., quartz) were used to simulate diamond. Today, the most common simulants are cubic zirconia (zirconium oxide, or CZ), and to a lesser extent, synthetic moissanite (silicon carbide). Because simulants differ completely from diamond, they display diagnostic properties by which they can be recognized with standard gem testing techniques, observations under magnification and commercially available "diamond testers."

Diamond simulants, from top (left to right): Strontium titanate, synthetic spinel, synthetic rutile, yttrium aluminum garnet (YAG), zirconium oxide (CZ), zircon.

Cubic Zirconia