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ALPHA DIAMOND ANALYZER

Diamond detection and **type screening** instrument

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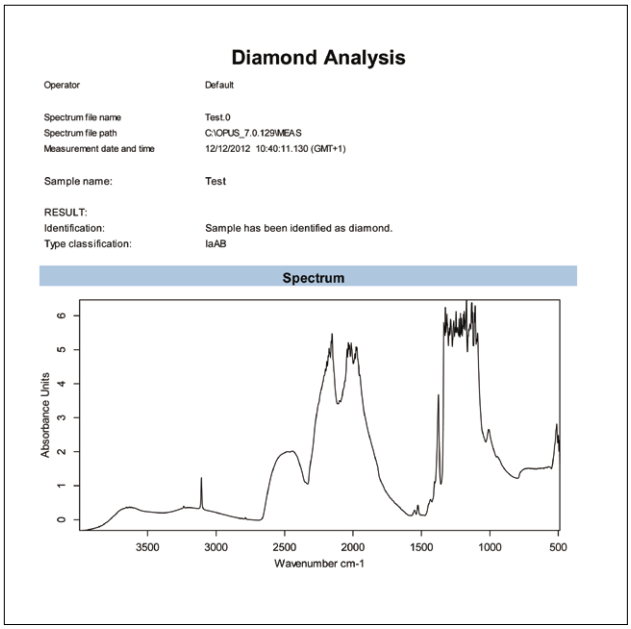
Robust gem **diamond detection** and **type screening** instrument

ALPHA Diamond Analyzer, your solution for

- **Diamond detection**
- **Diamond type classification**
- **Screening HPHT-colour enhanced colourless diamonds**
- **Screening lab-grown colourless diamonds**

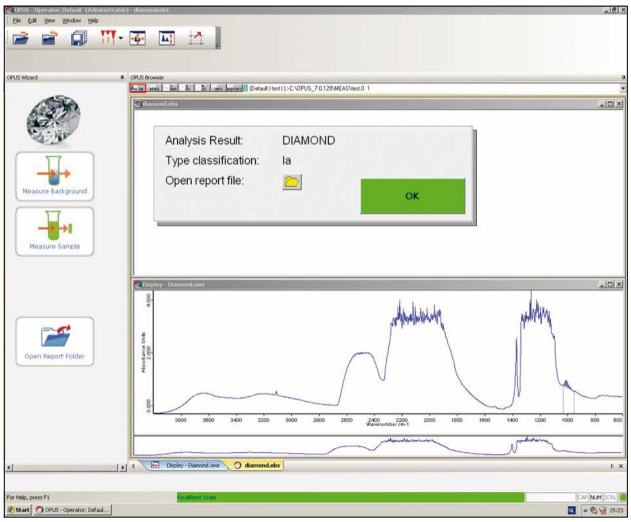
The ALPHA Diamond Analyzer allows you to classify any diamond within a minute, and is easy to use.

The ALPHA Diamond Analyzer has been designed to perform reliable diamond detection and type screening, which helps you to boost up consumer confidence. First of all, it distinguishes diamonds from imitations or other precious gemstones. In addition, its accurate and reliable determination of the diamond type allows you to select potentially HPHT treated or lab-grown colourless diamonds for further testing. Finally, the ALPHA Diamond Analyzer helps you to identify diamond types, and consequently, to create the highest added value in gem diamond sorting and valuing.



How does it work?

The ALPHA Diamond Analyzer uses Fourier Transform Infrared (FT-IR) absorption spectroscopy, an established optical technique used to obtain molecular information from a gemstone. The analysis is performed contact-free, within less than 60 seconds. As the measured FT-IR spectrum is directly related to the chemical structure and composition of the gemstone, it gives a reliable differentiation between diamonds and imitations. Impurities within the diamonds (nitrogen and boron) give unique signatures in the FT-IR spectrum, which can be used for classification of the different types of diamonds.



The ALPHA Diamond Analyzer facilitates FT-IR analysis on a gemstone. Guided by intuitive software, the user brings the stone into position and performs the measurement. Then, with the aid of an internal evaluation method, the analysis of the gemstone spectrum is performed fully automated. Finally, the result of the analysis is presented in a clear pdf report file.

What can infrared spectroscopy do for you?

Introduction

One of the traditional techniques used to differentiate diamonds from imitations and other precious stones is Fourier Transform Infrared (FT-IR) Absorption Spectroscopy. It is also used to classify the different types of diamonds based on impurities (nitrogen and boron). Up till now, traditional FT-IR technology has included sophisticated research-grade spectrometers. Hence, the interpretation and analysis of the FT-IR data were highly depended on experienced laboratory staff.

Today, the ALPHA Diamond Analyzer offers an automated, easy to use and dedicated solution for diamond detection and type analysis based on the FT-IR method. It distinguishes diamonds from imitations or other precious gemstones using the FT-IR diffuse reflectance method.

FT-IR spectra of diamond

Diamond shows characteristic absorption features in the mid-infrared range of the electromagnetic spectrum (4000-400 cm^{-1}). In diamond, there are intrinsic absorptions which are referred to as two-phonon (2665 to 1332 cm^{-1}) and three-phonon (4000 to 2665 cm^{-1}) bands. These absorption bands are characteristic for all diamonds. The most common diamond imitations are cubic zirconia (ZrO_2) and moissanite (SiC).

Figure 1 shows the FT-IR spectra of a natural diamond, cubic zirconia and moissanite. The differences between these specific spectral patterns are obvious.

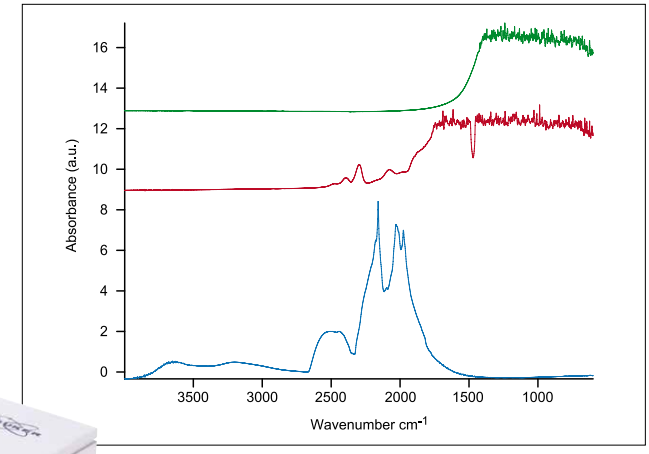


Figure 1: FT-IR spectra of a natural diamond (blue curve), cubic zirconia (green curve) and moissanite (red curve).

What you need to know about diamond types

The region in FT-IR spectra between 1332 cm^{-1} to 900 cm^{-1}, referred to as the one-phonon region, is where nitrogen impurities can produce characteristic features. As nitrogen is the most abundant atomic impurity in a diamond, the type classification scheme has been developed based on its presence. Type I diamonds contain detectable levels of nitrogen using FT-IR methods, while type II diamonds are classified as diamonds with no detectable nitrogen.

Type I diamonds

Diamonds containing nitrogen (Type I diamonds) are estimated to have an abundance of roughly 98% in the natural diamond population worldwide. Type I diamonds are divided into type Ia and type Ib, depending on how the nitrogen impurities are arranged. When the nitrogen atoms are grouped in aggregates, the diamonds are referred to as type Ia diamonds. When the nitrogen atoms remain isolated, the diamonds are of type Ib.

Figure 2 shows the one-phonon region of FT-IR spectra illustrating the different stages of nitrogen aggregation from single isolated nitrogen atoms, also known as C-centres, (detected at ~1344 cm^{-1} and ~1130 cm^{-1}), to A-aggregates, groups of 2 nitrogen atoms (detected at ~1282 cm^{-1}) and B-aggregates, groups of 4 nitrogen atoms surrounding a vacancy (detected at ~1175 cm^{-1}). They refer to the natural diamond types Ib, IaA and IaB respectively. When saturation due to nitrogen impurities occurs in the one-phonon region and A- and B-aggregates cannot be identified separately, the diamond is classified as a type Ia diamond.

Type II diamonds

Type I I diamonds are considered as the purest form of diamond from an atomic point of view. Type II diamonds are subdivided into types IIa and IIb. Type IIa diamonds do not contain any detectable nitrogen or boron using FT-IR methods. This group is very rare in nature (approximately 1% to 2% of all diamonds). Type IIb diamonds (< 0.1% of all diamonds) have substitutional boron atoms in the crystal lattice. As a result, these diamonds are blue, although they can also be brown and grey to near-colourless.

A schematic diagram illustrating "pure" type I and II diamonds is shown in Figure 3.

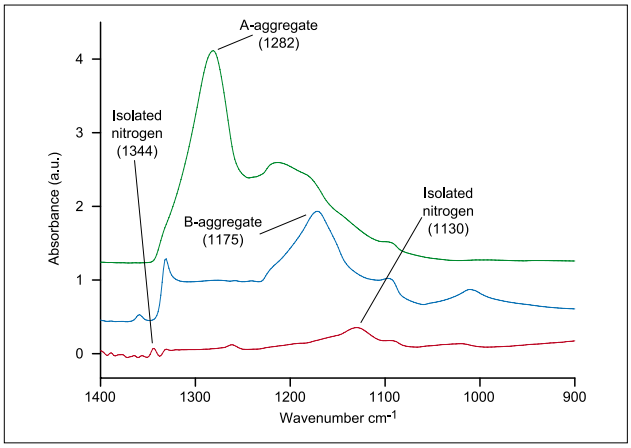


Figure 2: Nitrogen impurities in diamond. The characteristic features in the one-phonon region (1332 cm^{-1} to 900 cm^{-1}) of A- and B-aggregates and C-centres are indicated.

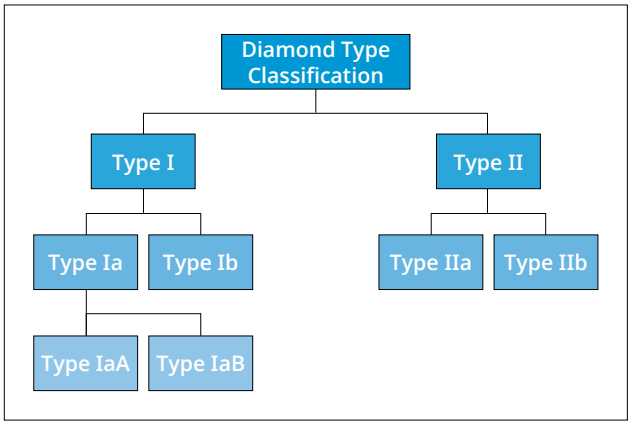


Figure 3: Diamond type classification is based on the presence or absence of nitrogen and boron impurities and their specific configurations in the diamond lattice. Note that this diagram only shows "pure" diamond types. Note that most diamonds are of mixed types.

How to benefit from diamond type?

The diamond type classification scheme not only provides a useful way to classify diamonds, it can do much more. The type of a diamond also provides valuable information on its history. This may refer to the geologic conditions to which natural diamonds have been exposed in the earth or to the laboratory conditions during treatment or synthesis.

In recent years, the production and the quality of lab-grown gem diamonds have increased dramatically. In particular, significant developments in the chemical vapour deposition (CVD) method have led to the introduction of high quality (near-)colourless and good clarity CVD lab-grown diamonds in the gem market. CVD synthetic diamonds are most commonly of type IIa.

Lab-grown diamonds can also be grown with the High Pressure High Temperature (HPHT) method. Since the seventies, gem quality diamonds have been produced by HPHT synthesis. The majority of these stones are coloured bright yellow to orange due to the presence of nitrogen atoms in the lattice. However, it is possible to grow colourless HPHT lab-grown type IIa diamonds but technical problems make them practically absent on the diamond market. All known colourless to near-colourless CVD or HPHT lab-grown diamonds are of type IIa.

In addition, it is well known that brownish type II diamonds can be HPHT treated to reduce or remove the brown colour component, making them appear colourless. Note that natural type IaB diamonds can be HPHT treated to enhance the colour or to make them more colourless.

Screening guide for colourless to near colourless diamonds

Diamond Type	Natural	Lab grown	HPHT enhanced
Type Ia	Yes	No	No
Type IaB	Yes	No	Yes
Type IIa	Yes	Yes	Yes

Table 1: Occurence colourless to near-colourless diamonds in relation to the diamond type.

In Table 1 the occurrence of natural, lab grown and HPHT enhanced colourless and near-colourless diamonds in relation to the diamond type is summarized. For the final conclusion on the origin of the diamond (natural or lab grown) and the origin of the colour (natural or HPHT treated), all colourless type II and IaB diamonds have to be submitted to a reputable lab for further testing. Moreover, fancy colour diamonds should always be submitted to a reputable laboratory for examination.

Furthermore, it is possible to produce attractive blue type IIb diamonds using the HPHT and CVD growth techniques. The HPHT treatment may produce pink and blue colours in some type IIa and type IIb diamonds respectively.

Therefore, the identification of the diamond type is critical. With the increasing availability and complexity of treated and lab-grown diamonds, all stakeholders (from diamond exploration to diamond sorting, diamond traders and diamonds labs) will benefit from an adequate identification of the diamond type, enhancing consumer confidence.

ALPHA Diamond Analyzer, your tool for

- **Enhancing consumer confidence**
- **Creating the highest added value in gem sorting and valuing**

Significant economic implications are at stake when considering type II diamonds. It is known that type II diamonds can be highly valued, frequently receiving the best colour and clarity grading. Moreover, most large diamonds such as the Cullinan and the Koh-I-Noor are type II diamonds. This is in distinct contrast to their low global incidence of only 1% to 2% in smaller sizes. Therefore, the presence or absence of type II diamonds can be a critical factor in the sorting and valuing of diamond parcels or in mining a diamond deposit.

ALPHA DIAMOND ANALYZER

Robust, **Reliable** and **Easy!**

What you need to know about your Alpha Diamond Analyzer

The key features of Alpha Diamond Analyzer

- Automated diamond detection and type classification
- Reliable results within a minute
- Reliable detection of common diamond imitations
- Applicable to any colour
- Wide range of shapes and sizes
- Easy to use:
  - no sample preparation
  - workflow guided by dedicated software
  - automatic generation of analysis report
  - can be used everywhere
- Low running costs

Alpha Diamond Analyzer characteristics

- Dedicated ALPHA FT-IR spectrometer
- Compact Dimensions 22 x 30 x 25 cm (wxdxh)
- Light weight (7 kg)
- Robust design, solid metal housing
- Autonomous operation using battery pack (option)

The benefits of Alpha Diamond Analyzer

- High customer confidence through reliable diamond detection and type screening
- Selection of possibly HPHT treated or lab-grown colourless diamonds
- Reliable sorting and valuing of polished diamonds

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