Attention: this version has been completed with Google Translate, it certainly contains errors or inaccuracies.

The Polariscope (gemological)

Name and Appearance	(**Italian** - Polariscopio) (**English** – Polariscope) (**French** - Polariscope) (**Spanish** - Polariscopio) (**Portuguese** - Polariscópio) (**Thai** - โพลาริสโคป (Polariscop) (***German*** - Polarisationsmikroskop) (**Arabic** - بولاريسكوب Polariscope) (**Russian** - Поляризационный микроскоп) (**Mandarin** -偏光显微镜 (Piān G uāng X iǎn W ēi J ìng) (**Swahili** - Polariskopi) (**Hindi** - पोलारीस्कोप (Polariscope)	**Photo** 
History	The polariscope is a device used in gemology to identify the optical properties of gemstones. Its history dates back to the early 19th century, when the French physicist Étienne-Louis Malus discovered the phenomenon of polarization by studying the reflection of light on a surface. In 1810, he invented the first polariscope, used to analyze polarized light passing through various materials. The polariscope was invented in 1811 by the **French physicist Étienne-Louis Malus** , who discovered the polarization of light. The polariscope was originally used to study the behavior of light rays, but over the years it has been developed for use **in gemology to identify the presence of single or double refraction** in a gemstone. Malus discovered the phenomenon of light polarization through his studies **of light interference** . The polariscope consists of **two calcite prisms** set in a holder so as to allow rotation of one of the prisms with respect to the other. The light passes through the first prism, called **a polarizer** , which polarizes the light in a single direction. The polarized light then passes through the sample to be analyzed and then through the second prism, called **the analyzer** , which is positioned so that **it can be rotated** . The amount of light passing through the second prism varies with the angle of rotation of the prism, and this variation can be used to determine the optical properties of the sample. Later in **1812 , Scottish** mathematician and physicist Sir David Brewster developed the first **hand-held polariscope** , which was used to identify the optical properties **of minerals and crystals** . His polariscope consisted of two polarizing filters arranged in a tube, which allowed the user to view the optical properties of the gem under examination. In **1860** , German mineralogist **August F. Köhler** developed the Köhler polariscope, which was an improved version of the Brewster polariscope. Köhler's polariscope was able to measure both **the double refraction** and **the birefringence** of gemstones. This innovation made it possible to distinguish between natural and synthetic gems. The first **gemological polariscope** was invented in **1892** by the French gemologist **Emile Bertrand.** However, his device was rather bulky and unwieldy compared to modern gemological polariscopes In the early 20th century, French mineralogist and **physicist Alfred Lacroix** invented the **conoscopic polariscope** , which is still widely used in gemology today. This polariscope consists of a light source, polarizing filters, and a quartz wedge that can be rotated to observe the interference patterns of the gem under examination. The invention and evolution of the polariscope revolutionized the field of gemology. By studying the optical properties of gemstones, gemologists are able to identify natural versus	

	synthetic gemstones, as well as determine the quality and value of a gemstone based on its optical properties. In the field of gemology, the polariscope was first used **in the 1930s** to identify gemstones. The gemological polariscope was developed to have greater precision in measurements than the general polariscope, and consists of **a series of polarized filters** and a rotatable analyzer to determine the optical properties of a gemstone. The gemological polariscope has become a vital tool for gemologists and jewelers to identify gemstones, as each gemstone has unique optical properties that can be identified through analysis of the polarization of light through it. Over time, the gemological polariscope has been further improved with the addition of other features, such as the ability to measure the hardness and density of gemstones.
Reference scientific laws	**Polarized light** The discovery of polarized light was the result of the work of many scientists and their studies on the interference and diffraction of light. The first to observe the phenomenon of polarization of light was the French physicist Étienne-Louis Malus in **1808** , who discovered that light reflected from a transparent surface becomes polarized when the angle of incidence is 57.5 degrees from the normal . In **1811** , Malus also discovered that **the angle of refraction of polarized light** is different from that of unpolarized light. In **1828** , French mathematician and physicist **Augustin-Jean Fresnel** developed a **mathematical theory to describe the polarization** of light and proposed the existence of transverse light waves that vibrate only in one direction. In **1852** , English physicist **William Rowan Hamilton** developed a **mathematical theory to describe the propagation of polarized light through an anisotropic medium** , such as calcite crystals, which led to the development of the polariscope. In **1877** , French physicist Éleuthère Mascart demonstrated that circular polarization of light can be produced using **a Fresnel prism** , also called a Nicol prism. In **1892** , German physicist **Wilhelm Röntgen** discovered **X-rays** using a vacuum tube and a fluorescent detector, which is based on the polarization of the light emitted by X-rays. In **1905** , the German physicist **Albert Einstein explained the polarization** of light using **his theory of relativity** , which led to the development of new technologies such as the microwave oscillator. Also, **in the field of gemology, the polariscope was first used in the 1930s** to identify gemstones, as described in the previous answer. **Single and double refractive index, birefringence and optical character** Birefringence is an optical property of anisotropic gemstones, i.e. those stones that have a crystalline structure that is not symmetrical in all directions. Birefringence means that light splits into two beams as it passes through the crystal, each beam traveling at a different speed. This effect is known as double refraction. **Anisotropic gemstones** that exhibit **double refraction are called "birefringent stones"** (those that do not exhibit this phenomenon are called **isotropic**) **.** Birefringence is an important optical characteristic for identifying and distinguishing gemstones. For example, diamond, which has a symmetrical cubic crystal structure, has no birefringence, while stones such as quartz, tourmaline, and sapphire exhibit birefringence. In general, **birefringent stones** can be classified into two categories: uniaxial stones and biaxial stones. Uniaxial stones have an optical axis, i.e. a direction in which double refraction does not occur, and they have two different refractive indices for rays polarized perpendicularly and parallel to the optical axis. Biaxial stones, on the other hand, have two optical axes and three different refractive indices. **The optical character of birefringent stones** can affect their brightness and coloration. For example, in the case of tourmaline, birefringence can cause bands of color to separate, creating the optical effect known as pleochroism. Additionally, double refraction can affect the stone's clarity and brilliance, as well as its scratch resistance.
	Polarized light has many practical applications in several areas, including: Optical Technologies: Polarized light is used to create polarized filters used in sunglasses, computer screens, cameras, and cell phones.

Medicine : Polarized light is used in microscopy to study the properties of biological cells and tissues, as well as in laser surgery.
Communications : Polarized light is used in optical fibers to transmit information over long distances.
Gemology : The gemological polariscope, described in the previous answer, uses the polarization of light to identify gemstones.
Physics : Polarized light has been used in several physical discoveries and theories, such as the discovery of X-rays and Einstein's theory of relativity.

Usage

Limitations

The use of the polariscope in gemology can have some limitations, including:

- The ability to determine only the optical character of the stone, but not its specific identity or chemical properties.
- The need for a good knowledge of the theory of optics and the characteristics of each single precious stone to correctly interpret the observed optical figures.
- The difficulty of distinguishing between stones with similar optical properties but different interference characters, thus requiring further testing.
- The possible presence of inclusions or internal defects in the stone that can affect the optical figures observed.
- The limitation in observing stones that are too small or too large to be placed correctly on the polariscope stand.
- The influence of external lighting on the reading of optical figures, which requires the use of an adequately lit and glare-free work environment.

How to use

- Here are the steps for using a polariscope to determine whether a gemstone has single (SR), double (DR), or anomalously double (ADR) refractivity:
- Turn on the polariscope and make sure the two polarizing lenses are aligned so that light can pass through both lenses.
- Place the gemstone on the polariscope table so that light can pass through it.
- Look through the eyepiece and observe the stone. Initially, the stone will appear to be illuminated by a uniform white light.
- Slowly rotate the stone on the polariscope table. As the stone rotates, the light passing through it will begin to change color and intensity.
- Observe the way the light behaves when the stone is rotated. If the stone has single refraction, the light will pass through the stone evenly and will not change color or intensity as the stone is rotated.
- If the stone has double refraction, the light passing through it will separate into two beams when the stone is rotated, creating a double image effect. These images can appear as two separate bright spots or as overlapping images with different colors.
- If the stone has anomalously double refraction, the light passing through it will split into three or more rays when the stone is rotated, creating an effect of multiple superimposed images with different colors.
- To confirm the nature of the stone's refractivity, a knowledge filter (Chelsea filter) or a monochromatic light source can also be used, which will highlight any additional optical properties of the stone.
- This process can help identify the nature of the gemstones' refractivity, which is an important characteristic in their identification and evaluation.

SR, DR and ADR

- The different optical figures that can be observed through a polariscope include:
- Uniaxial Negative: Gemstones that have a lower refractive index than the others. They produce a single dark cross that rotates as the gem is rotated. Examples include tourmaline and topaz.

- Uniaxial Positive: Gemstones that have a higher refractive index than the others. They produce a single glowing cross that rotates as the gem is rotated. Examples include garnet and zircon.
- Biaxial: Gems that have two different refractive indices that vary according to the direction of light passing through them. They produce a series of interference patterns that change as the gem is rotated. Examples include peridot and apatite.
- In addition to determining the optical character of the gem, the polariscope can also be used to identify double refraction (DR), single refraction (SR), and anomalous double refraction (ADR) in gemstones.
- To determine DR, place the gem on the polariscope table and view it through the analyzer filter by rotating it 360 degrees. If the gem produces two distinct images, it is double refractive.

- To determine SR, place the gem on the polariscope table and view it through the analyzer filter by rotating it 360 degrees. If the gem produces a single continuous image, it is a single refraction.
- To determine ADR, place the gemstone on the polariscope table and view it through the analyzer filter by rotating it 360 degrees. If the gem produces an interference pattern that changes as the gem is rotated, it is an anomalous double refraction.
- The polariscope can aid in the determination of the presence of double refraction in a gemstone, but cannot be used by itself to determine the authenticity or quality of a stone. It is necessary to use other assessment tools and methods.

Optical figures

- When using the gemological polariscope to determine the **optical character of a gemstone** , certain optical figures may be observed. These optical figures can help identify the nature of the stone's refraction. Here are the most common optical figures that can be observed:
- **Isochromy** : This optical figure occurs when the gemstone has a single refractivity. When the stone is rotated in the polariscope, the light passes through the stone evenly and does not change color or intensity.
- **Interference Patterns** : These optical patterns occur when the gemstone has double or anomalous double refractivity. When the stone is rotated in the polariscope, the light passing through it separates into two or more beams which overlap and create a double image effect. These images can appear as two separate bright spots or as overlapping images with different colors.
- **Becke figures** : These optical figures occur when the gemstone has double or anomalous double refractivity. When the stone is rotated in the polariscope, the light passing through it splits into two or more beams which overlap and create a double image effect. These images can appear as two separate bright spots or as overlapping images with different colors. Becke figures are distinguished from interference figures by having a more complex and symmetrical shape.
- **Uniaxiality and Biaxiality figures** : These optical figures occur when the gemstone has double or anomalously double refractivity. When the stone is rotated in the polariscope, the light passing through it splits into two or more beams which overlap and create a double image effect. The optical figure that can be observed depends on the type of double refraction of the stone. If the stone has a double uniaxial refraction, the optical figure will have a circular or elliptical shape. If the stone has a double biaxial refraction, the optical figure will have a more complex and symmetrical shape.
- These optical figures can be very useful in identifying the nature of the refractive nature of gemstones and in distinguishing between stones with different optical properties.

Stress lines in the diamond

- To read the stress lines within a diamond with a gemological polariscope, one must position the diamond between the two lenses of the polariscope, so that polarized light passes through the diamond. At this point, the diamond must be rotated and the optical figure that forms through the polariscope lenses must be observed.

	• Stress lines appear as thin dark or black lines that extend inside the diamond. These lines are formed due to the stresses that have occurred during the formation of the diamond. Stress lines can be caused by inclusions, microcracks or other imperfections within the diamond. • To read the stress lines, one must observe the optical pattern while rotating the diamond. As you rotate the diamond, the stress lines appear as dark or black bands moving across the diamond. Sometimes, stress lines may form a "V" or "X" shape within the diamond. • Observing the stress lines within a diamond can provide important information about its history and quality. Stress lines can indicate the presence of inclusions or microcracks that can affect the strength and beauty of the diamond. In general, diamonds with fewer stress lines are considered to be of higher quality than those with many lines.
Accessories	**Test fork :** it is an optional accessory that can be connected to the base of the polariscope and which allows you to test the hardness of the stone. **Cold light lamp** : it is a lamp that emits cold and uniform light, which can be used to illuminate the stone during observation. **Diffuser** : it is an optional accessory that can be placed on the cold light lamp to spread the light more evenly on the stone. **Microscope** : it is an optional accessory that can be connected to the upper part of the polariscope and which allows you to observe the stone in detail. **Tweezers** : These are clamp-like tools that can be used to manipulate the stone while examining it with the polariscope. **Testing liquids** : These are special liquids used to determine the optical properties of the stone, such as the refractive index.
Precautions	The use of the gemological polariscope requires some precautions to guarantee the safety of the device and the correct reading of the optical figures of the precious stones. Some of the necessary precautions include: Avoid exposing the polariscope to **sources of heat** or humidity and handle it with care to avoid damage to the parts of the device. Use only **clean and dry gemstones** to avoid distortion or interference in optical figures. Make sure you have **good ambient lighting** and avoid reflections on the stone surface when observing. **Never force** the polariscope parts or gemstones when inserting or removing them from the device. **Use polariscope accessories correctly** and only when necessary to avoid damage to device parts or gemstones. **clean** the polariscope and accessories to avoid the accumulation of dust or debris that could interfere with the reading of the optical figures. **Do not use** the polariscope continuously **for extended periods** to avoid overheating of the device. **close** the polariscope after use to avoid the accumulation of dust or moisture inside the device parts.
Set off	Parts of the gemological polariscope: **Base** - This is the bottom part of the polariscope and is designed to provide stability to the instrument during use. **Top Mount** : This is the top of the polariscope and is designed to hold the polarizing filter. **Polarizing Filter** : This is a special filter that polarizes the light entering the polariscope. This filter is located at the top of the polariscope. **Knowledge Prism** : This is a glass prism that is used to provide uniform illumination to the stone being examined. **Objective** : it is the objective through which the stone is observed. It usually consists of two polarizing lenses set in a metal tube. **Rotating wheel** : it is a wheel that can be turned manually to rotate the stone and observe the optical figures generated by the polariscope.

	Support stone : it is a small platform that is located in the center of the polariscope and serves to support the stone being examined.
Unit of measure	The Polariscope is normally used to determine if a stone is single refractive (SR), double refractive (DR) and single abnormally reacting (ADR)
Types	There are **different types of gemological polariscope on the market** , with different characteristics depending on the model and manufacturer. The first models of gemological polariscope consisted of two nicol prisms mounted on a wooden or metal base, with an opening for inserting the gemstone. These models were very simple but effective in determining the optical character of gemstones. Subsequently, more advanced gemological polariscopes were developed, equipped with additional accessories and functions to improve accuracy and ease of use. Some examples include: **Gemological polariscopes with Bertrand filter** : These models of gemological polariscope are equipped with a Bertrand filter, which allows the angle of interference of precious stones to be observed and measured with greater precision. **Gemological Polariscopes with LED Lighting** : These gemological polariscope models use an LED light source, which provides higher brightness and better color rendering than traditional incandescent lighting. **Gemological polariscopes with polarization analyzer** : These models of gemological polariscope are equipped with a polarization analyzer, which allows the optical character of gemstones to be determined more precisely. **Gemological polariscopes with heating** : These models of gemological polariscopes are equipped with a heating function, which allows to eliminate the internal tensions of the precious stones and to improve the legibility of the optical figures. **Portable gemological polariscopes** : These models of gemological polariscopes are compact and light, and are designed for use on the move or on small stones. In general, newer gemological polariscopes are characterized by greater accuracy, versatility and ease of use than older models.
Famous models	Here are some brands of gemological polariscopes on the market. Here are some of the more well-known brands and their approximate price: **BelOMO** - The average price of a BelOMO gemological polariscope is around 150-200 euros. **GIA** - The Gemological Institute of America produces a high quality gemological polariscope, with a price ranging from 600 to 800 US dollars. **Eurotool** - A mid-range Eurotool gemological polariscope can be purchased starting at around 150 euros. Presidium - The average price of a Presidium gemological polariscope is around 300-400 euros. **GemOro** - The average price of a GemOro gemological polariscope varies between 200 and 500 US dollars, depending on the model and available functions. However, it's important to note that prices may vary depending on the model, manufacturer, and available features.
Innovation	The prospects for the development of gemological polariscopes in the coming years could mainly concern the technology used for the production of the instruments and the integration of new functions. For example, **stronger and lighter materials could be used to improve the reliability and handling of the device** . **new features** could be implemented to simplify the use of the polariscope and improve the accuracy of the measurements. For example, spectroscopic or **photometric analysis tools could be integrated** to identify the properties of gemstones even more accurately. Finally, a further evolution could concern the integration of gemological polariscopes with **other technologies** , such as **artificial intelligence** , to improve the ability to analyze and interpret data. However, it is important to note that these are just some of the possible

	prospects for the development of gemological polariscopes, and that the future could hold new surprises.
Get curious	1. One of the more curious facts related to the polariscope is that it has also been used to analyze **chocolate** . Indeed, the crystalline properties of chocolate can be studied using a gemological polariscope. In addition, the polariscope has also been used in research on the biochemistry and structure of proteins. 2. The gemological polariscope has also been used in the **artistic field** to identify the presence **of crystals and inclusions in works of art, such as paintings and sculptures** . 3. Throughout history, gemological polariscopes have also been made from **unusual materials such as ivory and obsidian** . 4. Some gemological polariscopes are equipped with an **LED light** to enhance the visibility of the gemstone. 5. Using a gemological polariscope **requires some experience and knowledge of the optical properties** of gemstones, and it is a skill that can take years of practice to perfect. 6. **smartphone-compatible** gemological polariscopes on the market , which allow you to analyze precious stones quickly and precisely even outside the laboratory. 7. In **some countries** , the use of the gemological polariscope is **regulated by law** , and only professionals in the sector can use this instrument to analyze precious stones.
Spread	The polariscope is a relatively simple instrument to use and easily transported (especially the smaller models). It is a reference tool for all gemologists and is therefore used constantly and frequently in the identification of precious stones where there is no more sophisticated equipment.