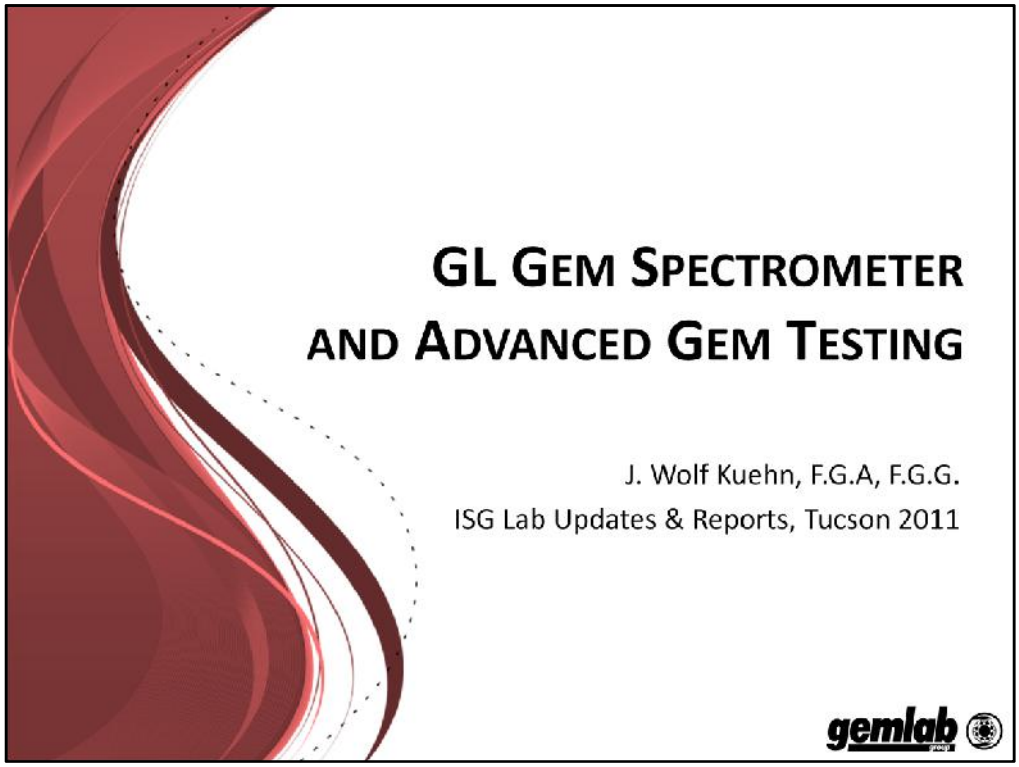


Robert, thank you for inviting me.

I also would like to welcome Dr. Bill Hanneman; we have known each other for a long time. It all started when Bill handed me a copy of his book “Video-Spectroscopy: 21st Century Gemology” back in 1988. Now 20 years later his new book “Pragmatic Spectroscopy for Gemologists” is ready just in time for this year’s Tucson shows. This book is an excellent introduction to the GL Gem Spectrometer.

Actually - HE should be giving this presentation.

I am sure you all know that no-one can teach the theory and practice of spectrometry in 25 minutes. I am talking to you here as an educator – not as a scientist. Please ask questions – if we need more time we can discuss them at the end.

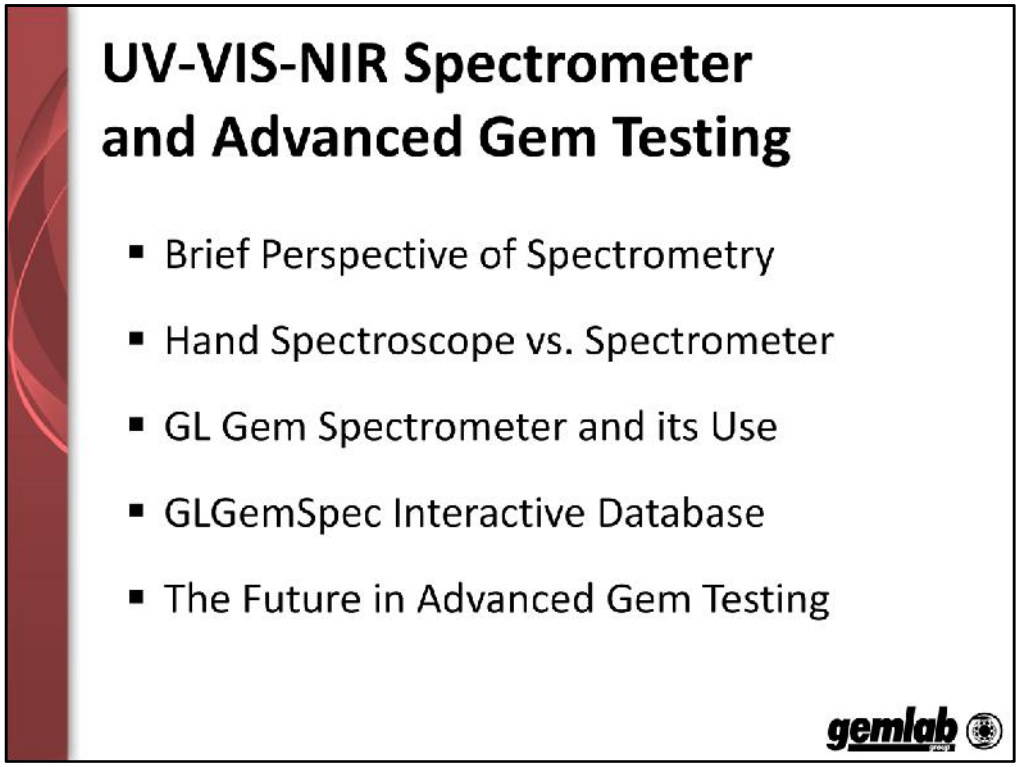
Let’s start.

Over 75 years ago Basil Anderson, whom we consider "The Father of Gemmological Spectroscopy" wrote: The spectroscope is the third leg of the tripod of instruments in which modern determinative gemmology rests secure.

Here is the first one - a diffraction grating type spectroscope.

Can you name the other instruments? There's the refractometer and then of course the microscope. And if money doesn't matter- an immersion scope.

In our lab we have a convertible Eickhorst immersion scope which, in my opinion, is absolutely necessary for serious gem identification.



Here are the topics I would like to cover in my presentation..

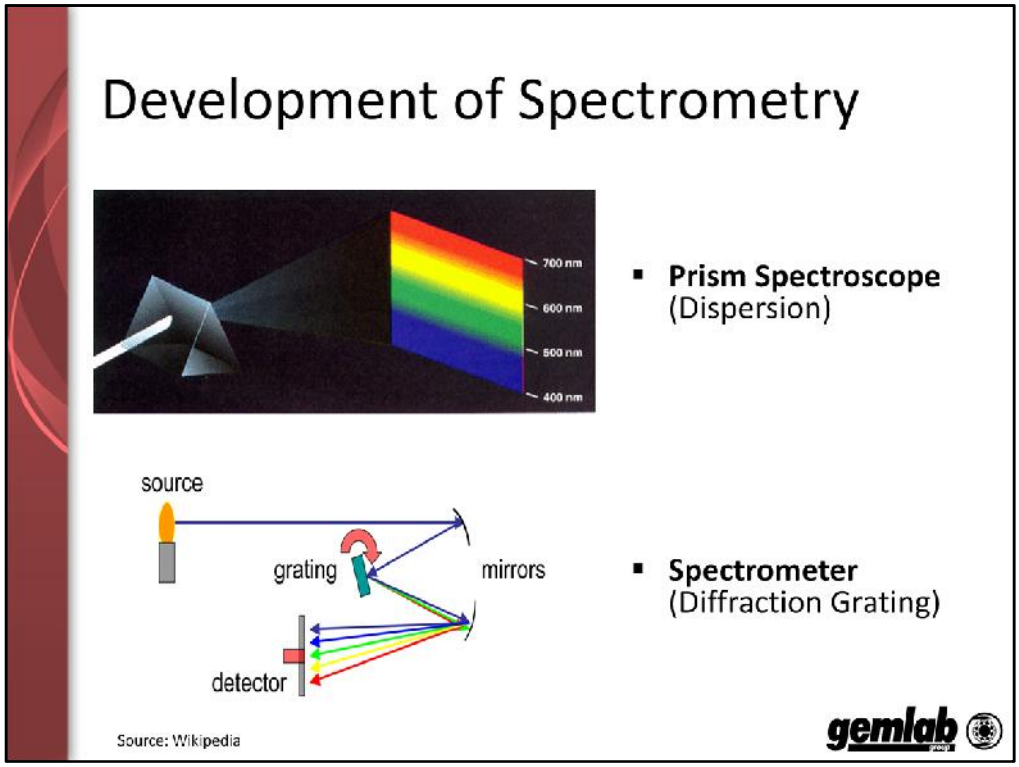
Gem testing instruments have varying degrees of usefulness. Some are being used by the practicing gemmologist on a daily basis; some are used less often and others are simply not liked that much. You probably know which instrument I am referring to.

First, lets review a few facts related to spectrometry.

A large part of my presentation will be centered on the GL Gem Spectrometer and its use.

In several video clips I will demonstrate how the instrument works and how reference databases are used to identify certain spectral characteristics.

At the end I will speculate on the future of advanced testing instruments.

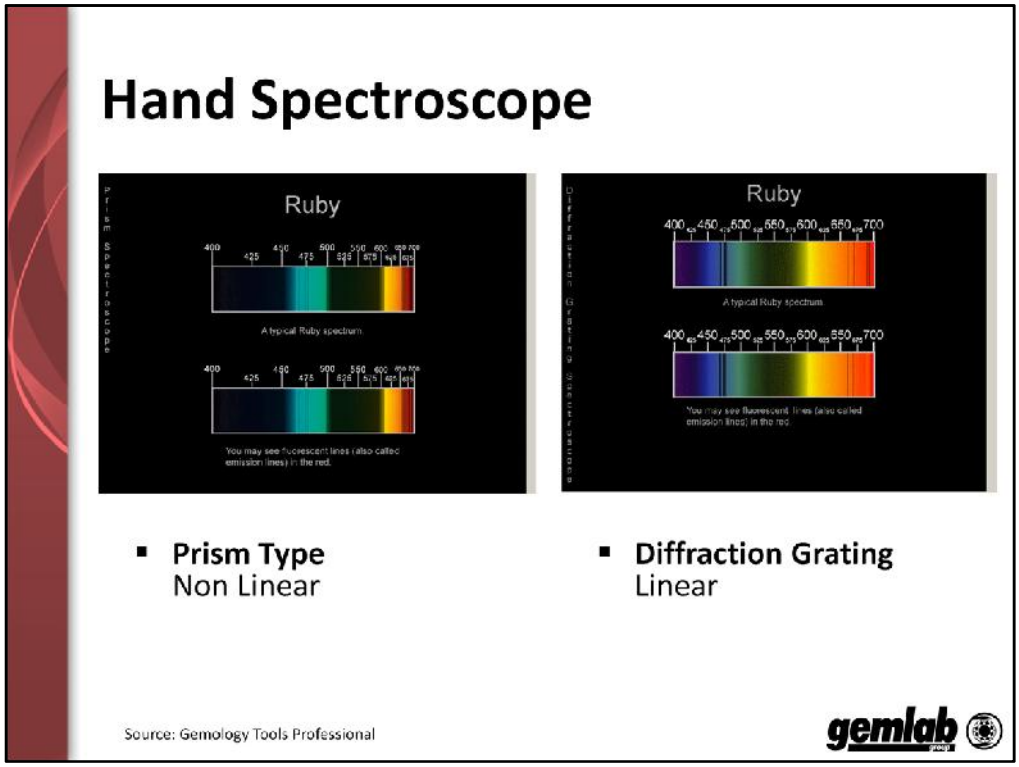


We all know how a prism spectroscope is built and understand the optical property called "dispersion" - the splitting of white light into its rainbow spectrum.

Spectrophotometers in the 1940s consisted of simply a light source, a prism, a monochrometer and a measuring device.

Today, most gemmologists are using a diffraction grating spectroscope. It was introduced 35 years ago as the so called OPL spectroscope and has replaced the prism spectroscope because it can be made at a lower price.

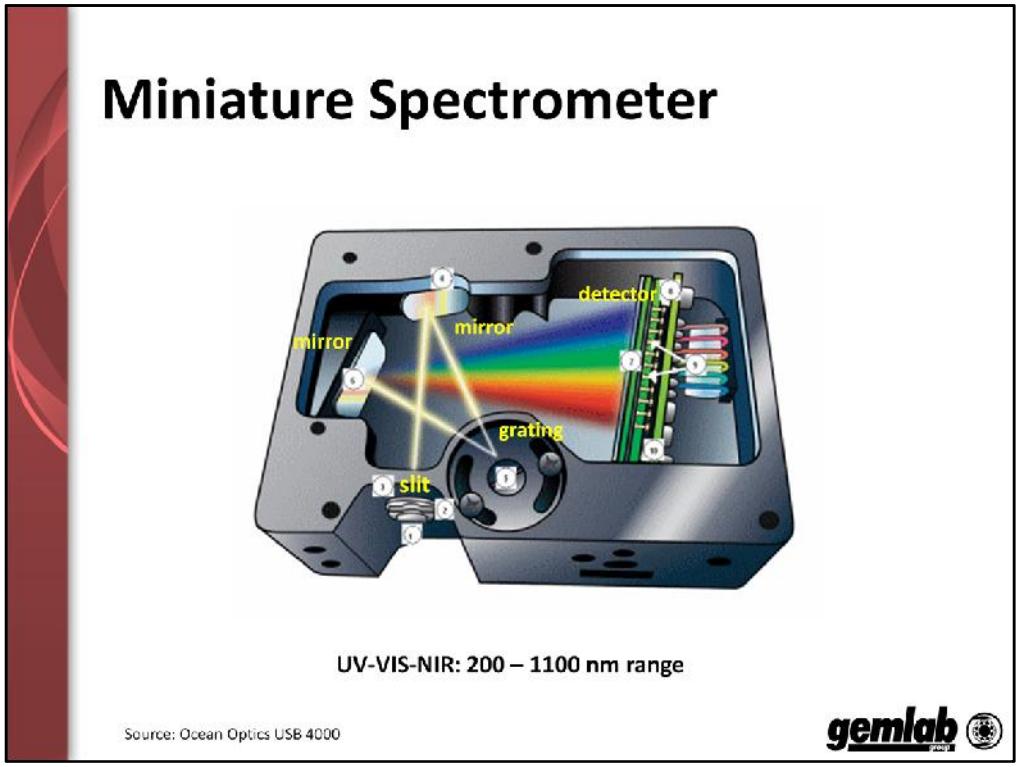
Similarly, the modern spectrometer does not use a prism anymore but a grating as you can see in the simple drawing.



To finish the review of the hand spectroscope, there is an important difference in how the two types display the absorption patterns.

In the prism type, the blue region appears to be “expanded” and the red end “compressed” while the diffraction grating spectroscope has a linear wave-length scale.

In Bill’s Video-Spectroscopy, a diffraction grating spectroscope is mounted onto a camera and connected to a black and white high resolution TV monitor. To learn more about this interesting approach, it is best to read the first part of his new book.



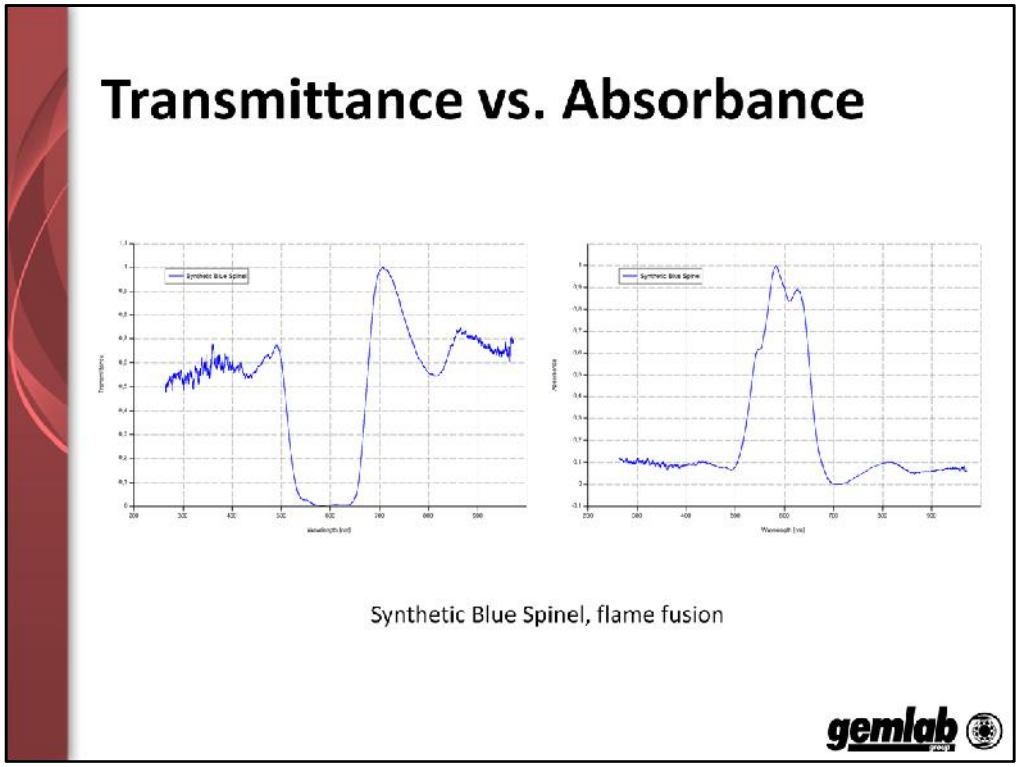
Here you have a diagram of a modern miniature spectrometer such as produced by Ocean Optics and other manufacturers. In our lab we have used a USB 2000 and a NIR256 infrared spectrometer; the price for these instruments is over $ 25,000.

A more economical solution is our GL Gem Spectrometer which covers a range from 300 – 1,000 nm. The optical bench looks very similar to this illustration.

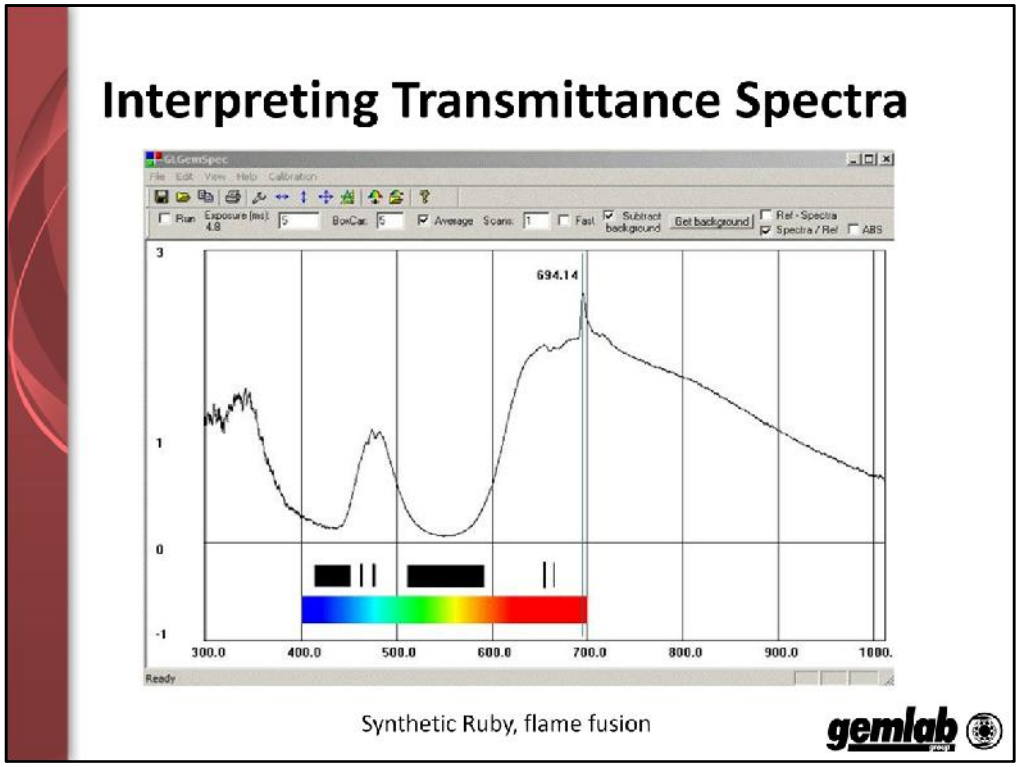
Above the slit is a connector for the light holder or an optic fiber. The slit is usually from 25 – 100 microns in size. *The slit regulates the amount of light that enters the optical bench and controls spectral resolution.*

The entering light is now reflected off a collimating mirror and focused towards the Grating of the spectrometer. *Gratings are available in different groove densities allowing you to specify wavelength range and resolution of the spectrometer.*

The light reflected from the Grating focuses now onto the detector plane. *The detector converts the optical signal to a digital signal. Software is necessary to display the data on a computer screen.*



Before we move on, lets take a quick look at transmittance and absorbance.

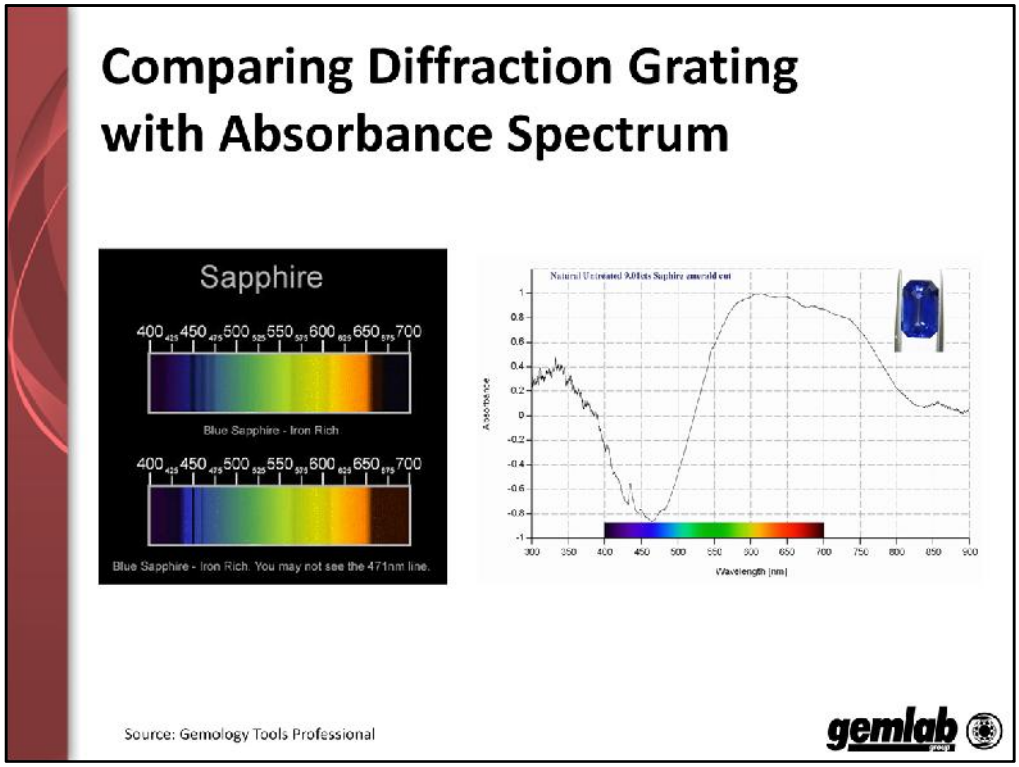


The GL Gem Spectrometer measures transmission.

Here is an actual graph illustrating transmittance compared to what you would see in a hand spectroscope.

We are looking for peaks, dips or valleys.

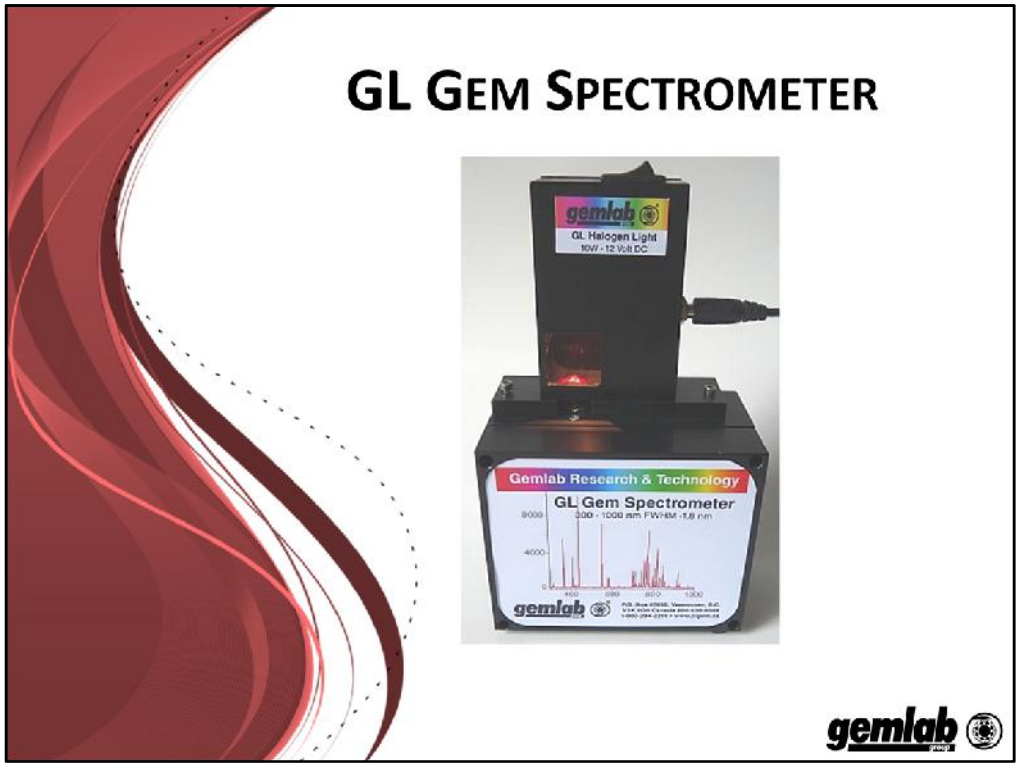
The dips or valleys represent low transmission or, in other words, areas where more light is being absorbed. In a hand spectroscope you would see black lines or bands in these areas.



Here's another sample.

A user sent me this spectrograph of an untreated 9.0 ct sapphire; it has a superb colour with an estimated value of $ 80,000. It comes with a GIA certificate stating "Origin Unknown".

One can match the absorption peaks in this diagram with the spectral graph to the left.

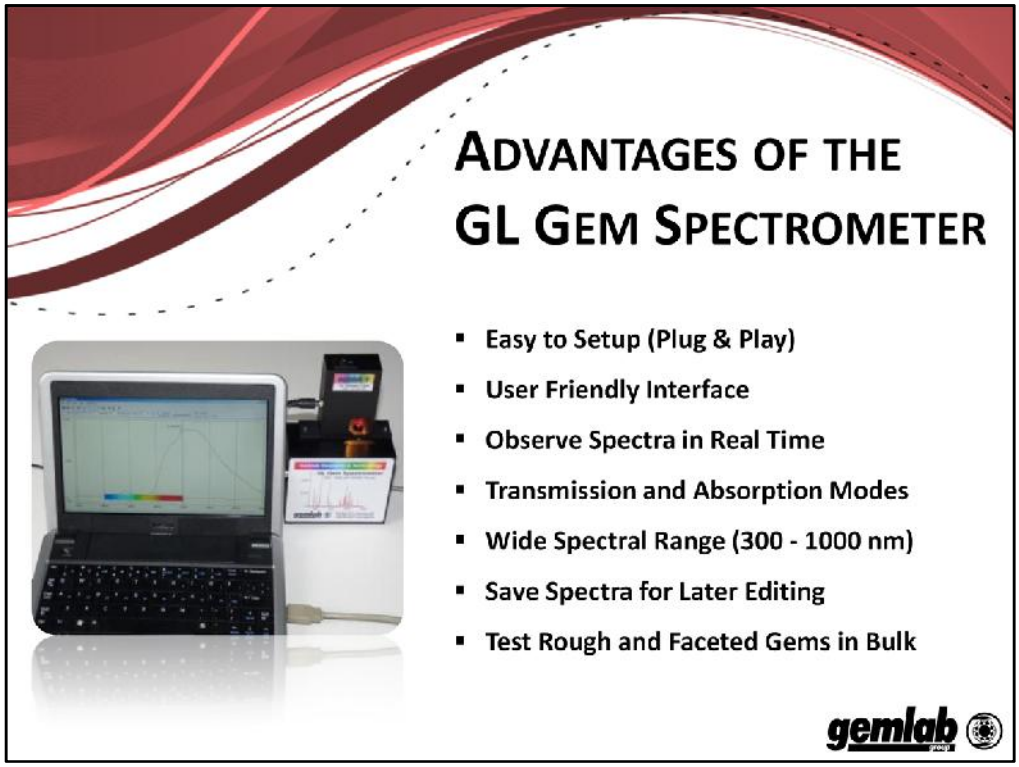


Now let's take a closer look at the GL Gem Spectrometer.

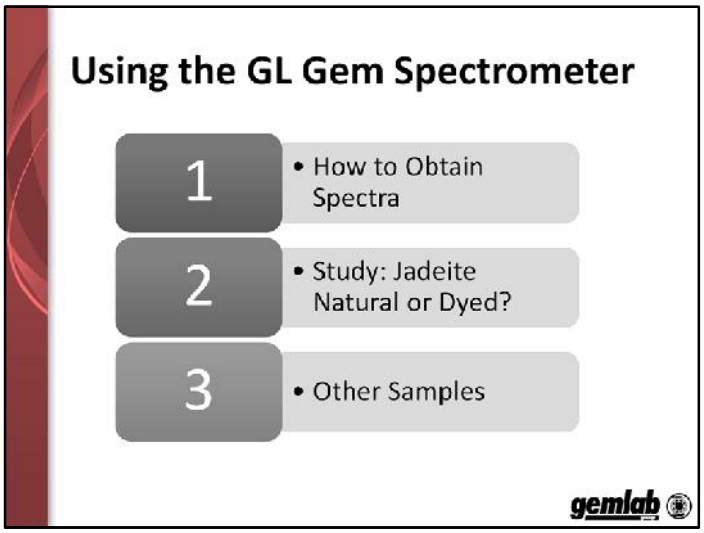
I started developing this instrument about a year ago when a local research scientist introduced me to his newly designed spectrometer. I immediately saw its potential for gemmologists and designed a halogen light holder to be mounted onto the spectrometer. It took about 6 months for us to write the software and test the unit. Last September the GL Gem Spectrometer or GemSpec - as we call it - was officially introduced. Since then we have sold over 30 units worldwide.

To protect the gemstone the built-in light holder has a cooling fan. Special firmware in the micro-processor optimizes the unit for the near infra-red range which is of interest to gemmologists.

I won't go into any further technical detail. This information can be found in our brochure or at our website.



A gem dealer has this unit in his office and checks a batch of incoming gemstones. When there is something that doesn't appear as expected he can then scrutinize the data.

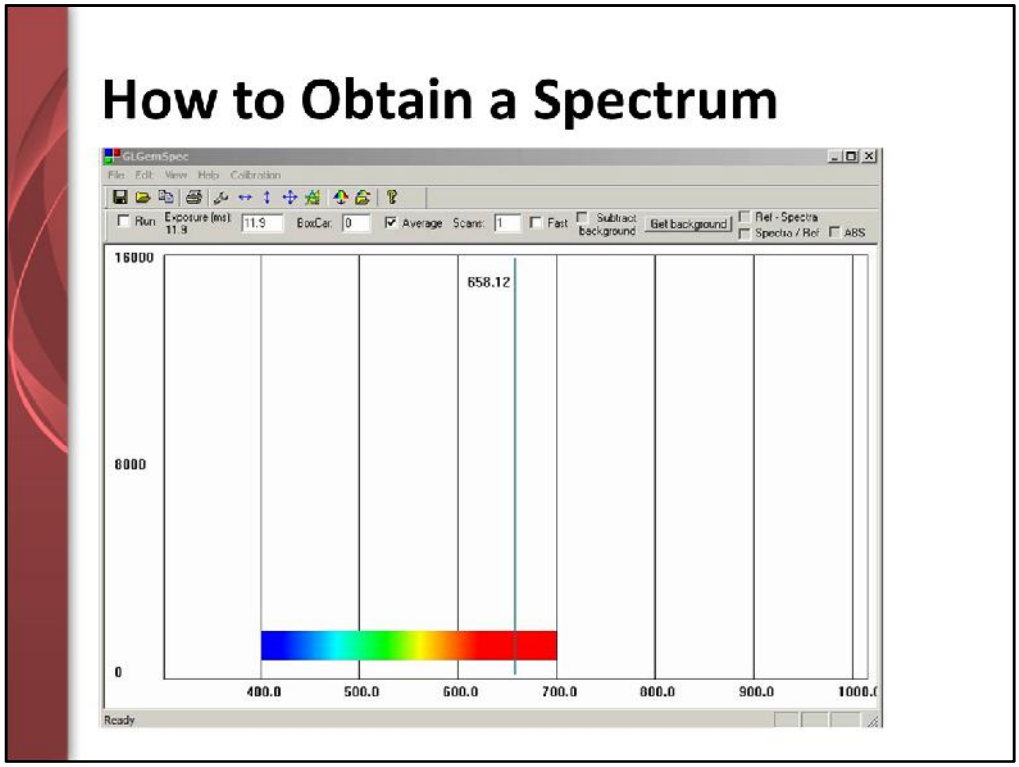


Let's have a look at how this spectrometer works.

First I will show you in a video-clip how the software works to obtain a spectrum.

Then I will talk about a study we did on jadeite.

After that I will discuss other samples and how reference spectra are used.



This is how the interface of the GLGemSpec program looks when you first start the program.

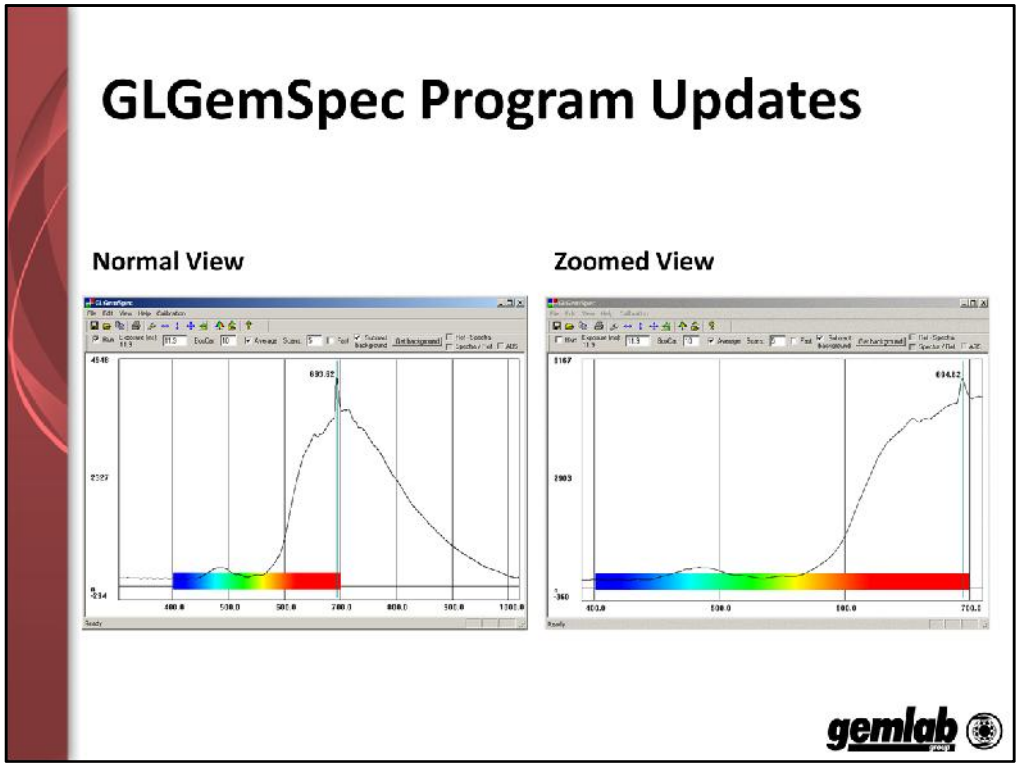
A spectrometer is similar to a digital camera. You have to make certain adjustments for light conditions, the object and its background.

Exposure time is in milliseconds. For darker stones we will increase the exposure time. BoxCar smoothens the spectral curve at the expense of resolution.

When we click on RUN we will see a wiggling line near zero. Now we click GET BACKGROUND and the box next to it will lighten up. We click on SUBTRACT BACKGROUND . Next we TURN THE LAMP ON and immediately you will see the bell-shaped curve of the halogen bulb. We are now in SCOPE mode.

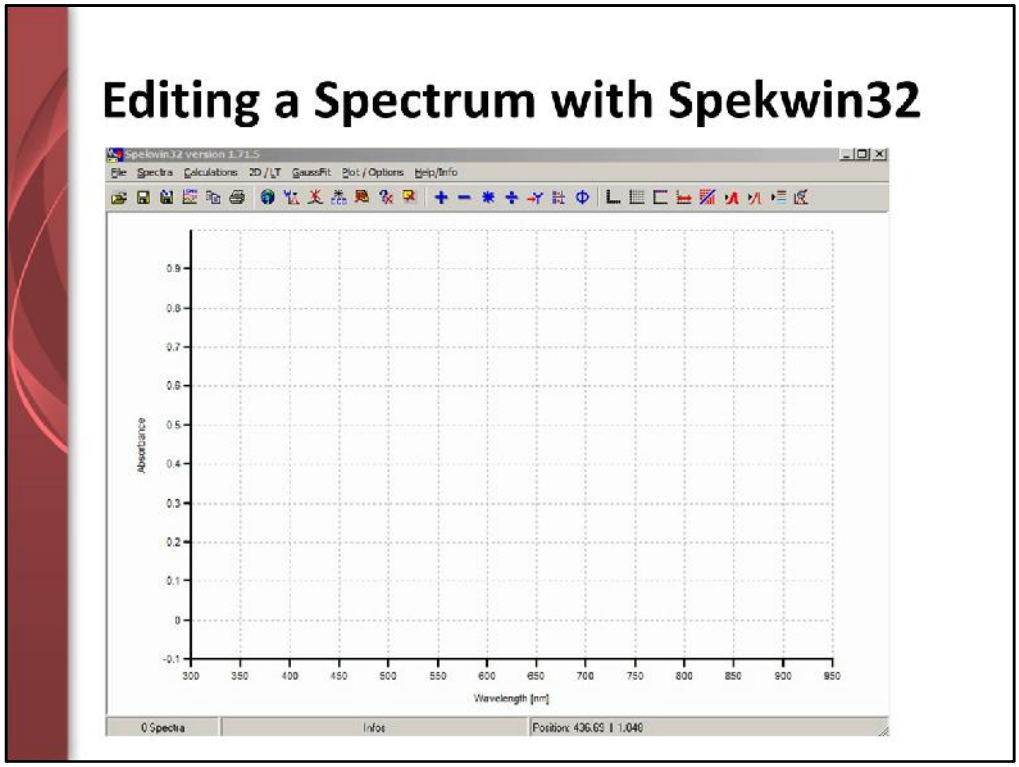
Next we click on the rain-bow icon to take a lamp spectrum. Now all the boxes to the right lighten up. Click on HERE for a transmission spectrum or ABS to obtain an absorption spectrum.

Let’s watch.



In the latest version of the GLGemSpec program we added a ZOOMED view and a colour bar which can be removed under settings.

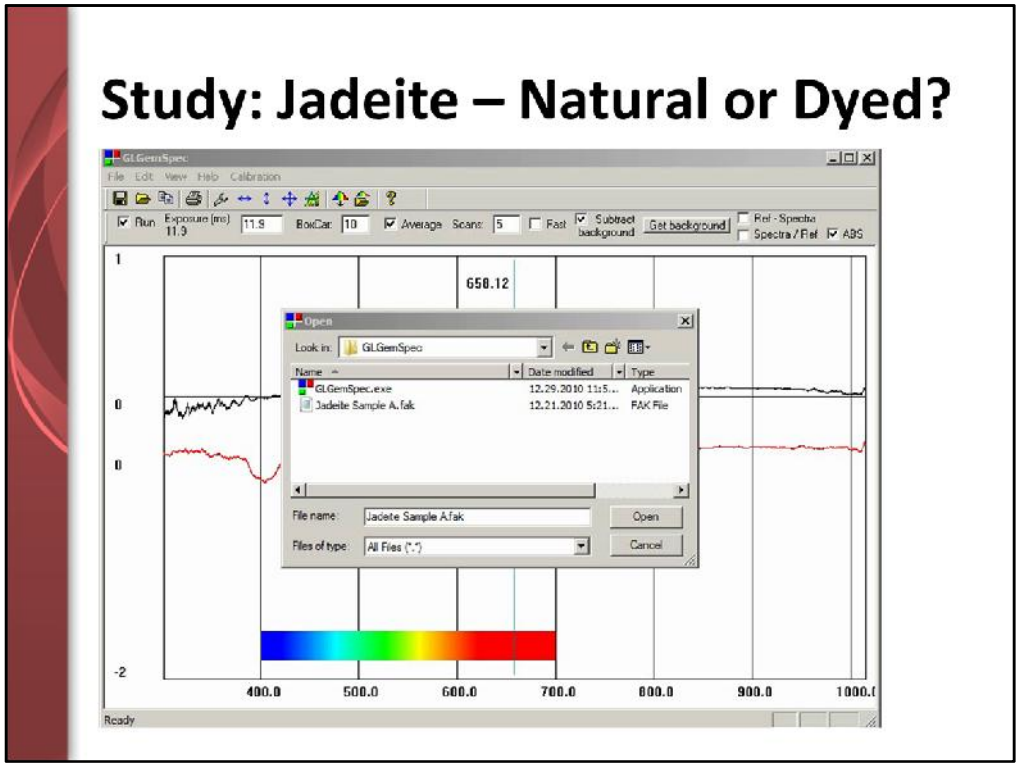
At the moment we are working on version 2.3 which improves certain features in the 400 – 700 nm range and also supports a SAVE settings option. This update will likely be released next week.



The GLGemSpec program is very lean with limited features; it is just 100 kilobytes in size.

This is one of the main reasons the program is so fast; it allows real-time observation of a sample. Switching from transmittance to absorbance mode takes less than a second.

For editing and publishing, we recommend the free Spekwin32 program . The author, Dr. Menges revised his program to allow direct import of a saved GLGemSpec file into his program. He has also promised to add a few new features in a future update.



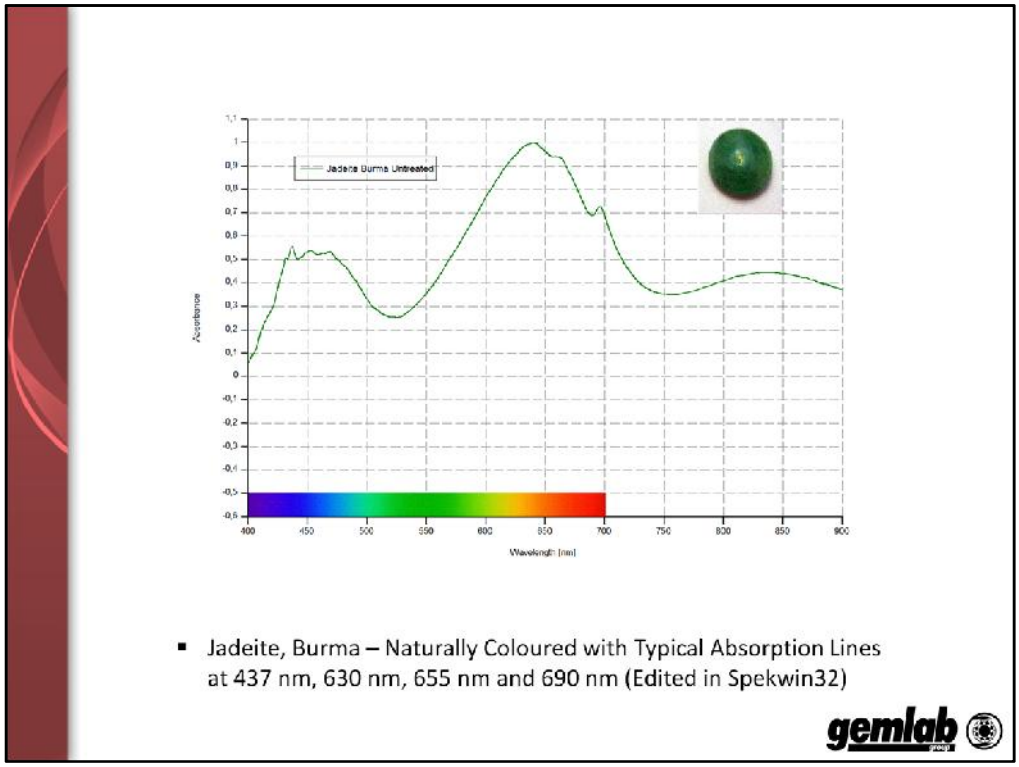
This study is based on research by the National Gem Testing Center of China and was published in the Journal of Gemmology last year.

Gemmologists conducted a survey with 3,000 samples of untreated jadeite and found that they all had the same characteristic absorption peaks.

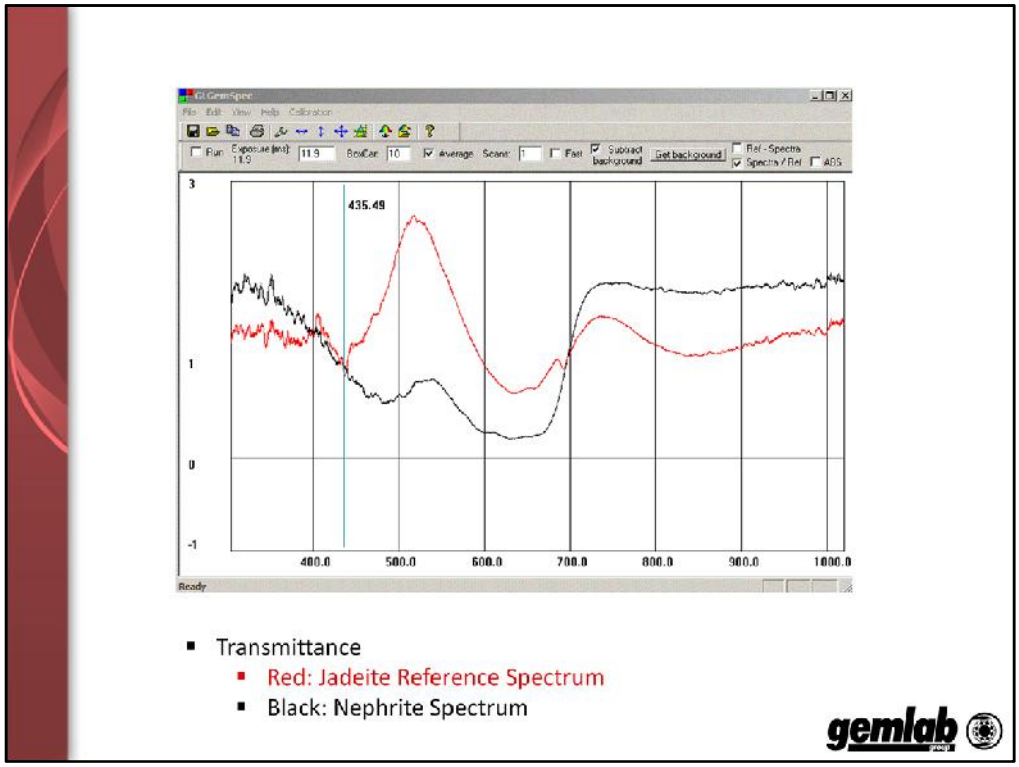
We will look at a video using a sample spectrum of untreated jadeite. Then three known samples are compared with the reference spectrum.

The first will match the reference spectrum, the second one does not match the reference spectrum and is dyed jadeite and the third specimen is nephrite.

The samples were all opaque and we used an external Xenon flash-light to increase the amount of light passing through the sample.

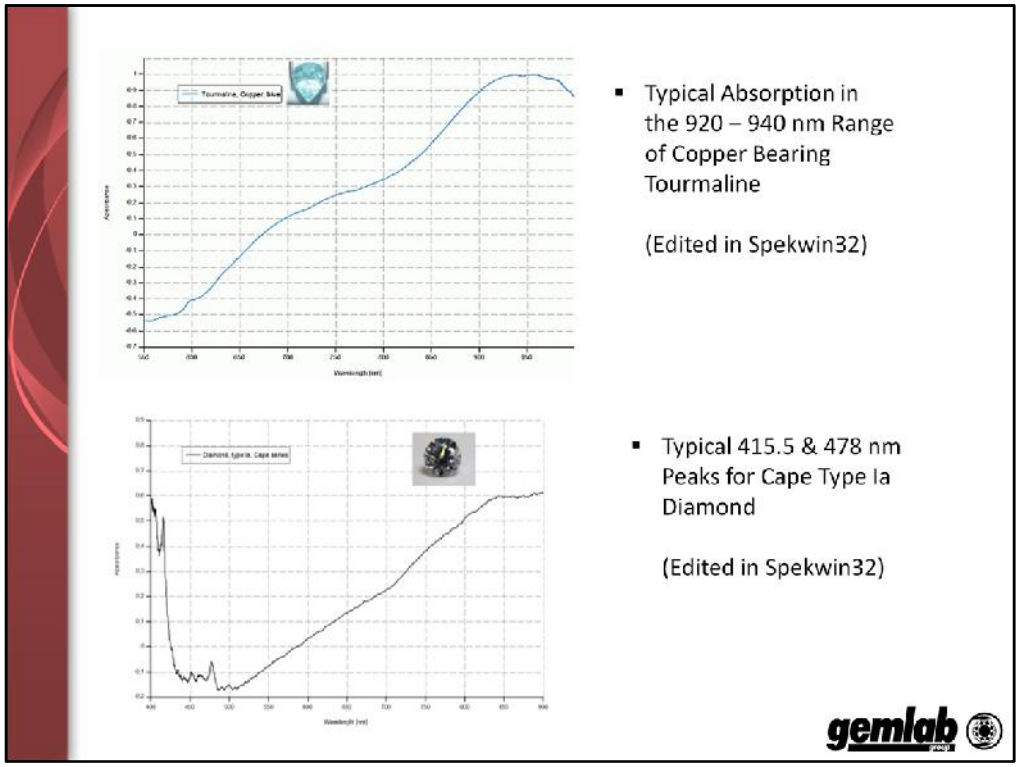


It is always recommended to do a FTIR test if the stone may be very valuable.



Back into transmittance mode.

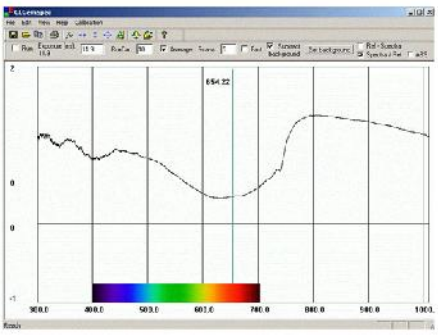
In red you see the jadeite reference spectrum we loaded into the GemSpec program. Then we put green nephrite in the light holder; the spectrum looks quite different.

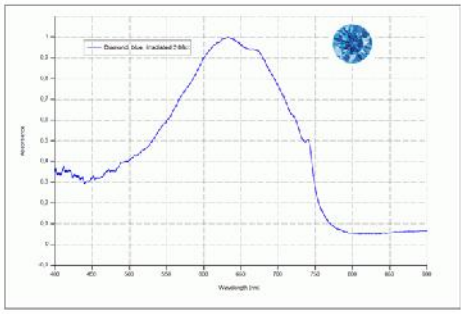


The GemSpec allows quick checking for certain features.

Diamond: Blue - Irradiated

- Seen as Transmission Spectrum in GLGemSpec
- Irradiated Diamond with Typical GR-1 Band at 743 nm

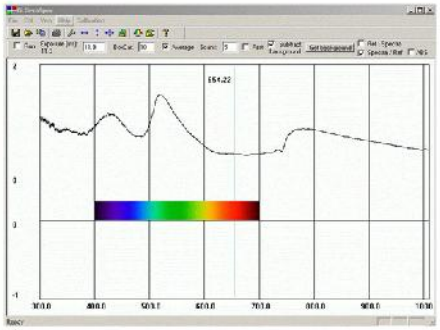


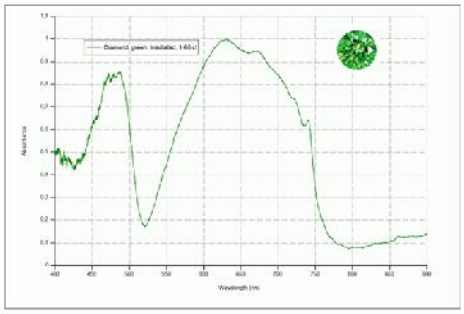


We are trying to identify treatments in diamonds, or whether they are HPHT treated or irradiated. The absorption peak is due to radiation damage.

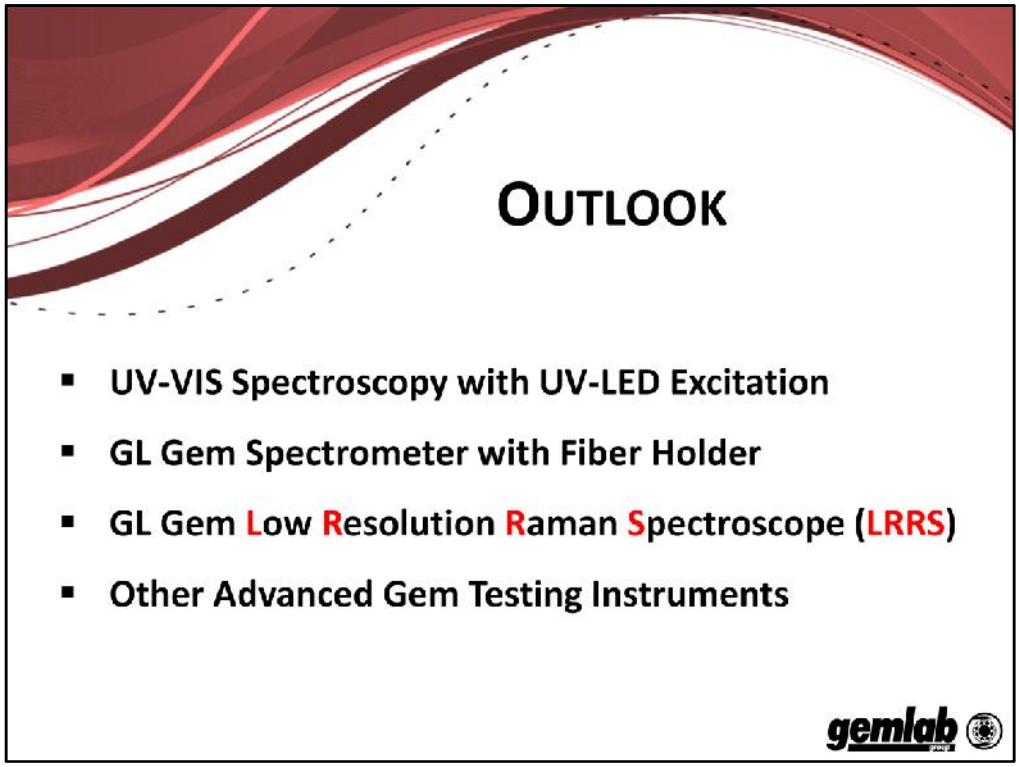
Diamond: Green - Irradiated

- Seen as Transmission Spectrum in GLGemSpec
- Irradiated Diamond with Typical GR-1 Band at 743 nm

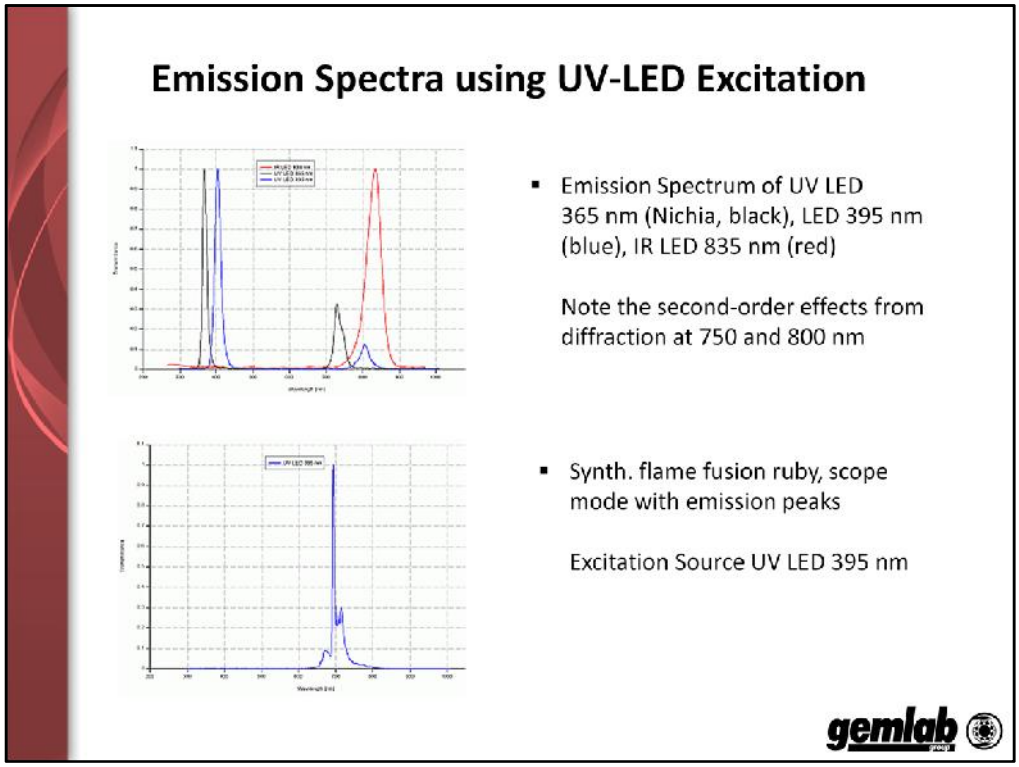




gemlab



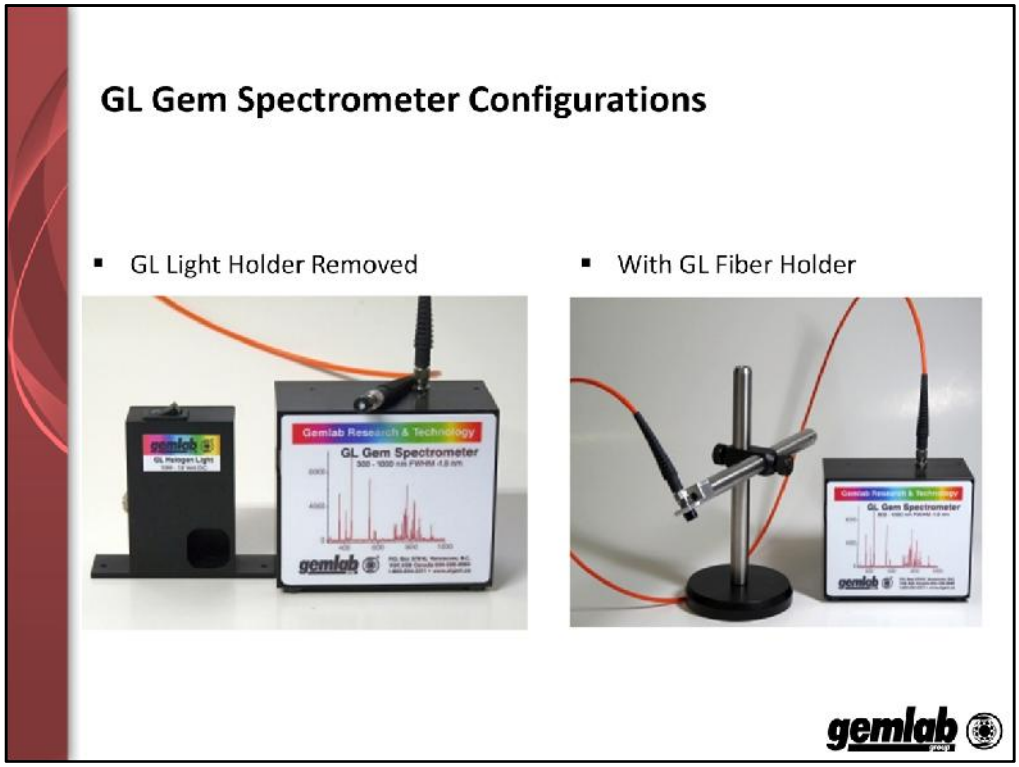
There is a lot of potential for spectrometers in advanced gem testing.



Several people have experimented with UV-LEDs and believe that emission spectra are helpful in gem identification. There has been very little work done in this area; most studies of the past use obsolete mercury lamp as an excitation source.

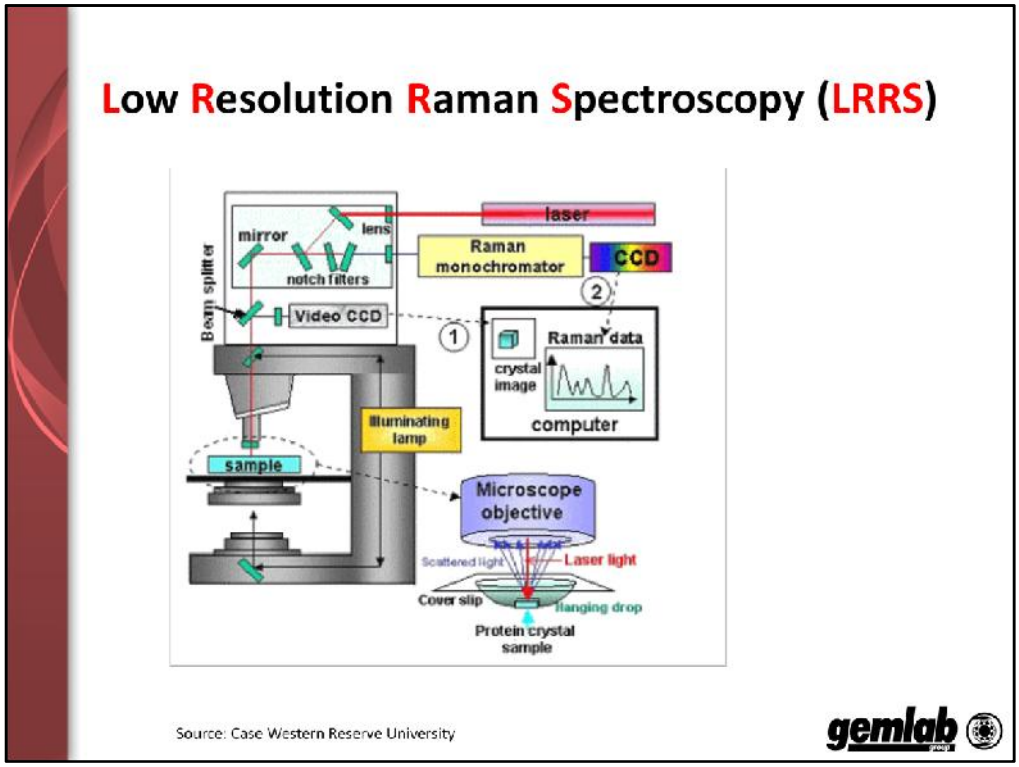
Emission behaviour of a gemstone depends largely on the excitation source. We found that a just slight change in wave-length of the LED lead to unexpected emission patterns.

A proper graph recording these spectra must be 3-dimensional because an array of light sources must be used. Educating people on how to interpret these results could be a challenging task.



The GemSpec system is best used with the Halogen Light holder. You can unmount it and replace it with a fiber.

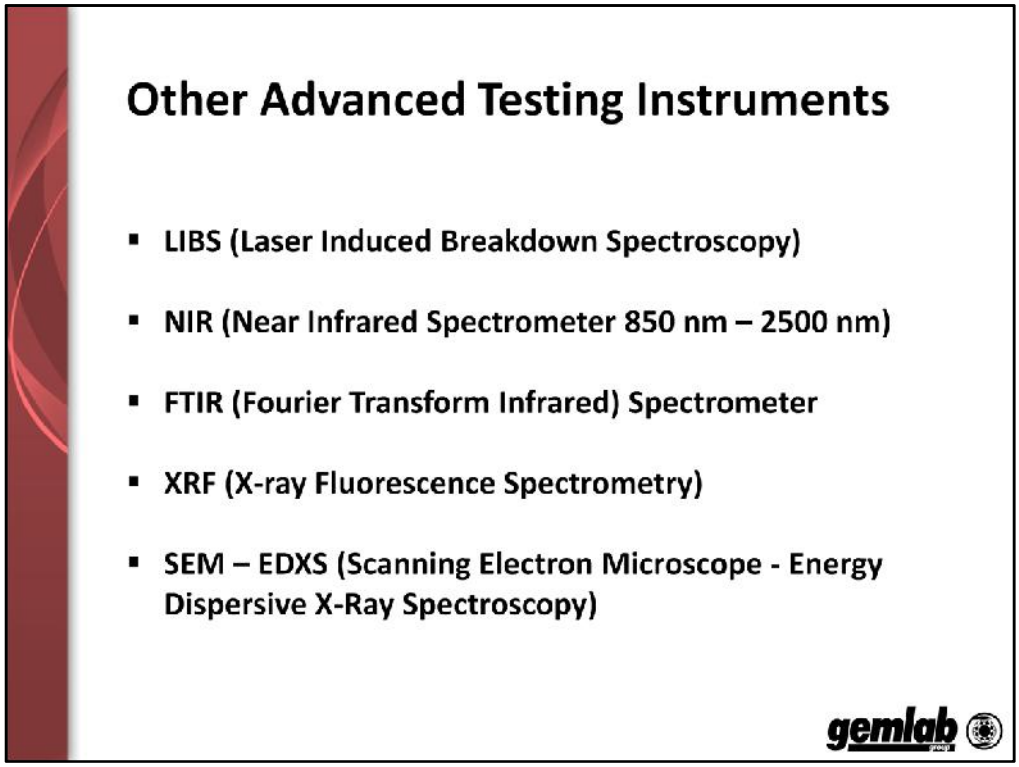
For gemstones set in jewellery or larger samples we developed a separate stainless-steel holder which can be adjusted in height. An external light source such as a fiber optics light can be used.



We have started working on a Gem Raman Spectrometer. Raman spectroscopy is a technique used to study vibrational, rotational, and other low-frequency modes in a system.

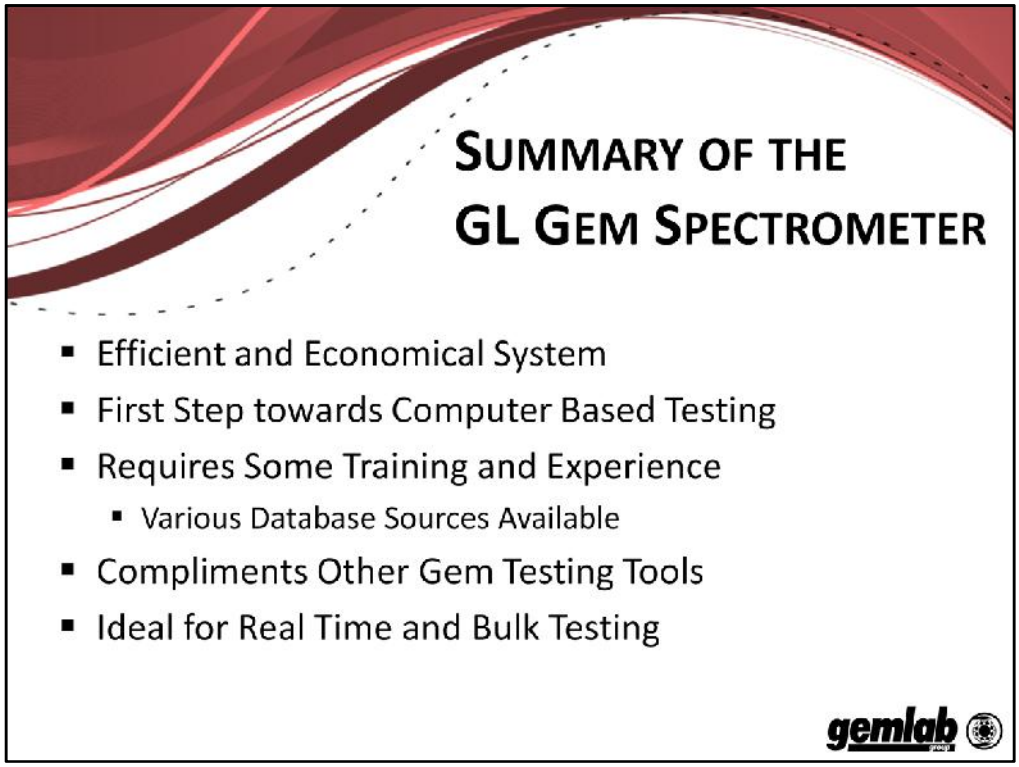
It relies on inelastic scattering of monochromatic light, usually from a laser in the visible, near infrared, or near ultraviolet range. The laser light interacts with molecular vibrations, phonons or other excitations in the system, resulting in the energy of the laser photons being shifted up or down known as the Raman shift.

Ideally the device will be mounted onto a microscope. We are still in the early stages, but our goal is to develop a unit under $ 7,000 price point.



There are other instruments used in advanced gem testing but they can be expensive and require advanced training and knowledge.

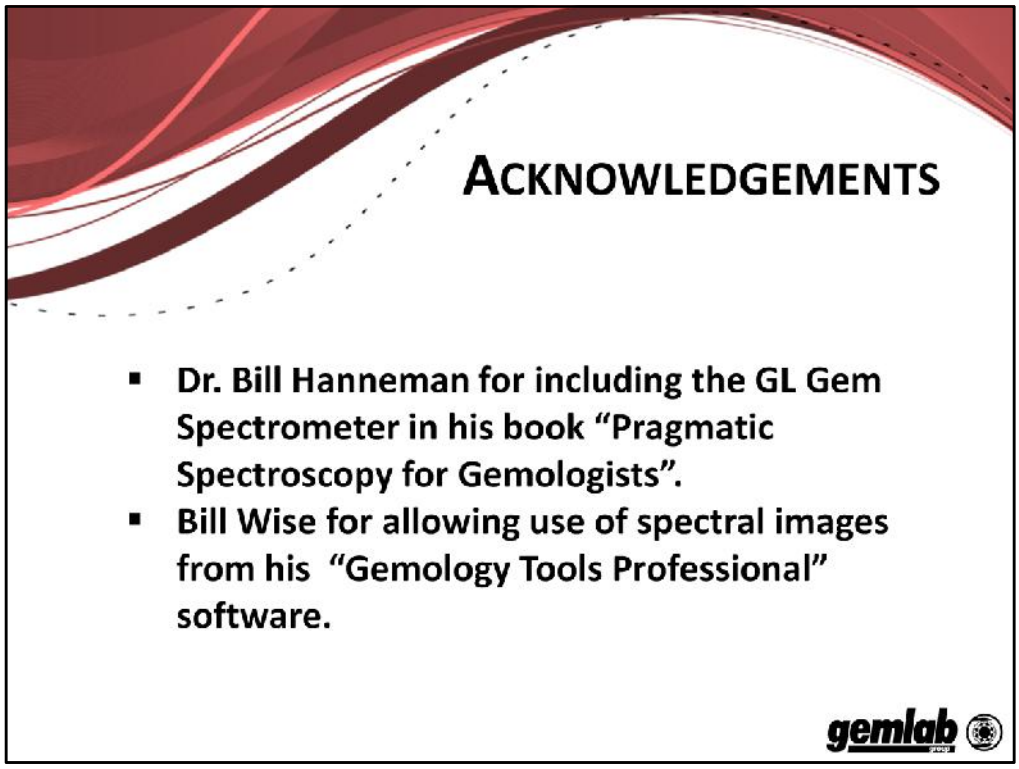
LIBS for instance is used – to detect for Beryllium diffused corundum
NIR Spectrometer – We have an Ocean Optics Near Infrared spectrometer but we stopped our testing because a gem related information and a reference data-base are essentially non-existent.
FTIR spectrometer – Used - to determine the nature of fissure fillings in emeralds – to distinguish between natural and synthetic quartz – to detect treatments in jadeite, turquoise – to distinguish between natural amber and its imitations.
X-ray fluorescence/dispersive spectrometry – is used in identification and authenticity determination of all gemstones - origin determination of rubies, sapphires, emeralds, spinels and alexandrites - determination of saltwater/freshwater pearls - determination of glass- filled fissures of corundum and diamond



Until recently similar miniature spectrometers were prized in the $ 3 – 4,000 range. Packages with software were offered for $ 20,000 and above. *The GemSpec system is the first low cost portable system selling for under $ 1500 (Fifteen Hundred Dollars).*

The computer is a necessity in the daily work of a gemmologist. My GemSpec instrument is plugged in all the time and I often use it when I would have traditionally used a refractometer first. Another important part of our project is the creation of a reference data-base. A number of GemSpec users have already contributed to the on-line data-base and others are available for reference on the internet.

There is a learning curve to familiarize yourself with all aspects of spectrometry. If you are comfortable with the hand spectroscope you will quickly adapt to a spectrometer. I again highly recommend Bill Hanneman's book "Pragmatic Spectroscopy" as it is a perfect introduction to the GemSpec system. It also contains numerous spectra of Bill's private collection of gemstones.


ACKNOWLEDGEMENTS
Dr. Bill Hanneman for including the GL Gem Spectrometer in his book "Pragmatic Spectroscopy for Gemologists".
Bill Wise for allowing use of spectral images from his "Gemology Tools Professional" software.
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QUESTIONS?
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