



Raman and Photoluminescence Spectroscopy in Mineral Identification



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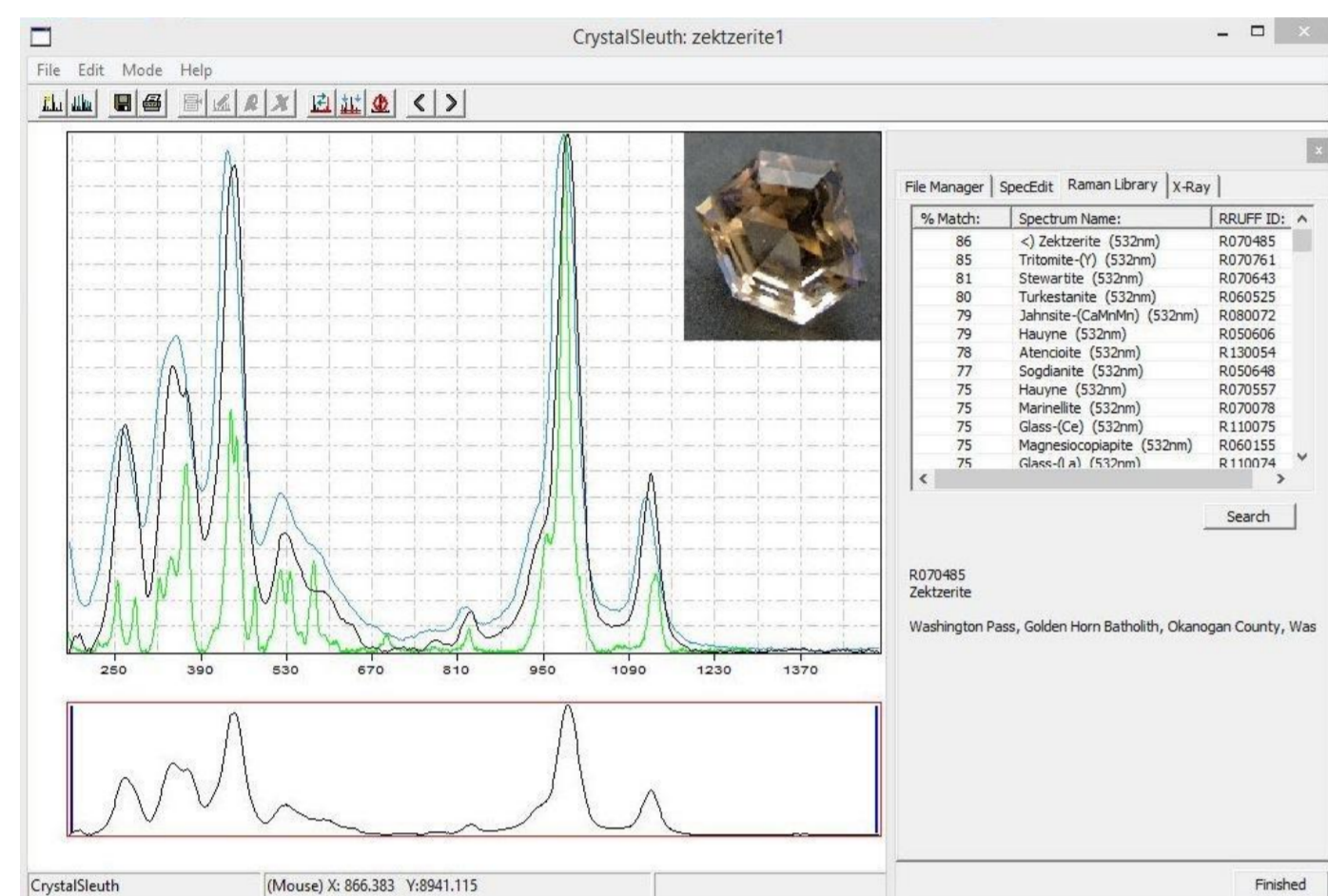
Introduction

Raman spectroscopy is particularly useful for rapid identification of minerals and gemstones. Searchable data-bases such as in the RRUFF project contain a large number of reference spectra and are in public domain; the data-bases can be modified and expanded to the user's requirements.

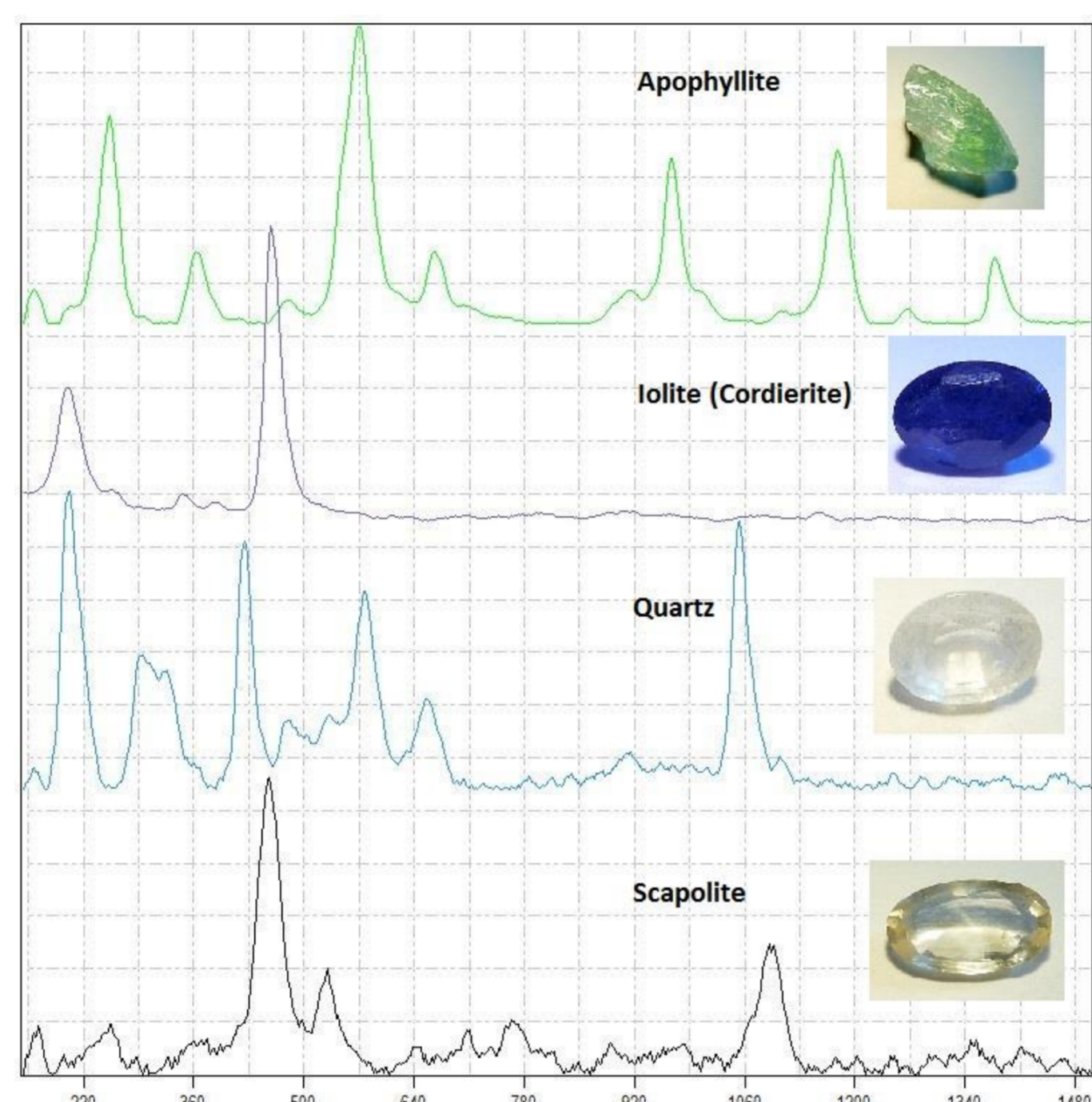
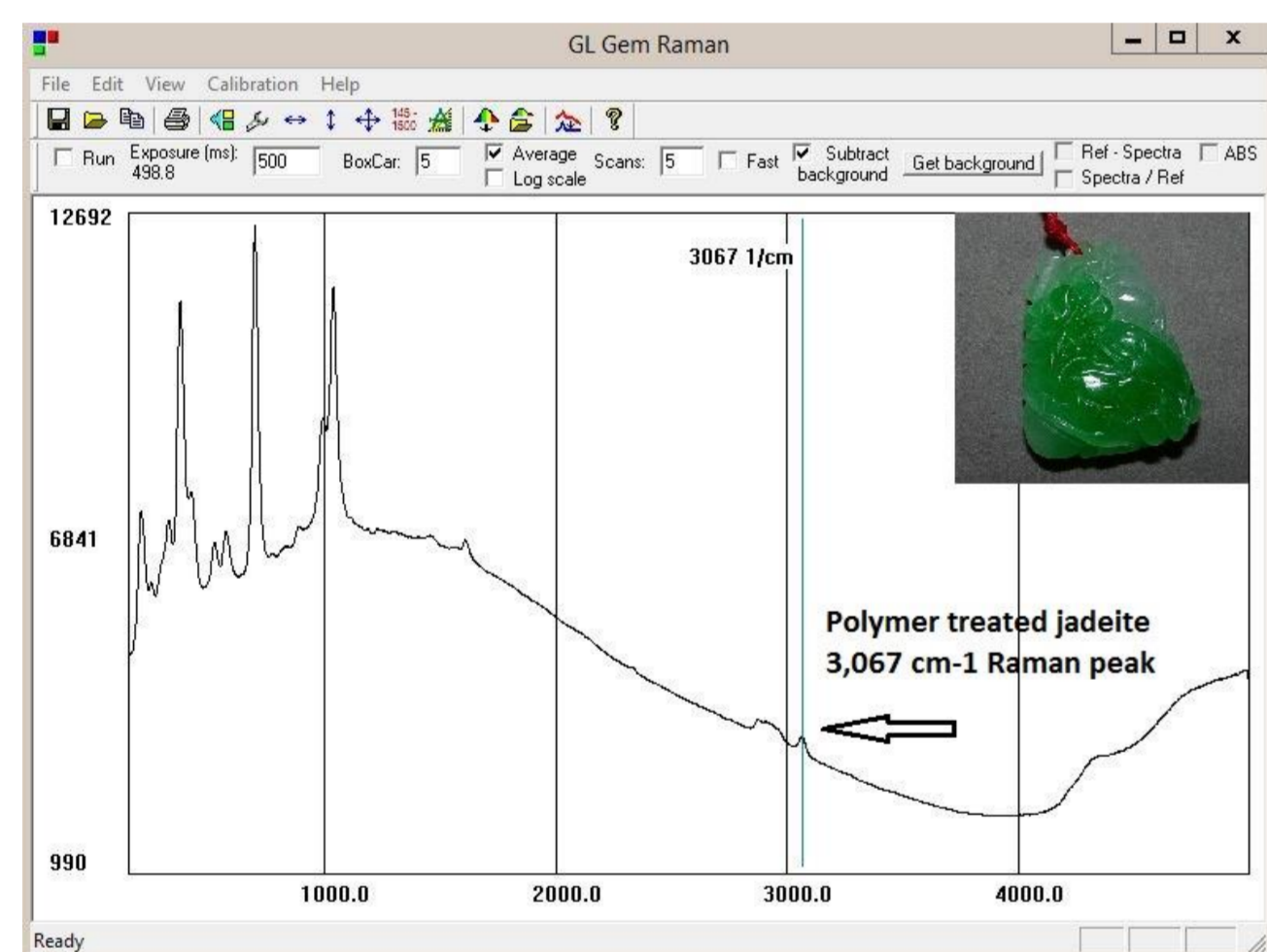
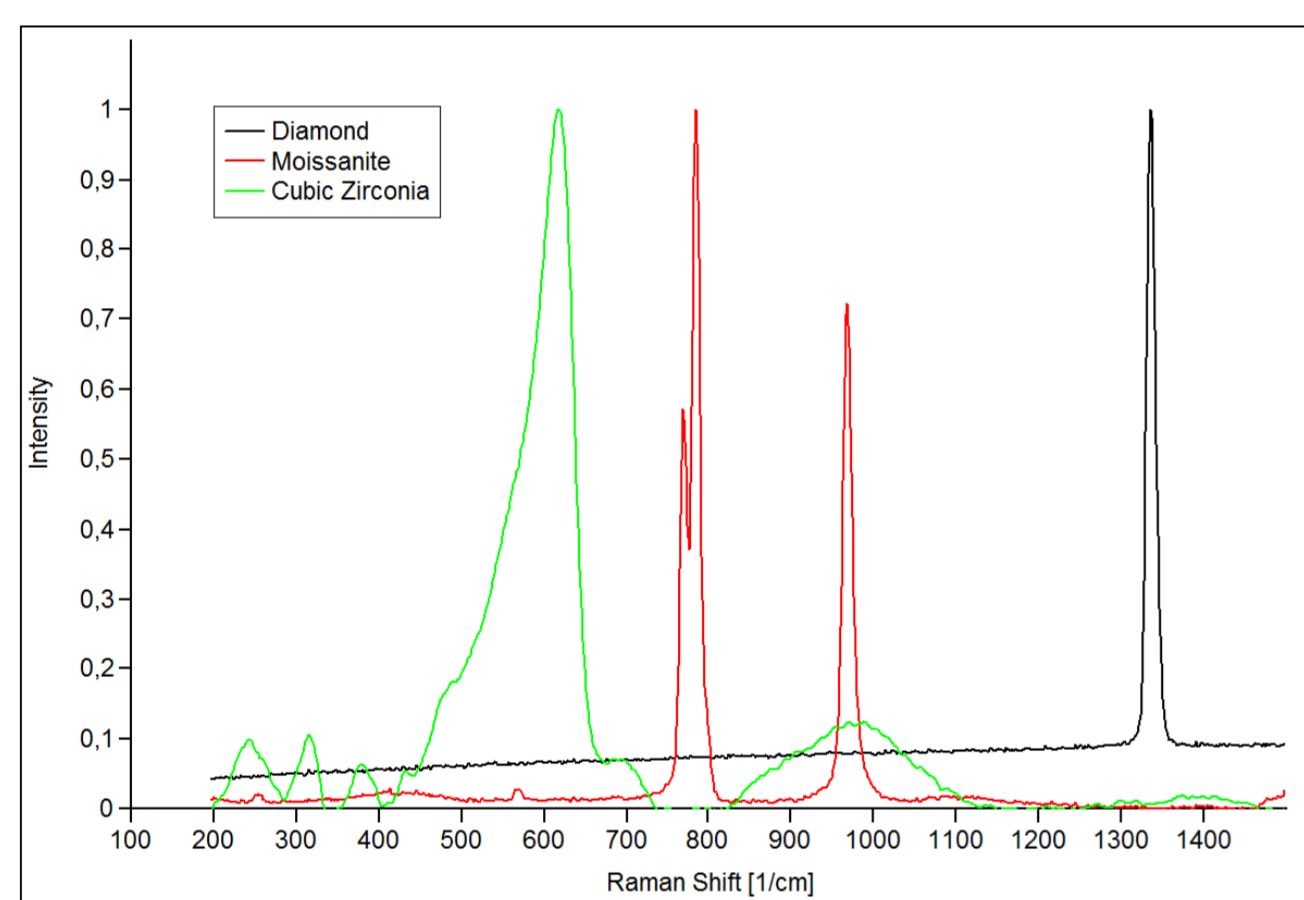
In some minerals luminescence features are so intense that one can no longer see the Raman peaks associated with the atomic vibrations of the mineral. The insertion of a band pass filter for suppression of fluorescence in Raman mode can be useful.

Aim

Raman Applications



Rare Zektzerite could be quickly confirmed with the RRUFF database. Diamond is easily separated from its most popular imitations.



Gemmologists often have difficulty to identify gemstones set in jewellery.

A Raman spectrometer can rapidly identify gems with overlapping refractive indices (all in the range of RI = 1.54 – 1.56).

Garnet varieties cover the full colour spectrum and due to their similarity are difficult to identify; Raman based spectral measurements can give a precise and relatively inexpensive solution for these problems.

The detection of treatments in gem materials is often challenging; for example the use of extended Raman spectroscopy can detect polymer treatment in jadeite.

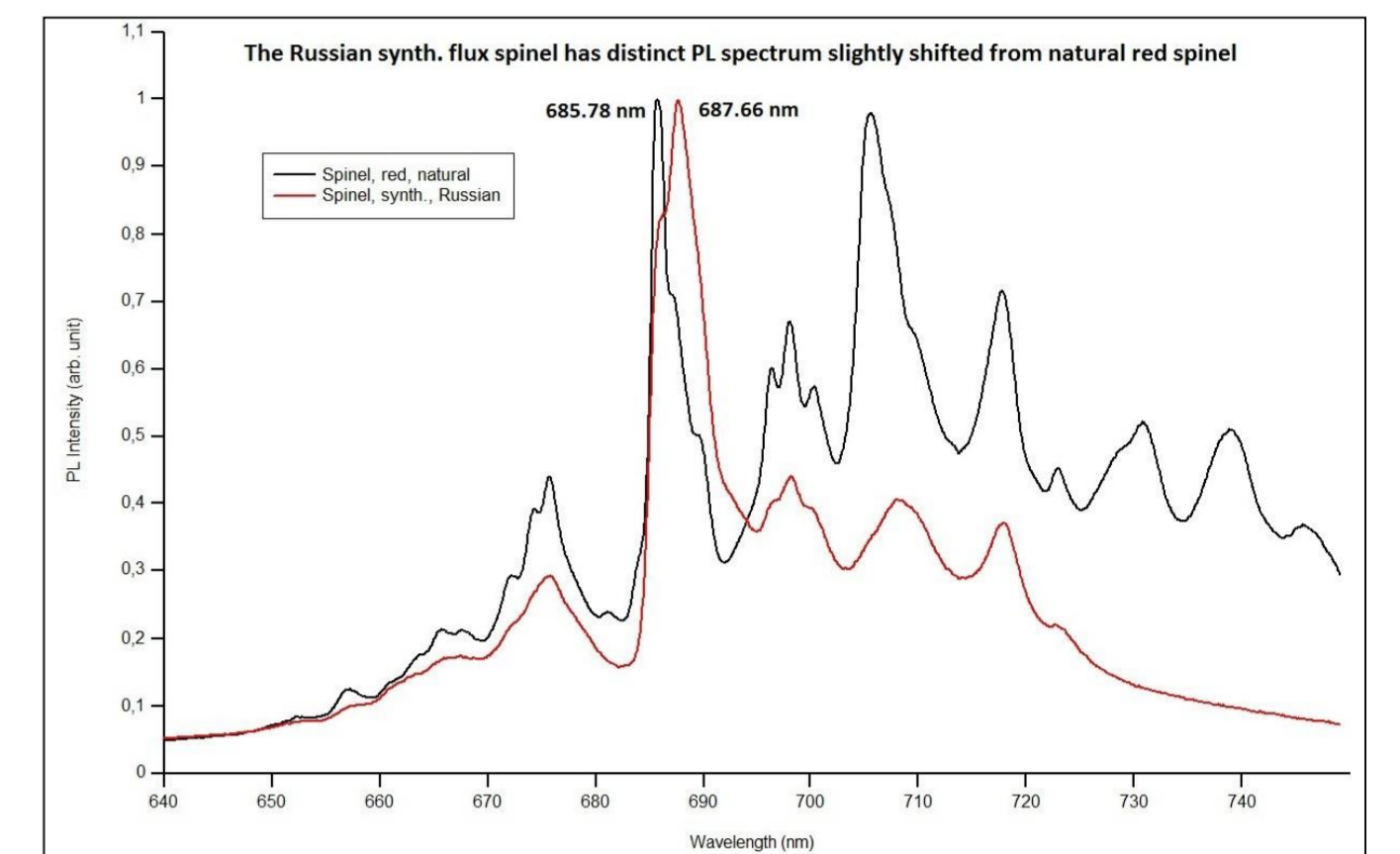
Results

PL Applications

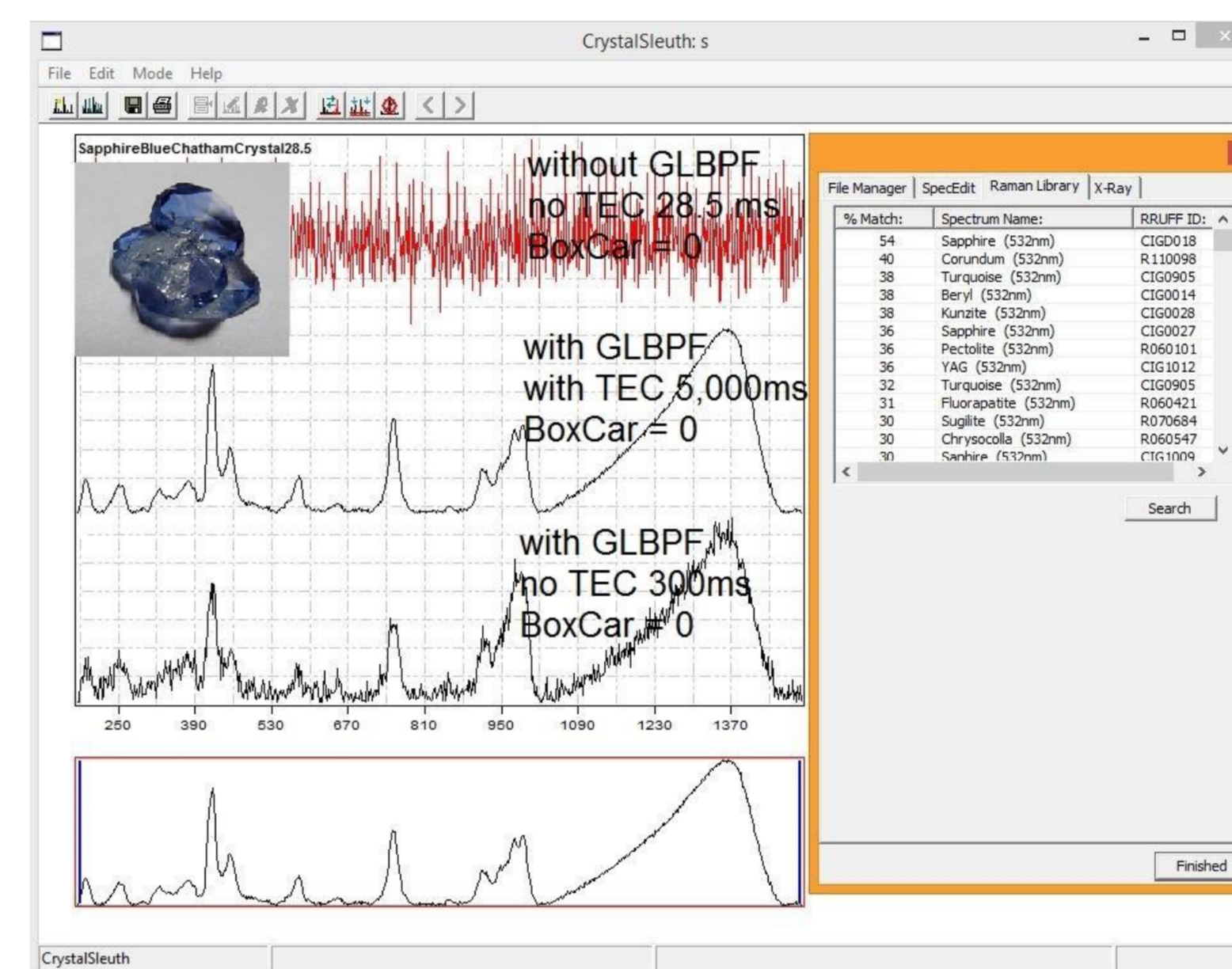
The GL Gem Raman PL532 TEC is a dual purpose Raman spectrometer with an adjustable 532 nm laser source (200 mW) and is suitable for PL studies in the range from 530 – 750 nm. After reducing the laser output to approximately 30% of full power photoluminescence patterns become visible.

Synthetic red flux grown spinel is quickly separated from natural red spinel; to arrive at the same conclusion using a microscope and other gem testing tools would have been more time consuming.

In a similar manner emerald types (whether natural or synthetic, also geological provenance) can be determined by observing chromium PL peak locations.



GL Gem Raman Band Pass Filter (GLBPF)



As seen in this strongly fluorescent flux grown sapphire crystal (Chatham) there is a dramatic signal improvement in Raman mode after insertion of a band pass dielectric filter.

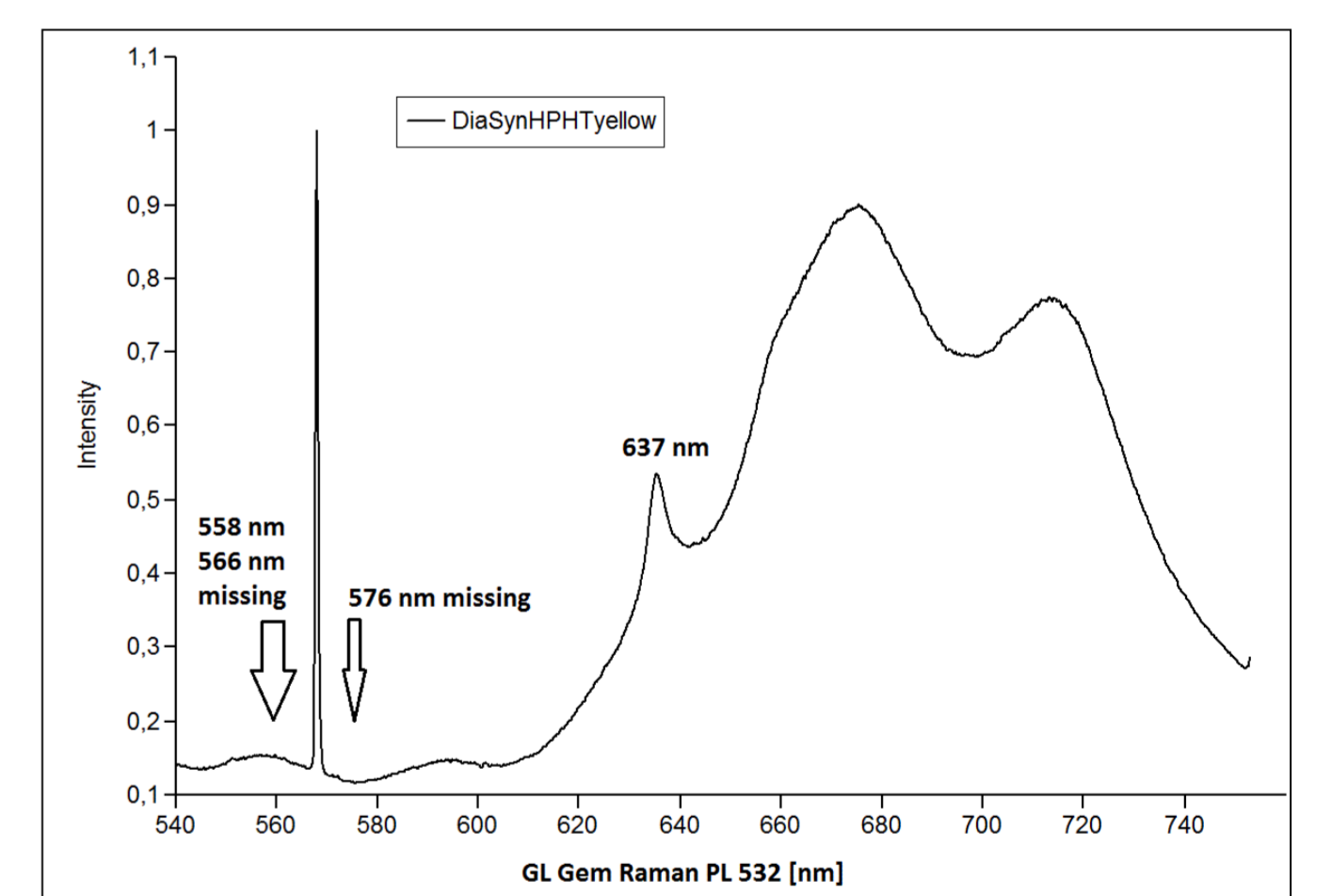
Combined with the TEC option exposure time was increased to 5,000 ms and the sample could be matched with an entry in the RRUFF database.

Current Challenges

One area of great interest are photoluminescence studies for diamond type screening and detecting HPHT treatments; intensive research is in progress. However, this method should be supported with other instrumentation and not be used alone.

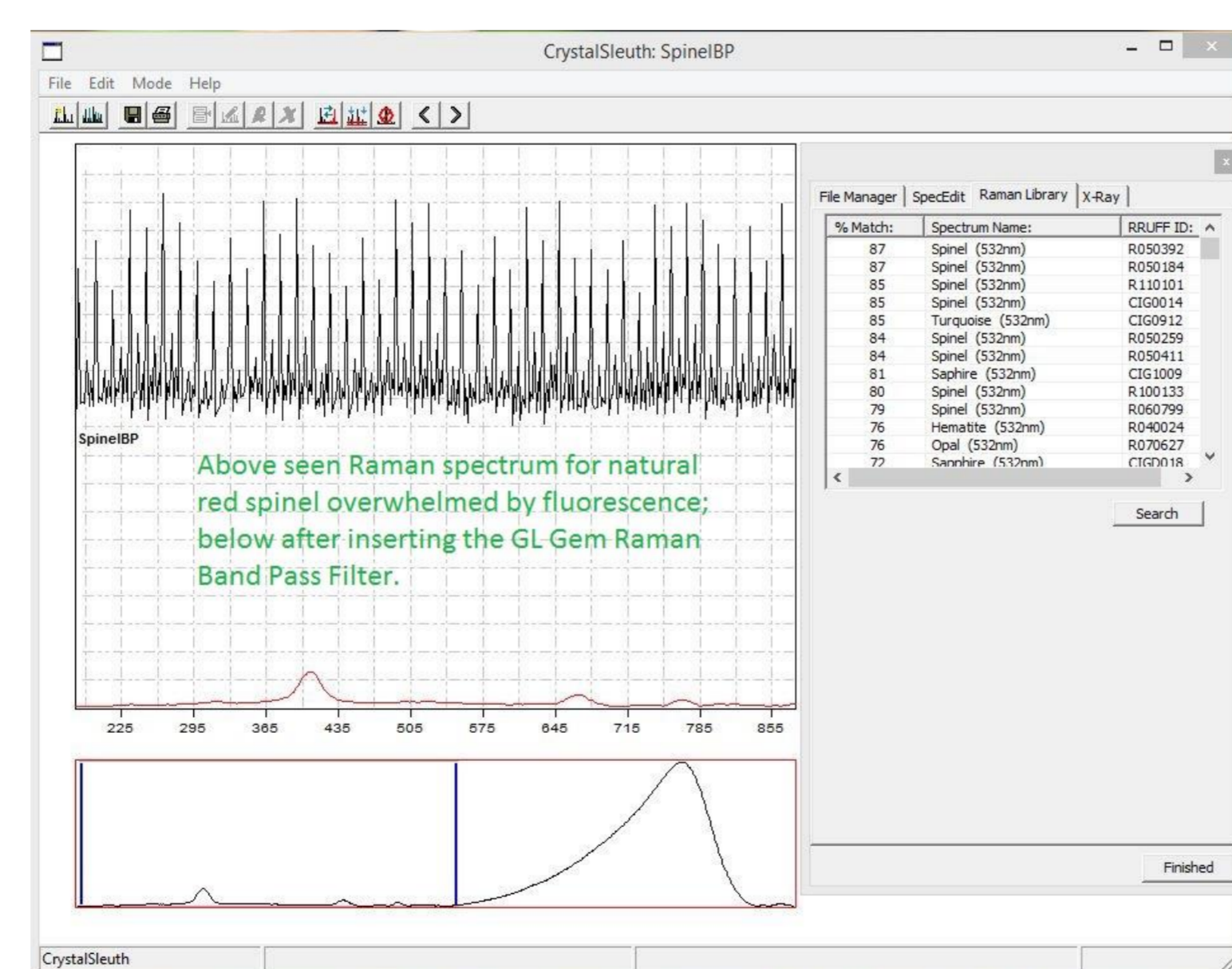
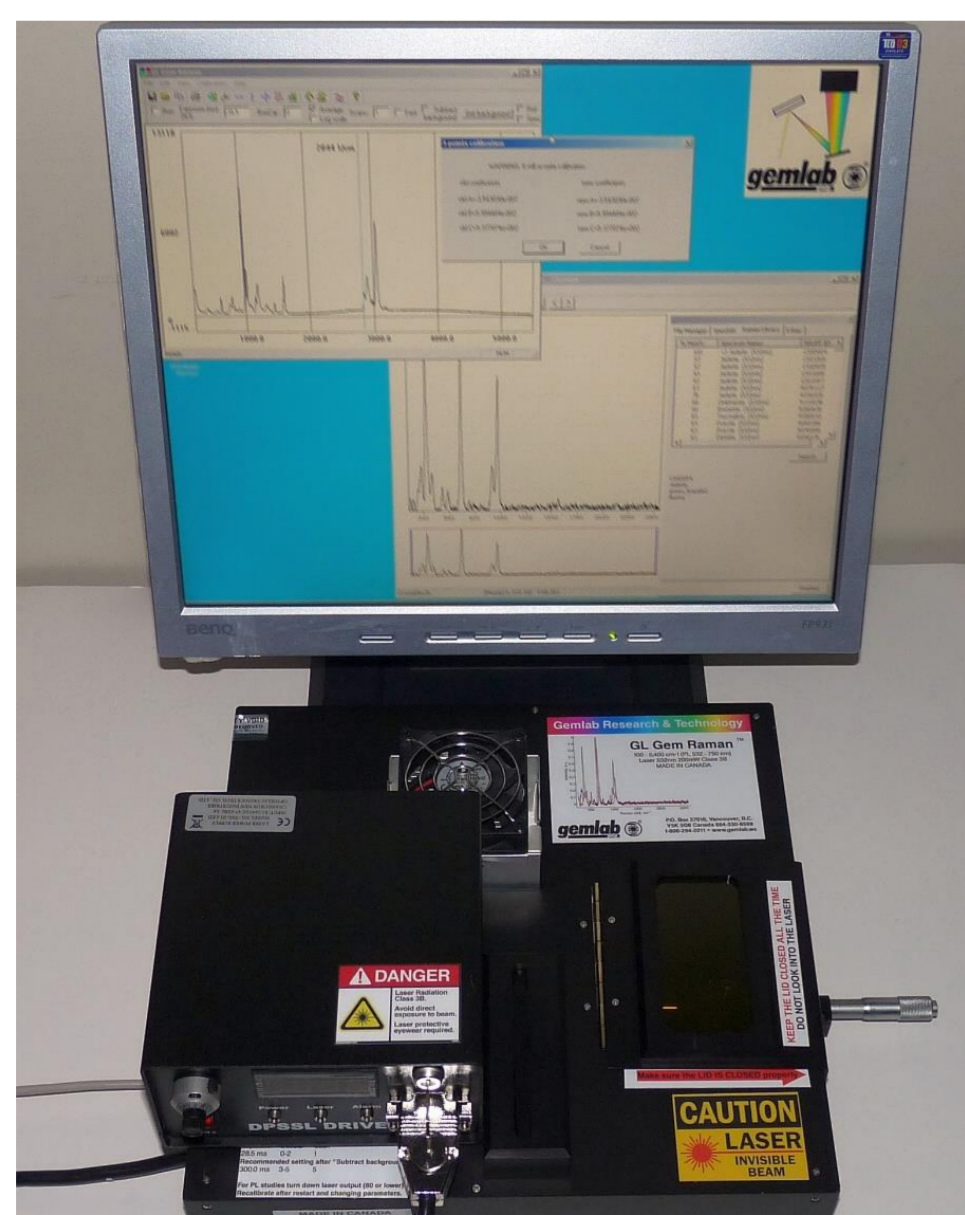
A synthetic HPHT treated diamond shows a nitrogen-vacancy defect at 637 nm; note also the suppression of the 558, 566 and 576nm bands which usually indicate untreated diamond if the 637 nm peak is missing as well. Strong silicon-vacancy peak at about 737nm may indicate CVD (chemical vapour deposition) grown diamond.

Crystallographic defects causing the above mentioned PL peaks for natural diamonds are not fully understood.

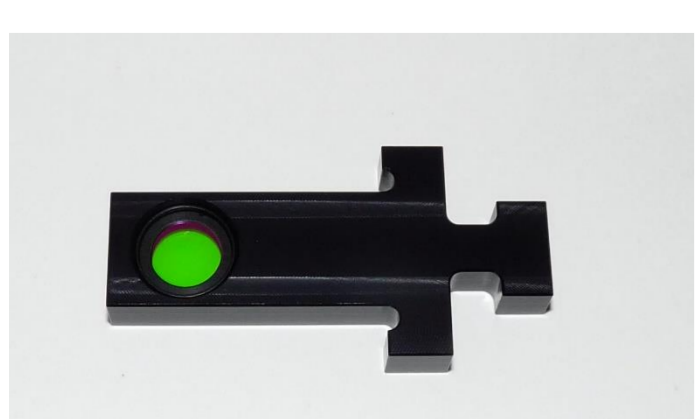


Method

Raman spectroscopy is scattering-based, not a result of transmission/reflection; i.e. there is no need for sample preparation. Only a small sample area is required; there are no movable optical parts in the Raman unit and maintenance is minimal.



TEC (thermo-electric cooled) Raman spectrometers are capable of detecting smallest Raman and photoluminescence signals with very high signal to noise ratio (up to 150 times lower dark current).



Recently (June 2014) the removable GL Gem Raman Band Pass Filter™ (GLBPF) for suppression of fluorescence in Raman mode has been introduced. In combination with the TEC option useful Raman signals can be measured in strongly fluorescent samples which was almost impossible with basic Raman spectrometers before.

Conclusion

Several economically priced Raman spectrometer systems are now available and allow for rapid identification of gems and minerals.

In general polished surfaces of gemstones produce good Raman scattering with high percentage matches in the RRUFF data-bases. For rough surfaces spectrometers with thermo-electric cooling (TEC) allow for low signal detection at exposure times of 1,000 ms and higher. The insertion of a dielectric band pass filter (such as the GLBPF) significantly suppresses fluorescence in Raman mode.

For the detection of synthetic diamonds and HPHT (high pressure high temperature) treatments the PL option of the Raman spectrometer is of particular value. With experience it may even provide a semi-quantitative estimate of trace elements such as chromium.

Acknowledgement

Raman and PL spectra were obtained with a GL Gem Raman PL532 TEC (175 – 5,470 cm-1) system with band pass filter from Gemlab Research & Technology; spectra were edited in Spekwin32; sample gemstones courtesy Canadian Institute of Gemmology, RRUFF Project Website: <http://www.ruff.info>

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