Applications in Gemology using the Spectrolaser

Introduction

The Spectrolaser® is a laser induced breakdown spectroscopy (LIBS) instrument that allows simultaneous determination of all detectable elements present in the material being analyzed. In LIBS, a laser pulse is used to form a small high-temperature and highly-electric field region on the sample surface. A portion of the sample is vaporized during the laser pulse, forming electronically excited atomic species under the plasma conditions formed at the surface. Fluorescence from the plasma is resolved using optical spectrographs to yield the elemental composition of the material.

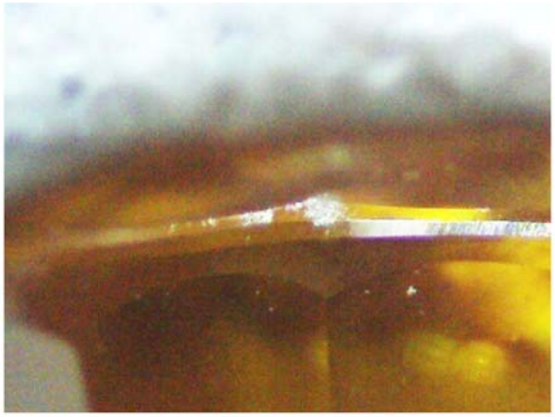
To overcome these challenges and achieve simultaneous elemental analysis, the Spectrolaser uses a patented multiple spectrograph, and a synchronous, multiple CCD spectral acquisition system. Typically four high-resolution spectrographs are used to observe fluorescence from the ultraviolet to infrared spectral region (190 – 950 nm). Each spectrograph and detector has its own analysis electronics triggered synchronously with the laser so that the entire spectral range is captured in a single laser pulse.

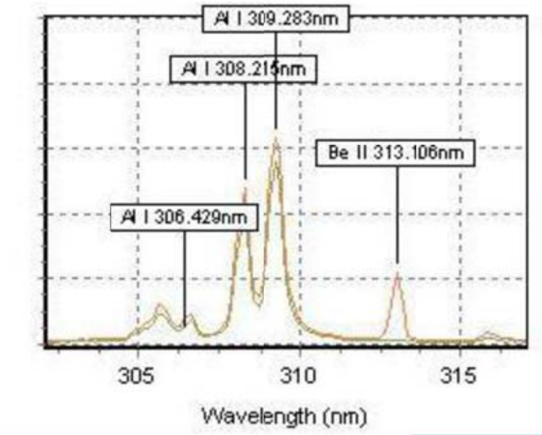
Traditionally the relative intensity of observed spectral lines is used to calculate elemental concentrations by comparison with standards. This has been a successful approach in analyzing many material types including a diverse range of mineral ores, industrial, and biomedical products[1-2].

Gemology Instrumentation

In gemology a new instrument known as the Spectrolaser *Target* has been developed to aid gemologists in gemstone classification. The new instrument differs in design to previous Spectrolaser instruments in a number of ways. Firstly, to aid gem classification, the infra-red 1064nm Nd:YAG laser typically used in Spectrolaser instruments, was replaced with an ultraviolet 355nm frequency tripled Nd:YAG laser (alternatively a 266nm option is also available). The UV laser produces a smaller focal point on the gemstone and is only absorbed at its very surface, thereby producing an inconsequentially small area of laser damage. Also included in the Spectrolaser *Target* is a cross-hair targeting camera system and a precisely adjustable mounting assembly that enables quick and easy positioning of the laser strike-point on the gemstone.

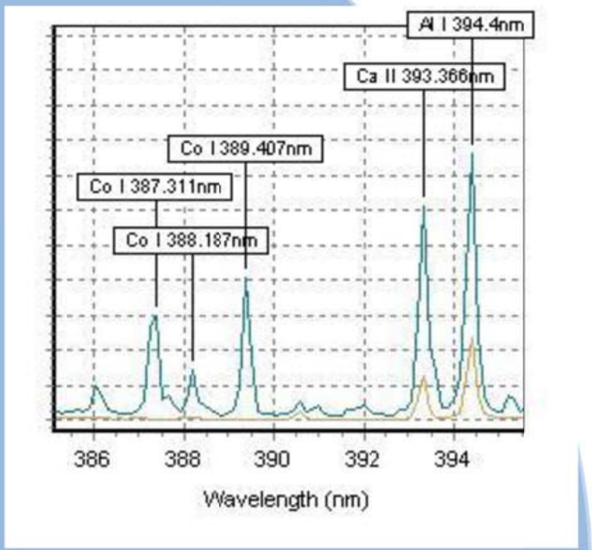
The result is minimal gem damage during the analysis process, such as the laser mark shown at right on the girdle of a sapphire (at 200x magnification). This particular laser crater is approximately 50 microns in diameter and was a result of five laser pulses at full laser power. Using one laser pulse an operator can reduce the laser mark to virtually imperceptible levels.





Applications of the instrument in gemology are widespread. For example, the identification of beryllium treated sapphire (left) is easily accomplished with the Spectrolaser *Target* by qualitative examination of the distinctive Be emission at 313.106 nm.

Another gemology application of the Spectrolaser is the identification of coated gemstones. For example, cobalt coating of natural topaz is a means of changing the color of the stone. Shown right is the comparison of natural and coated topaz where the difference is quite distinctive.



In addition to qualitative comparisons such as these, quantitative elemental analysis can also be achieved via calibration with standard materials. This has been a widely reported approach used in the analysis of a broad range of material types in solid, liquid, and even gaseous form. An alternative method of calibration is to use predictive spectral modeling to calculate the elemental component concentrations. A recently developed analytical software package is now included in Spectrolaser instruments to model LIBS emission spectra and predict sample composition using a calibration-free algorithm. The model uses a database of atomic emission lines to create a theoretical emission spectrum for selected elements using defined plasma parameters. The resulting theoretical spectrum is fitted to experimental data obtained from the Spectrolaser instrument. Good agreement has been obtained between predicted and certified values of elemental compositions in a variety of matrices, including metals and mineral ores[3].

References 1. D. A. Rusak, B. C. Castle, B. W. Smith, and J. D. Winefordner, Fundamentals and applications of laser-induced breakdown spectroscopy, Crit. Rev. Anal. Chem. 27 (4) (1997) 257-290 2. I. Ahmed and B. J. Goddard, An overview of laser induced breakdown spectroscopy, J. Fizik Malaysia. 14, (1993) 43-54. 3. Pavel Yaroshchyk, Doug Body, Richard J.S. Morrison, and Bruce L. Chadwick , A semi-quantitative standard-less analysis method for laser-induced breakdown spectroscopy, Spectrochimica Acta Part B 61 (2006) 200–209.