UV-LEDs - Setting a New Standard for Fluorescence Observations

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Extended Abstract

Until now luminescence in gemstones was best observed using long-wave (LW) and short-wave (SW) ultraviolet (UV) light sources. Numerous articles have been written about UV reaction as a useful property to help in the identification of natural, synthetic rubies, sapphires, diamonds, etc. and their treatments.

Recent studies published by Williams (2007) and confirmed by the author indicate that most SW "black-light" type (filtering out the 400 – 700 nm visible range) UV light devices show an additional mercury emission peak at 365 nm which is the LW reference (Figures 1 and 2).

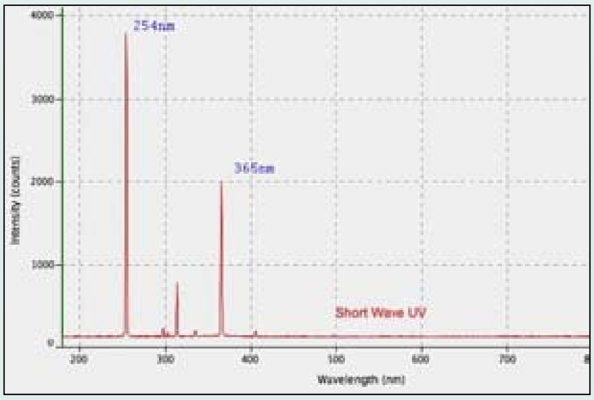

Figure 1: Emission spectrum of SW UV light.

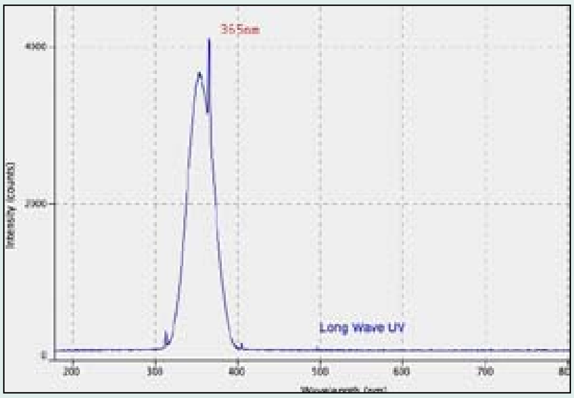

Figure 2: Emission spectrum of LW UV light.

Williams cautions that its existence (in addition to the SW reference line at 254 nm) "could lead to what is often interpreted as the stone "weakly fluorescing in SW", when in fact it is probably induced by the leaking LW component".

As a consequence gemmological reports without disclosing the spectrum pattern of the used UV light have questionable value and make it difficult to reproduce or confirm lab results.

LED Technology

We conducted further studies with our Ocean Optics USB 2000 (200 – 850 nm) spectrometer using inexpensive 395 nm LEDs found in key-chains, money, diamond and moissanite testers (Figure 3).

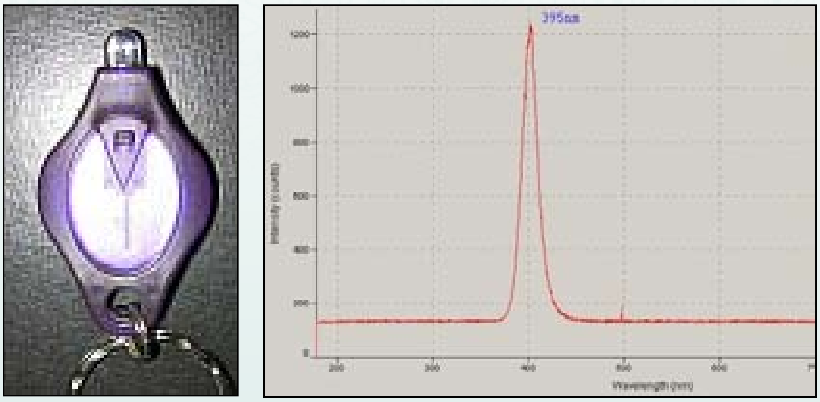

Figure 3: LED (395 nm) and its emission spectrum.

Using two synthetic yellow diamonds of different production (Figure 4) we were able to detect an interesting fluorescent reaction which was not present when using the classical SW/LW UV light source.

Figure 4: Synthetic diamonds.

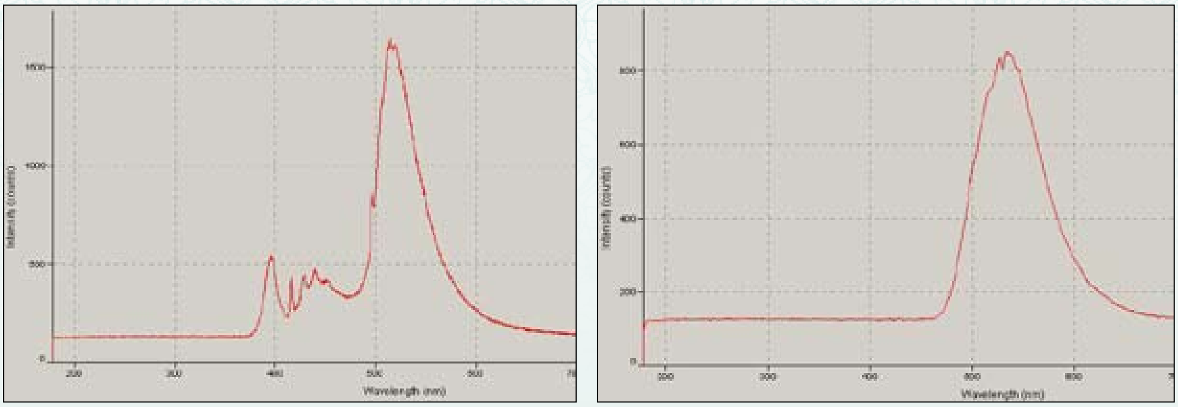

Figure 5 : Fluorescence (emission) spectra using 395nm excitation source.

The synthetic yellow diamonds (left deeper yellow, right of earlier Russian production) show a visible emission shift (into the 600nm area) with the left diamond having additional peaks in the 400nm area (Figure 5). The results are in accordance with Stokes Law: the emissions occur at a longer wavelength (lower energy level) than the energy source used to excite the stone.

We also observed strong fluorescence in different garnet species previously thought inert under both SW and LW light.

However, slight variations in energy levels (switching amongst similar LEDs) significantly affect the luminescent response. Hoover-Williams (2005) in "Crossed Filters Revisited" caution that different illuminants do not necessarily "increase the value of fluorescence in diagnostic testing."

Conclusions and Discussion

Deep UV-LEDs are being developed and a 270 nm UV LED is now available for under $ 100. Fox UV LEDs emit a narrow band focused on the i-line of mercury (365 nm) and could be introduced as a new reference standard for LW fluorescence reactions now.

A set of UV-LED "masters" at 254 nm (when commercially available), 270 nm, 365 nm and 395nm (all available) could be developed for gem testing in the future.

A stone might then be described as "no fluorescence at 254nm, slightly yellowish at 365nm, strong greenish yellow at 395 nm". The use of a UV-VIS spectrometer could help to compile an accurate spectro-fluorometry data-base for many gemstones.

Outlook

- UV LED power is rapidly increasing to be competitive with HP-Hg lamps.
- Narrow spectrum, cool operation, compact size and integration into digital testing equipment make UV LEDs ideal for fluorescence observations in gemstones.
- Cost of UV LEDs will rapidly decrease as demand increases.

The advent of low-cost blue/violet lasers (such as found in Blu-ray disc players) and other lasers provide additional fields of potential research. Now is the time for the gemmological community to explore and set new and accurate standards based on available technology.

References

Fox Group of Electronics, 2009, Product Description UV LEDs, Available from http://www.thefoxgroupinc.com
Hoover, D. and Williams, B., 2005, Crossed Filters Revisited, Journal of Gemmology, Vol.29, No.7-8, p. 473-481.
Williams, B., 2007, Technology Update-Ultraviolet Light, The Guide, Gem world International, January/February 2007, p.8 – 11.