Ancient TL

www.ancienttl.org · ISSN: 2693-0935

Galloway, R. and Neal, M., 1998. *Green light-emitting diodes used for stimulation of luminescence.* Ancient TL 16(1): 1-3. https://doi.org/10.26034/la.atl.1998.284

Green light-emitting diodes used for stimulation of luminescence

R. B. Galloway and M. A. Neal

Department of Physics and Astronomy, The University of Edinburgh, Mayfield Road, Edinburgh EH9 3JZ, Scotland.

(Received 25 July 1997 ; in final form 10 February 1998)

This note concerns measurements of the spectra of the light emitted by diodes which have been used for the stimulation of luminescence from quartz. The measurements justify previous empirical conclusions concerning the choice of optical filters for separation of luminescence from scattered stimulating light. Also, past indirect inference of the optical power from the LEDs at the sample is substantiated by direct measurement. Data is presented on three LEDs, the III-V number TLMP7513 as used in the first account of the stimulation of luminescence by green LEDs (Galloway, 1992), the Toshiba TLPGA183P which was briefly investigated as as a possible improvement, and the recently produced Nichia NSPG-500 which has proved to be a substantial improvement on the original (Galloway *et al.*, 1997, in which the Nichia NSPG-500 was denoted 110104). The manufacturer's specifications for these diodes are summarised in table 1.

Optical spectra from one of each type of diode were measured using a spectrophotometer (type EO-85 made by Daedalon Corporation, 35 Congress Street, Salem, MA 01970, U.S.A.) which comprised a 25 μm wide slit from which light was collimated on a 700 lines/mm holographic grating, with the diffracted light focused by an f/1.8 50 mm lens on to a CCD detector of 1728 active pixels (with additional pixels for dark signal subtraction). A PC microcomputer displayed and recorded the spectral data. A spectrum from the type NSPG-500 LED at a current of 20 mA is shown in fig. 1. Of principal interest for luminescence stimulation are the wavelength at the maximum intensity and the range of wavelengths of light emitted. This information is summarised in table 1, in which the range of wavelengths of light emitted is indicated by the full width at half maximum and by the short and long wavelengths at which the intensity falls to 0.5% of the peak value. The 0.5% of peak intensity was the lowest intensity that could be distinguished from background noise, which can be seen in fig. 1 as the finite intensity recorded extending to the extremes of the wavelength scale.

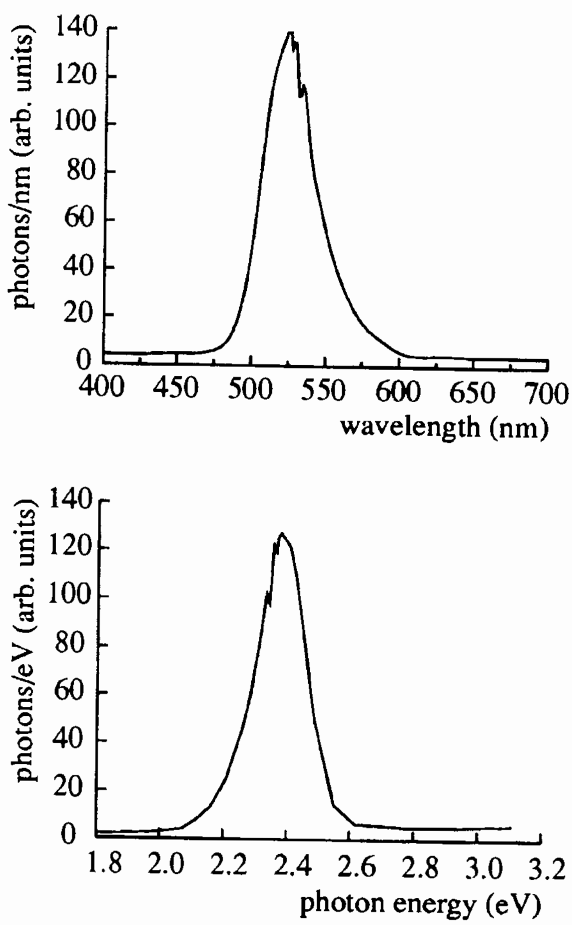

Figure 1.
A spectrum (corrected for the variation of sensitivity of the CCD with wavelength) from the Nichia NSPG-500 LED at a current of 20 mA with, for comparison, the spectrum plotted in terms of photon energy.

The emission spectrum is not symetrical; for diode type NSPG-500 (fig. 1) the fall in intensity from the peak towards shorter wavelengths is sharper than the fall towards longer wavelengths; the same is true for diode type TLMP7513; the reverse is the case for diode type TLPGA183P, which has the sharpest emission peak.

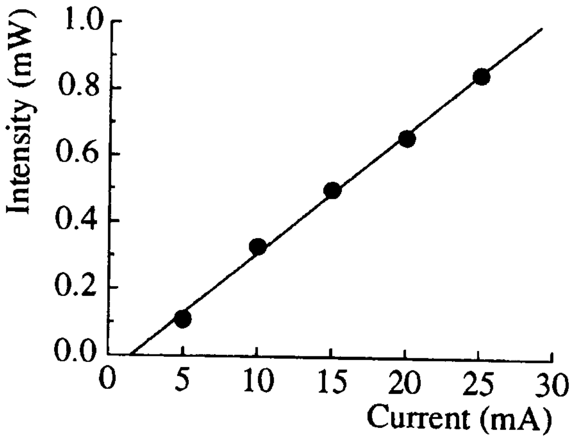

Figure 2.
The power emitted within a 20° cone by the NSPG-500 LED related to the current through the diode. The measurements were made using an optical power meter with pin diode, supplied by Ealing and factory calibrated at 652 nm.

For all three diodes the emitted light intensity is proportional to the current through the diode from 5 mA up to the maximum specified by the manufacturer (data for diode type NSPG-500 is shown in fig. 2), with no noticeable change in the shape of the spectrum. Further, there is no change in spectral shape with time from switching on the current through the diode. A current of 20 mA was switched through the diode under test and spectra recorded (which takes 140 ms measurement time) immediately and after 30, 60, 120, 240, 480 seconds. The only change with time since switch-on was that the initial spectrum showed a slightly higher intensity, of a few percent. This small change in intensity with time since switch on was investigated further by using a photomultiplier (type 9635QA) preceded by a neutral density filter to detect the change in photon counting rate with time, fig. 3. For the NSPG-500 diode, the photon counting rate during the first two seconds was 3% above the average value during the following 250 s. The (3 ± 0.6)% initial decrease in intensity is reproducible. The TLMP7513 diode showed a (6 ± 0.7)% initial decrease. The TLPGA183P diode was not tested in this way. Fig.3 shows that for the NSPG-500 diode, after the first two seconds the counting rate decreased by 1% in 4 minutes. Three similar measurements over a period of 2500 s indicated that, after the first 2 s, the counting rate increased by (1 ± 1)% in 40 minutes.

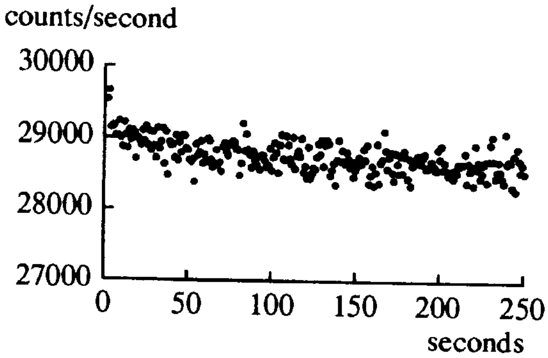

Figure 3.
The number of photons recorded in 250 successive 1 s intervals immediately following the switching of 20 mA through a Nichia type NSPG-500 LED, with the photomultiplier protected by a neutral density filter. The first two points are 3% above the mean. After the first 2 s, the decrease is 1% in the following 4 minutes.

Although it was not possible to follow the short wavelength side of the spectrum from the type NSPG-500 diode to less than 0.5% of the peak intensity, the fall from 50% to 0.5% was approximately exponential, and extrapolation to shorter wavelengths indicated that $\sim 10^{-4}$ of the total intensity could be emitted at wavelengths less than 400 nm. When using these diodes to stimulate quartz luminescence, the typical filter combinations used to separate luminescence from scattered green light transmit light of wavelengths less than 400 nm. The power output from the type NSPG-500 diode corresponds to the emission of 1.8×10^{18} photons/s, so that $\sim 10^{14}$ photons/s could be in the pass-band of the luminescence selecting filter. Even if this simple calculation is off by several orders of magnitude, the need to deal with it is clear. In line with these findings, it had been noted empirically (Galloway *et al.*, 1997) that Schott GG475 'long-pass' filters in front of the diodes adequately blocked the short wavelength photons when the type NSPG-500 were used for stimulation; without them the luminescence detecting system was swamped by scattered light.

The power emitted within a 20° cone by each LED was measured using an optical power meter with pin diode (supplied by Ealing Electro-Optics plc, Graycaine Road, Watford, Herts, WD2 3PW, U.K., factory calibrated at 652 nm), table 1. Thus the system of 16 type NSPG-500 diodes (Galloway *et al.*, 1997) should have about 11 mW illuminating the 1 cm^2 sample, in agreement with the indirect estimate of about

10 mW cm^{-2} made from the time taken to reduce luminescence from quartz to 50% of the initial value.

In changing from the type TLMP7513 diodes (Galloway, 1992) to the type NSPG-500 diodes (Galloway et *al*., 1997) an improvement in efficiency of luminescence stimulation of 70 times was attributed to the change in diodes. This should be due in part to the increased power from the diodes (~14 times from table 1) and in part to the increased sensitivity of quartz to the shorter wavelength light. The sensitivity change on changing from 565 nm to 525 nm (2.20 to 2.37 eV) stimulation is 5 times (Huntley *et al*., 1996; Botter-Jensen *et al*., 1994; Spooner, 1994). Combining the diode power ratio and the sensitivity change gives a factor of 70 in agreement with the measured ratio ~70.

References

Botter-Jensen, L., Duller, G.A.T. and Poolton, N.R.J. (1994) Excitation and emission spectrometry of stimulated luminescence from quartz and feldspars. *Radiat. Meas*., **23**, 613-616.

Galloway, R.B. (1992) Towards the use of green light emitting diodes for the optically stimulated luminescence dating of quartz and feldspar. *Meas. Sci. Technol*., **3**. 330-335.

Galloway, R.B., Hong, D.G. and Napier, H.J. (1997) A substantially improved green-light-emitting diode system for luminescence stimulation. *Meas. Sci. Technol*., **8**, 267-271.

Huntley, D.J., Short, M.A, and Dunphy, K. (1996) Deep traps in quartz and their use for optical dating. *Can. J. Phys*., **74**, 81-91.

Spooner, N.A. (1994) On the optical dating signal from quartz. *Radiat. Meas*., **23**, 593-600.

manufacturer	III-V	Toshiba	Nichia
type no.	TLMP7513	TLPGA183P	NSPG-500[(a)]
specification:			
peak wavelength (nm)	565	562	525
emission angle (deg.)	25	8	15
luminous intensity (mcd at 20 mA)	300	272-1288	3000-6000
max. current (mA)	25	50	30
measured (for 20 mA):			
peak wavelength (nm)	567 ± 2	570 ± 2	522-526 ± 2
FWHM (nm)	30 ± 2	11 ± 2	42 ± 2
0.5% of peak intensity (nm)	475 ± 20, 655 ± 10	510 ± 10, 620 ± 10	420 ± 10, 655 ± 10
power into 20° cone (mW)	0.051 ± 0.005	0.076 ± 0.005	0.687 ± 0.005

Note: (a) The Nichia NSPG-500 was denoted 110104 in Galloway et al. (1997), the part number used by our supplier, M.I. Cables Ltd., Inverness IV3 6EX, Scotland.

Table 1.
Properties of the light emitting diodes tested.

Reviewer
D.J. Huntley