Characterisation of AlGaN detectors for UV measurements

N. Swift, J. D. Hamlin and K. M. Nield
Measurement Standards Laboratory, Industrial Research Ltd, PO Box 31-310, Lower Hutt, New Zealand

Richard L. McKenzie
National Institute of Water and Atmospheric Research (NIWA), Lauder, Central Otago, New Zealand

Abstract. Characterisation of commercially available AlGaN Schottky detectors was performed and their spectral response compared with that of the CIE defined Erythemal and Vitamin-D response curves and older technology detectors. We found these detectors had an excellent 'solar blind' nature and are a good match to these CIE response curves.

Introduction

Since the late 1990s, $Al_xGa_{1-x}N$ detectors have advanced from being the focus of research in the lab to becoming a cheaply manufactured commercial product. Their bandpass shape can be adjusted by varying the concentrations of Aluminium (Al) and Gallium (Ga) relative to each other. Higher Al concentrations provide a short wavelength cut-off. These detectors have various applications in the measurement of UV irradiance such as in solar measurements, sterilisation processes and communications devices. In the case of the detectors tested, their suitability as personal dosimeters was assessed. The detectors measured were:

- Two SVTA UV-B sensors – $Al_{26}Ga_{74}N$ concentration.
- One SVTA UV-B sensor with UG11 filter.
- Two GUVB-S11GD UV-B sensors – $Al_{17}Ga_{83}N$ concentration (as used in the dosimeter badges that are currently being used by NIWA).

The AlGaN Calibration Process

The spectral response of the device under test was compared with that of an MSL reference detector calibrated for spectral response. Each detector was sequentially irradiated with monochromatic light of increasing wavelengths from a McPherson 2035D double monochromator.

A slow response time from the detectors was observed which could be due to the low irradiance monochromatic light used during calibration but otherwise may still be a problem under sun light. This slow response was characterised by data-logging the output from the detector during a series of exposures to 300 nm monochromatic light. Additional techniques were applied during spectral response calibration to minimise this slow response:

- Extended the time delay between irradiating the detector and taking measurements from around 5 s to 30 s.
- Applied a -0.015 V bias for some measurements.

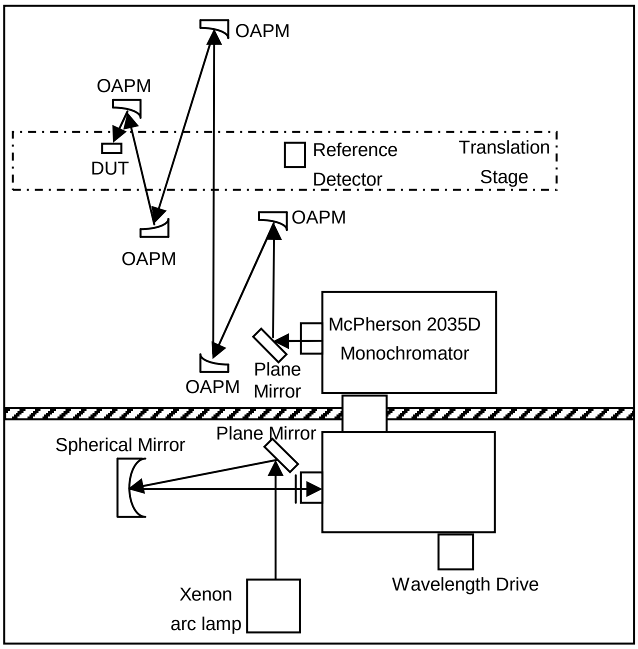

Figure 1. Optical layout of the detector responsivity system.

AlGaN Results

Response Time Measurements

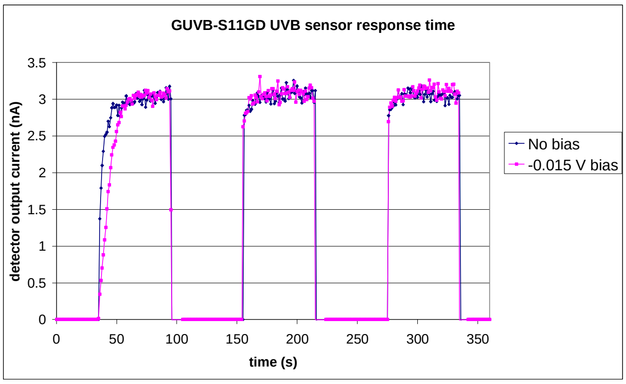

Figure 2. Response time measurements of GUVB-S11GD detector.

After an extended period of time under no UV irradiation, the response time became significantly slower:

- 10 % - 90 % rise time of around 10 s with no bias applied.
- 10 % - 90 % rise time of around 15 s with bias applied.

Contrary to expectations, applying a -0.015 V bias actually slowed the initial response time further. On subsequent exposures the response time was much reduced as observed in Figure 2.

Spectral Response Measurements

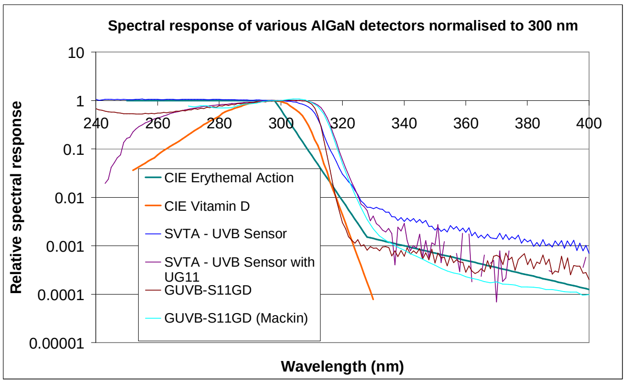

Figure 3. Spectral response of the AlGaN detectors compared with the CIE erythemal and Vitamin-D action spectra.

As anticipated, the AlGaN detectors displayed a sharp edge in spectral response, with no response to visible irradiation. However, in the case of the SVTA detectors the edge was steeper than the manufacturer data suggested and identical detectors showed small changes in edge position. Slow response time was the primary uncertainty factor, giving an overall expanded uncertainty of around 5 %.

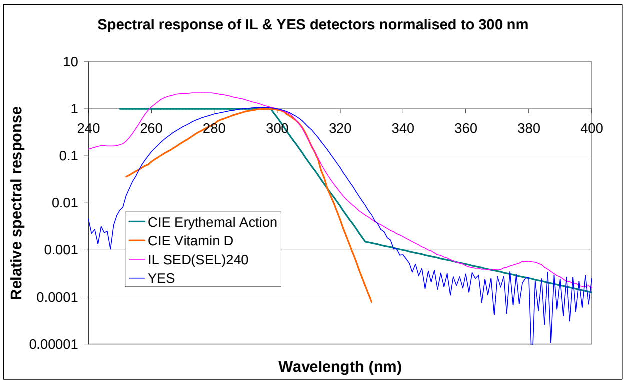

Figure 4. Spectral response of International Light and Yankee Environmental Systems (YES) broadband radiometers as compared with the CIE erythemal and vitamin-D action spectra. Both are intended for solar measurements.

The older vacuum photocell based International Light detector and fluorescent phosphor and Silicon based Yankee are prone to long wavelength leakage and require additional filtering to ensure effective solar blindness. Although common practice, finding a suitable filter-detector combination which matches the response function adequately can be challenging and introduce additional performance issues. For example, the transmittance of interference filters may vary with the angle of incidence of incoming light and some filters are susceptible to fluorescence.

Discussion

For UV measurement purposes, AlGaN detectors are increasingly being used as a better alternative to Si based detectors due to their superior UV response, solar blindness and greater resistance to UV degradation. It is well known higher Al concentrations produce poorer quality layers in the detector and move the cut-off to shorter wavelengths. With the bulk, low cost manufacturing of this type of detector, a concern is their characteristics may be inconsistent between each batch produced or indeed each detector.

Conclusions

The AlGaN detectors measured have shown they can be tailored to closely match the CIE Erythemal and Vitamin-D action spectra. However to have confidence in such devices, it is recommended to perform independent spectral response measurements to verify the general specifications supplied by the manufacturer and perform such measurements on a random sample to verify the variability between detectors.

References

Saito, T., Group III – Nitride Semiconductor Schottky Barrier Photodiodes for the Radiometric use in the UV and VUV Regions, *Metrologia*, vol. 46, S272-S276.

R. L. McKenzie et al. “Quantifying Personal UV Exposure History and Application to Health Issues”, Presentation to European Society of Photobiology, Wroclaw, Poland, 10 September 2009.

Steve Mackin (Solartech Inc) and Richard McKenzie (NIWA) Personal communication.

Touzi C., F. Omnes, T. Boufaden, P. Gibart, B. El Jani, Realisation of ‘Solar Blind’ AlGaN Photodetectors: Measured and calculated spectral response, *Microelectronics Journal 37*,(2006) 336-339.

Butun, S., T. Tut, B. Butun, M. Gokkavas, H. Yu, E. Ozbay, Depp Ultraviolet Al$_{75}$Ga$_{25}$N photodiodes with low cutoff wavelength, *Applied Physics Letters 88*, 123503 (2006).