A comparison of the performance of a photovoltaic HgCdTe detector with that of large area single pixel QWIPs for infrared radiometric applications

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Abstract. Newly developed single pixel, large area Quantum Well Infrared Photodetectors (QWIPs) and a photovoltaic HgCdTe detector have been characterized using the NPL infrared detector characterization facilities. Spectral responsivity and D* values of both detector types were shown to be high enough to satisfy the requirements of a number of applications in infrared radiometery. However, neither detector type can be considered for high accuracy radiometric applications, mainly due to serious drawbacks in their spatial uniformity of response profiles.

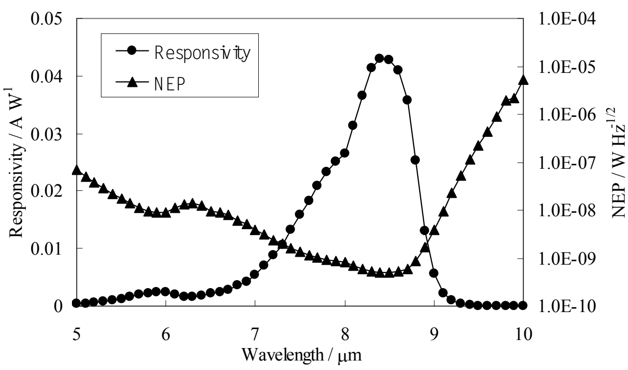
Introduction

A previous evaluation of infrared detectors for radiometric applications has shown that the performance of commercially available detectors is far from ideal, for wavelengths longer than 5 µm [1]. For example, large area (up to 4 mm by 4 mm active area) photoconductive (PC) HgCdTe detectors exhibit very large (>20%) spatial non-uniformities in their response [1] whereas thermal detectors such as pyroelectric detectors based on non-hygroscopic crystals have relatively low specific detectivity (D*) values. Extrinsic photoconductors require cooling to well below 77 K and are not available with sufficiently large active areas [2]. Additionally, the response of PC HgCdTe devices has been shown to be non-linear at relatively low levels of incident photon irradiance [3]. If the operating temperature of the detector is restricted to 77 K or higher, then PV HgCdTe detectors offer the highest D* values in the 8 µm to 12 µm spectral region. However, PV HgCdTe detectors whose response extends to 12 µm are currently available with active areas up-to 2 mm diameter which is smaller than the active areas required for the majority of applications in infrared radiometry [1]. Quantum Well Infrared Photodetectors (QWIPs) [4] are now well established for use in state-of-the-art cooled thermal imaging systems. For fundamental optical measurement applications, for example infrared spectral responsivity standards, it is normal (and sufficient) to use a single element detector [1]. Some QWIPs are made from layers of $GaAs/Al_xGa_{1-x}As$ which can be mass grown on large substrate wafers. The fabrication of these materials is well established and promises to deliver large area, single pixel photodetectors with high spatial uniformity of response.

Results

The performance of two single pixel, large area QWIPs which were specially commissioned by NPL and manufactured by QWIP Technologies, USA, were compared with that of a commercially available 2 mm diameter photovoltaic (PV) HgCdTe detector. Parameters which were compared include the absolute spectral responsivity, Noise Equivalent Power (NEP), spatial uniformity of response, non-linearity and stability. Figure 1 illustrates the DC equivalent absolute spectral responsivity and noise equivalent power of one of the QWIP detectors in the wavelength range from 5 µm to 10 µm. Both detector types were shown to have sufficiently high spectral responsivity and D* values to satisfy a number of applications in infrared radiometry when operated at 77 K. However, the spatial non-uniformity of response of both QWIPs examined was unacceptably high. Furthermore the spatial uniformity of response of the same detectors was shown to be strongly dependent on the state of polarisation of the incident radiation as well as also exhibiting some dependency on wavelength. The spatial uniformity of response of the PV HgCdTe detector was shown to be very poor due to the very low shunt resistance of this detector. However, it exhibited no polarisation dependency and only a slight dependency on wavelength for wavelengths below 5 µm. Neither detector type could be considered for high accuracy radiometric applications in their current form.

Figure 1. Absolute spectral responsivity and NEP of the QWIP



detector.

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