The NPL Infrared Spectral Responsivity Measurement Facility

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Introduction

The establishment of a spectral responsivity scale requires detectors on which to base the scale and a facility which can be used to calibrate these detectors. FT spectrometers cannot readily be used for the establishment of a spectral responsivity scale because the responsivity of most detectors exhibits a dependency on the modulation frequency. NPL has assembled an infrared spectral responsivity measurement facility which is based on a double-grating monochromator and is able to cover the 0.9 µm to 24 µm wavelength range. The purpose of this poster is to summarise the construction of this facility and describe some of the measurements accomplished with it.

Description of the Facility

A schematic of the layout of the NPL infrared spectral responsivity measurement facility is shown in Figure 1. The facilities are based on two 0.25 m focal length double grating monochromators operating in the subtractive mode. The double-grating monochromator uses aspheric mirrors to minimise aberrations and a total of six pairs of gratings are used to cover the 0.8 µm to 24 µm spectral region. The six grating pairs are blazed at 1 µm, 2 µm, 4 µm, 8 µm, 12 µm and 24 µm. The exit slit of the monochromator has been modified to accept thin film circular apertures whose diameters vary from 50 µm to 3 mm. Sets of standard monochromator slits are also available. Two sets of optics are used after the exit slit of the monochromator. One set consists of an identical pair of optically polished Off Axis Parabolic (OAP) mirrors so that the real image of the exit slit of the monochromator is formed with unity magnification (see Figure 2). These F/4 OAP mirrors are coated with protected gold reflective coatings for maximum reflectance in the infrared and have focal lengths of 457 mm. The OAP mirrors ensure that the real image formed has very low aberrations and can easily under-fill the active area of detectors of 100 µm diameter for radiant power spectral responsivity calibrations. A second set of optically polished OAP mirrors are used to magnify the image of the exit port by approximately a factor of four. The first mirror of this pair is an F/4 mirror with a 152 mm focal length and is used to collimate the monochromator output. The second OAP mirror has a 640 mm focal length and focuses the collimated output. This enables the production of magnified real images of the exit slit of the monochromator of diameters up to 12 mm and allows the calibration of the irradiance responsivity of infrared detectors and detector arrays and matrices.

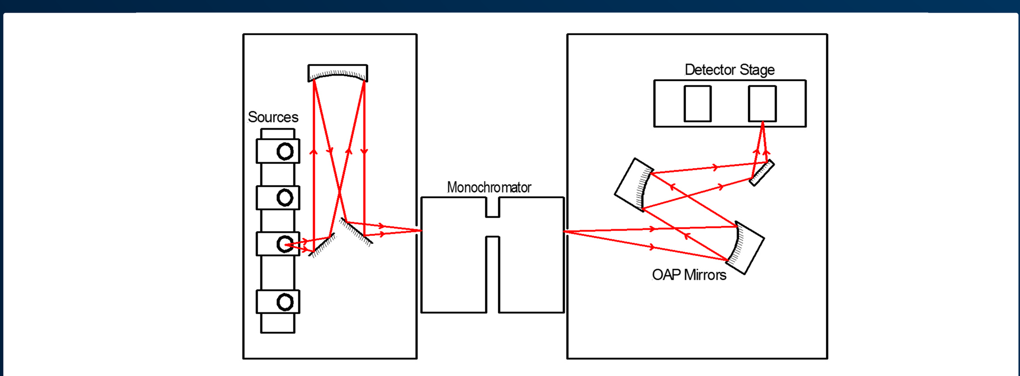

Figure 1: Schematic diagram of the layout of the NPL infrared spectral responsivity measurement facility.

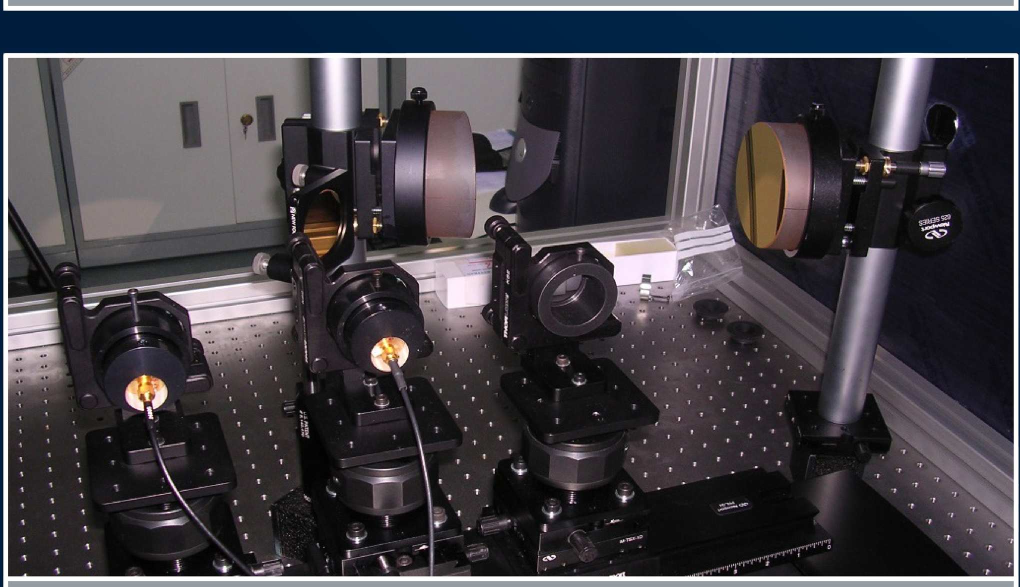

Figure 2: Two OAP mirrors image the monochromator exit slit on to the active areas of the detectors whose responsivity is being compared.

The detectors whose spectral responsivity profiles are being compared are mounted on computer-controlled linear translation stages (see Figure 2). The software that controls this fully automated facility compares the spectral responsivity of the detectors at one particular wavelength before the monochromator wavelength changes and the comparison is repeated at the new wavelength. This ensures that any problems due to apparent drifts in the detector responsivity, highlighted elsewhere [1], are reduced in magnitude. The facility is divided into three different light-tight compartments (see Figure 1) that can be independently purged with dry, CO_2-free air for further suppression of the atmospheric absorption effects [2]. The addition of a third OAP mirror permits the radiation forming the real image of the exit slit to be re-collimated and used to calibrate the relative spectral responsivity of thermal imagers/imaging radiometers.

The source compartment includes two different sources; a tungsten strip lamp with a sapphire window which can be used for wavelengths up to 5.5 µm and a glow-bar source which is used at longer wavelengths. The sources are imaged onto the entrance slit of the monochromator using reflective optics. A mechanical chopper with a two-slot blade is mounted in front of the entrance slit as part of the noise suppression system. The frequency of the chopper is actively stabilised to eliminate problems that could arise due to the frequency dependent responsivity of many thermal detectors.

The facility is used in association with a set of cavity pyroelectric detectors [3] to establish the NPL relative spectral responsivity scale in the 0.9 µm to 24 µm wavelength range [3]. Figure 3 shows a sketch of the NPL cavity pyroelectric detector on which the NPL relative spectral responsivity scale is based in the 200 nm to 20 µm wavelength range [3]. The technique involves repeating a measurement with and without the reflective hemisphere in place [3]. Figure 4 shows a photo of an NPL cavity pyroelectric detector with a gold-coated reflective hemisphere [3].

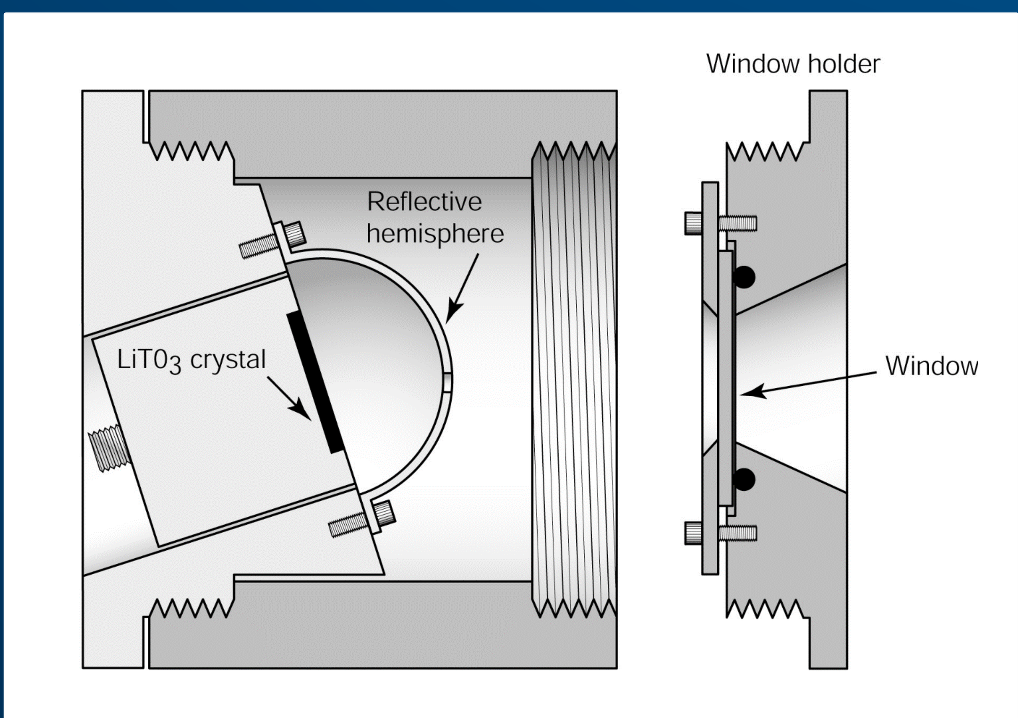

Figure 3 (above): Sketch of the NPL cavity pyroelectric detector on which the NPL relative spectral responsivity scale is based [3].

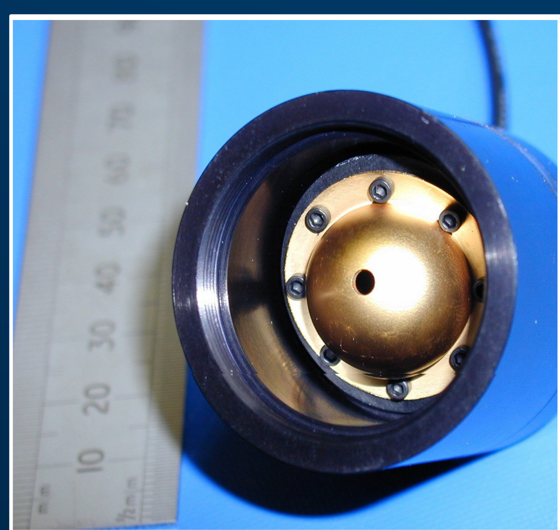

Figure 4 (right): Photo of an NPL cavity pyroelectric detector with a gold-coated reflective hemisphere [3].

The infrared spectral responsivity measurement facility is also being used to disseminate the absolute spectral responsivity scales which is derived from the NPL cryogenic radiometer [4]. Figure 5 shows the absolute spectral radiant power responsivity of a 5 mm diameter InSb detector (includes fixed-gain amplifier) in the 1 µm to 6 µm wavelength range.

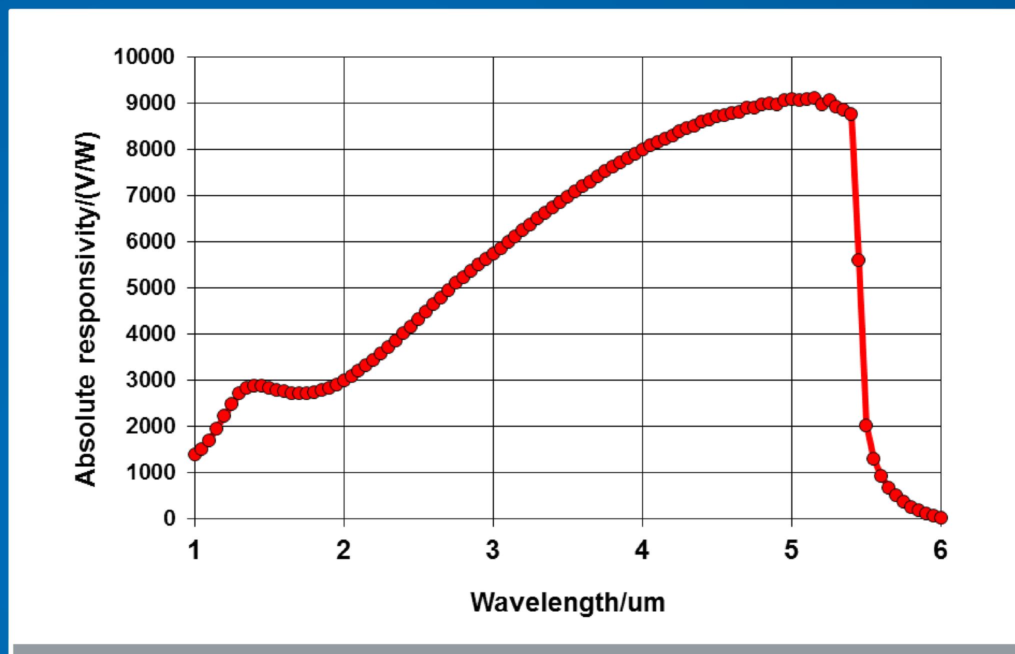

Figure 5: The absolute spectral radiant power responsivity of a 5 mm diameter InSb detector (includes fixed-gain amplifier) measured using the NPL infrared spectral responsivity measurement facility.

Figure 6 shows the absolute spectral responsivity of a large area Quantum Well PhotoDetector (QWIP) in the 2 µm to 10 µm wavelength range, measured using the NPL infrared spectral responsivity facility [5]. Also shown in the same Figure is the Noise Equivalent Power (NEP) of the same detector as a function of wavelength at a modulation frequency of 80 Hz.

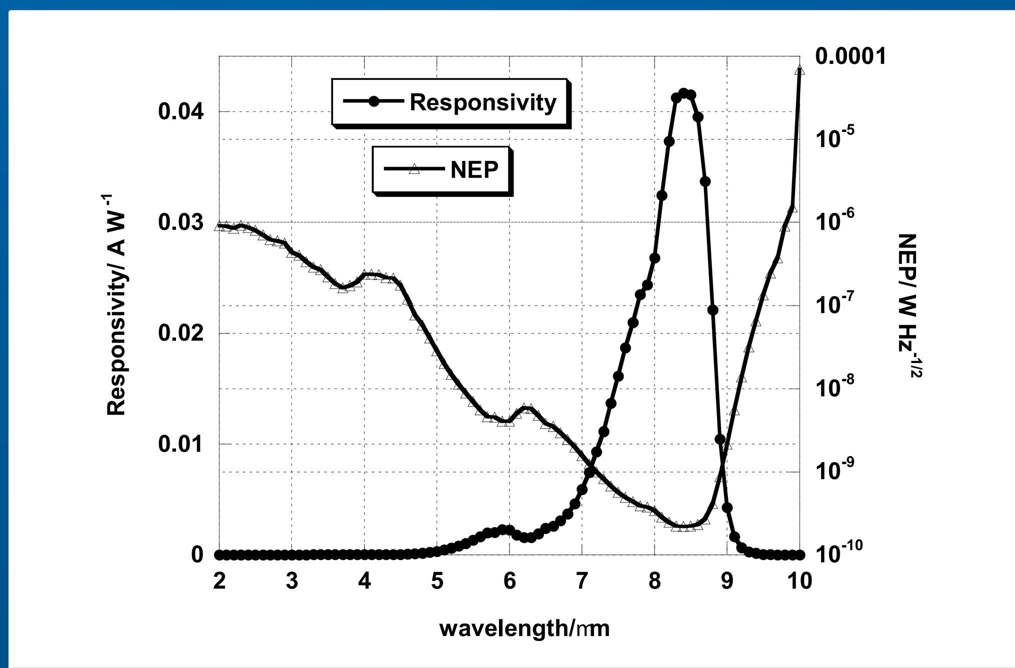

Figure 6: Absolute spectral responsivity and NEP of a large area QWIP in the 2 mm to 10 mm wavelength range for a modulation frequency of 80 Hz.

Conclusions

NPL has assembled a spectral responsivity measurement facility which is based on a double grating monochromator and six pairs of gratings. This facility is able to produce quasi-monochromatic radiation covering the 0.9 µm to 24 µm wavelength range. This facility is routinely used to calibrate the relative and absolute spectral responsivity of infrared detectors and radiometers. The construction of this facility was summarised and some of the measurements completed on it were described.

References

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