Calibration of Near Infrared Photovoltaic Detectors Using a Wavelength Tunable Supercontinuum Light Source

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We introduce a portable wavelength tunable light source to calibrate the spectral responsivities of two indium gallium arsenide (InGaAs) and one germanium (Ge) based near infrared photovoltaic detectors against a calibrated pyroelectric radiometer over the wavelength range from 800 nm to 2000 nm. The setup consists of a supercontinuum laser source based on a photonic crystal fiber, laser line tunable filter and coupling optics. The pyroelectric radiometer is used as a reference detector due to its spectrally flat responsivity. The setup is automated by using a motorized filter wheel and XY translation stage and controlled via custom-made LabVIEW software, which improves the accuracy of the spectral responsivity measurements of detectors. In addition, wavelength tunable laser sources have higher output power and narrower spectral bandwidth compared with traditional lamp-based monochromators. For our setup, the maximum output power of approximately 20 mW with spectral full-width-half-maximum of 3 nm is available at 1200 nm.

The aperture diameters of InGaAs and Ge photovoltaic detectors are 5 mm and 10 mm. To ensure that all the incident power hits to the active area of the detectors, the beam is focused on the detector plane. The InGaAs detectors are calibrated at three different temperatures of 273.15 K, 283.15 K, and 293.15 K, whereas the Ge detector is only calibrated at room temperature since it does not have an option for cooling. Figure 1 shows an example of measurement results. Junction temperature is an important factor for these detectors since the band gap edge of the spectral responsivity shifts towards shorter wavelengths with decreasing temperature.

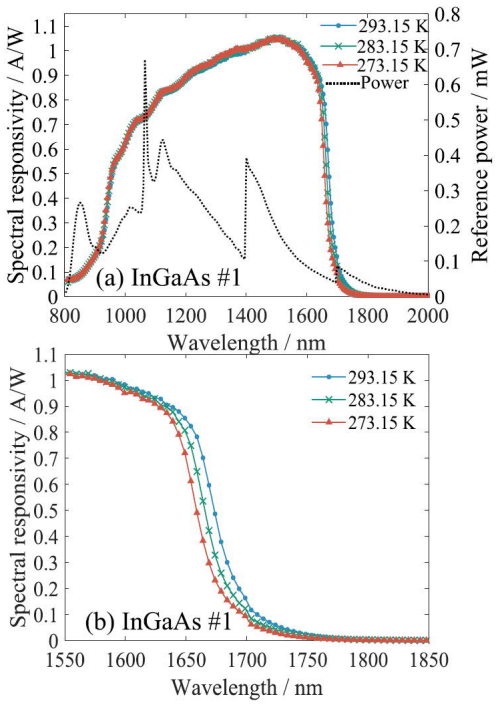

Fig. 1. Spectral responsivity of the InGaAs #1 measured with the wavelength tunable laser source over the spectral range of 800 nm - 2000 nm along with the optical reference power within 3-nm bandwidth (a). Close-up of spectral responsivity of InGaAs #1 near the band gap edge (b).

The spectral responsivities of the InGaAs detectors were compared with the earlier calibrations in 2010 and 2016 performed using the reference spectrometer setup at the Metrology Research Institute, Aalto University. Through a careful analysis of the experiments and comparisons, we conclude that the wavelength tunable light source decreases the expanded uncertainty in detector calibrations from 4 % to 2.2 % – 2.7 % over the spectral range of 820 nm – 1600 nm. However, the uncertainty increases to approximately 10% below 820 nm and above 1600 nm due to the band gap edge of the detectors and decrease in the power of the laser source.