Design and development of laser power transfer standard in telecommunication wavelengths under scientific collaboration MOU between NIMT and PTB

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Up to date, fiber optics laser systems are the most efficient way to carry information and very important in the field of telecommunication in Thailand. Typical optical fiber systems composed of laser sources, optical fibers as the transmission mediums, and detectors as receivers, where the most basic measurement necessary is optical power. To maintain quality and standard of information transmission, optical power measurement calibration is very important. The objective of this research was to design and development of InGaAs detectors, to use as an optical power transfer standard in the wavelengths where the optical fiber communication systems are operated. The design and development of the transfer standard under scientific collaboration between the national institute of metrology Thailand (NIMT) and Germany (PTB) will be presented.

INTRODUCTION

At present, the NIMT's reference standard is laser calorimeter (M 601). It has the measurement uncertainty at 0.13-0.22 %. The M 601 reference standard is calibrated with another calorimeter with higher accuracy at the National Metrology Institute of Japan (NMIJ). The M 601 is then used to calibrate the calorimeter M 602, the reference standard for fiber optics laser power meter, with the measurement uncertainty at 0.5-0.6 %. In 2017, cryogenic radiometer, a primary standard for the measurement of the absolute optical radiant power, was installed at NIMT. This instrument can achieve measurement uncertainty below 0.01% [1]. Thus, the objective of this project was to design and characterize single InGaAs photodiode as transfer standard detector in near infrared wavelength, where the optical fiber communication systems are operated. This transfer standard, designed and characterized at PTB, will then be calibrated by the cryogenic radiometer, and it will be used to calibrate the reference standard M601, as shown in Fig. 1.

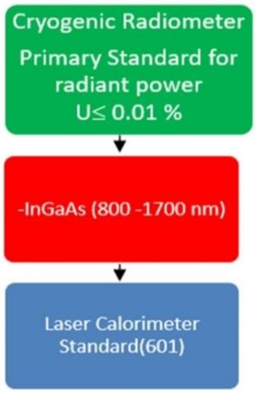
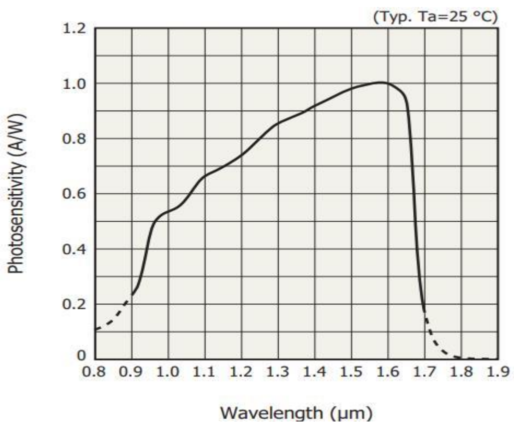


Figure 1. Traceability chain of the transfer standard.

MEASUREMENT METHOD AND SETUP

For metrology purpose such as this project, where high responsivity and linearity is very important, photodiode with the largest sensitive area was chosen. The InGaAs photodiode used in this project, Hamamatsu G8370-10, with diameter of 10 mm, had sensitive area of 78.54 mm^2. The spectral responsivity of the InGaAs photo diode from the product's data sheet is shown in Fig. 2 [2].

Figure 2. Spectral responsivity of a InGaAs photo diode



(from Hamamatsu data sheet).

The detector was mounted on an aluminum housing designed and fabricated at the PTB. Next to the photodiode in the housing, mounted a temperature sensor (Pt100) to monitor the temperature of the diode during the measurement process.

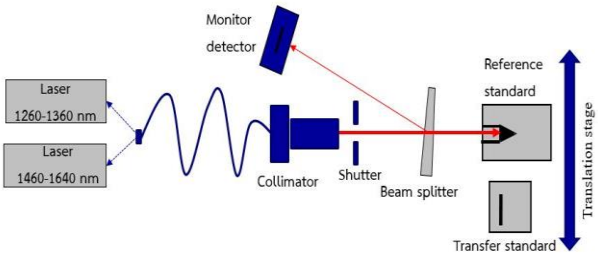


Figure 3. Experimental setup for the measurement of the absolute spectral responsivity of the transfer detector.

The responsivity of a InGaAs photodiode is obtained by measuring the photocurrent generated by the detector I_{photo} and the incident optical power Φ. Schematic diagram of the experimental setup used to measure the responsivity of the detector is depicted in Fig.3. Two tunable diode lasers, with optical power stability of ± 0.2 % within one hour, with adjustable wavelength from 1260 nm to 1360 nm and from 1460 nm to 1620 nm were used as radiation source. The laser beam is then collimated by a fiber optic collimator. To minimize possible influences on the measurement due to the laser power fluctuation, the beam was monitored by a monitor detector. A beam splitter is used to separate a laser beam into 2 beams, one goes to reference power meter or transfer standard and one goes to a monitor detector. A monitor detector (Ge-diode) is used for the correlative power measurement. A shutter is used to control the on/off of laser beam. Transfer standard (InGaAs) and reference power meter (thermopile sensors, BT14) are mounted on X-and Z- stage for comparison measurement. The laboratory was highly stabilized at 20.5 ± 0.5°C to minimize the influence from temperature fluctuation. Moreover, the temperature of the InGaAs detectors was measured with the temperature sensor (Pt100) mounted in the housing [3].

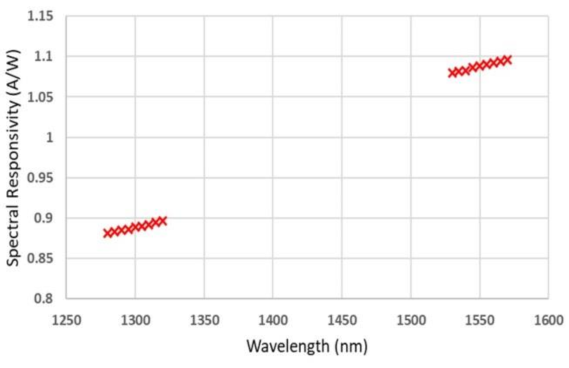


Figure 4. Absolute spectral responsivity of the InGaAs detector measure against reference thermopile detector.

RESULTS

The absolute spectral responsivity of the InGaAs detector, measured by calibration against the PTB reference thermopile detector (BT14) at different laser wavelength available (from 1280-1320 nm and from 1530-1570 nm) is shown in Fig. 4. The measurement uncertainty (k=2) is less than 1%.

CONCLUSION

In this paper, the design and development of InGaAs detector to use as a transfer standard for optical fiber communication was presented. The optical characterization of the detectors in this project was determined by measuring the absolute spectral responsivity of the detector. The absolute spectral responsivity of the InGaAs detector measure against reference thermopile detector at PTB was presented and was comparable to the spectral response graph from the manufacture.

The future work is to calibrate the InGaAs detector against the NIMT's cryogenic radiometer, a primary standard for the measurement of the absolute optical radiant power and compare the spectral responsivity results with the results measured at PTB. The calibrated InGaAs detector will then be used to calibrate the Thailand reference standard for optical fiber communication.

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