APPLICATION NOTE

A BREAKTHROUGH IN THz CALIBRATION AT GENTEC-EO IN THE 10µm TO 440µm REGION

NOW FOR THE FIRST TIME, GENTEC-EO HAS DEVELOPED A RIGOROUS CALIBRATION METHOD AND NEW THERMAL THz DETECTOR THAT ALLOW ABSOLUTE POWER AND ENERGY MEASUREMENT BASED ON A VALIDATED REFERENCE CURVE FROM 10 µm TO 440 µm (30 THz TO 0.70 THz). THE PURPOSE OF THIS APPLICATION NOTE IS TO EXPLAIN THE NEW METHOD OF CALIBRATION AND VALIDATION FOR GENTEC-EO THZ DETECTORS AND TO CHARACTERIZE ITS NEW SPECTRALLY FLAT THz THERMAL PROBE.

CALIBRATING IN THE THz REGION - A CHALLENGE

Typical traceable detector calibration methods involve the calibration at one particular wavelength with traceable Gold Standard previously obtained from a recognized international institution such as NIST in USA and PTB in Germany (most typical wavelength are 1.064 or 10.6 µm). In addition, the relative spectral absorption of the sensor is determined, using a Near IR (0.25 to 2.5 µm) spectrometer and a traceable spectral standard. A wavelength correction factor is then applied to provide the best possible calibration uncertainty over the detector's calibrated spectral range. Both calibration systems need to be traceable to an international calibration laboratory. Calibration can then be called traceable to NIST and/or other recognized international standards laboratory. Thus, with quantitative traceability, the total uncertainty of the calibration can be calculated and specified. It is important to know that, however, the calibrated range using this method is somewhat limited and doesn't begin to cover the broad THz wavelength range.

The rapidly expanding development of THz sources, both CW and Pulsed, has posed numerous challenges to our industry, including how to make accurate measurements of power and energy. One of the biggest difficulties is that there has been no recognized international calibration standard or service available that covered THz spectrum. This has forced us to offer THz products that are not calibrated in the THz range and can therefore only be used for relative measurements. However, just recently, the staff at PTB in Germany announced that they now provide traceable, low uncertainty calibration of THz detectors at the single wavelength 119 µm (or 2.52 THz).

We are working very closely with PTB Germany and NIST USA and other well-known international laboratories in order to take advantage of these new standards and to continue to develop better calibration methods for the Gentec-EO THz product line.

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Because of the lack of calibrated spectral reference in the THz range, it has been critical that Gentec-EO develop a new spectrally flat absorber for a THz sensor. It has been demonstrated that our organic black and metallic coatings display significant changes in sensitivity in the THz range and thus cannot be used as a wavelength reference there. In order to be a valid THz detector reference, the optical absorption must be measured with high accuracy. This requires measuring the total reflectance, both specular and diffuse. In addition, the transmission of the material must be negligible.

Currently, only specular reflectance can be measured in the spectral range of interest; 10 µm to 440 µm. Thus, it was an essential requirement that our new absorber have only specular reflectance and negligible diffuse reflectance. In addition, a very high and constant absorption throughout the THz range is also necessary because of the lack of multi-wavelength THz standards in the World.

THE BREAKTHROUGH

Gentec-EO has intensified its THz development program in recent months, which has led to a technical breakthrough. We have discovered a spectrally flat and very high absorption material for the THz range, from 10 µm to 440 µm (and up to 600 µm) that will be used as the THz absorber for our new thermal probe. This probe, model **THZ12D-3S-VP, is believed to be the first low uncertainty spectral reference in this portion of broad THz spectral range.**

Figure 1 below shows the spectral absorption of two Gentec-EO THz detectors. The red curve represents the low uncertainty "reference absorption spectrum" for our new THZ12D-3S-VP probe. The blue curve gives the typical relative absorption of our "BL" coated Pyroelectric THz probes THZ9D-20mS-BL. The Pyroelectric THz probes cannot be considered as a reference detector for this portion of the Terahertz spectrum, but can be used for relative measurements over the entire THz spectrum (30 THz to 0.1 THz). The reference absorption curve of the new THZ12D-3S-VP was first validated through extensive reflectance measurements together with multiple single wavelength power measurements using the INO SIFIR-50 gas laser, calibrated Gold standards from PTB and additional validation from NIST power measurements.

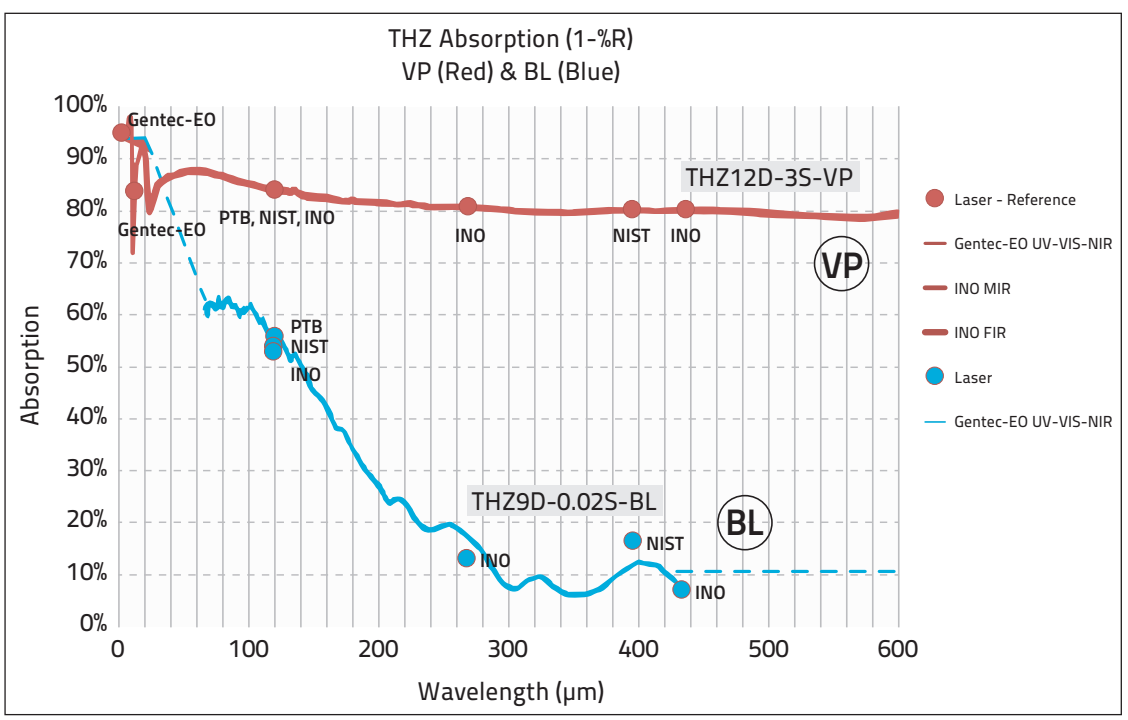

FIGURE 1: Reference Spectral Absorption Curves and Traceable Power measurements for Wavelength Response Validation

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In collaboration with the INO (National Institute of Optics) located in Quebec City, Canada, we have characterized our THz detector absorbance at different wavelengths (from 3 µm to 430 µm) using FTIR spectrometers that employ multiple sources to measure over this range. In between the different wavelengths delivered by the source, sensitivities were interpolated from the FTIR absorption curve. The absolute power of the source was measured with two different methods in order to increase the degree of confidence in the measurement.

FTIR absorption curves were validated in the 0.25 µm to 2.5 µm region with our in-house traceable absorption measurement spectrometer. In addition, traceable sensitivity measurements were made at 10.6 µm against a NIST gold standard and at 118 µm against a PTB gold standard using our THZ12D-3S-VP and THZ9D-20mS-BL PTB traceable detectors. These calibrated power measurements are shown on Figure 1 (Red and Blue dots).

As can be seen from the red curve in figure 1, we have successfully created a thermal THz detector that meets our two criteria, for a low uncertainty reference, flat spectral response and high absorption. The spectral response of the THZ12D is the same at 10.6 µm versus our NIST gold standard and at 119 µm versus the PTB Gold standard measurement. Furthermore, the absorption variation from 10.6 µm to 600 µm is of the order of ± 4% and ± 2.5% from 119 µm to 600 µm. In addition, other points of validation were made using NIST and INO measurements. A very good agreement has been obtained with the THZ12D-3S-VP and THZ9D-20mS-BL PTB Gold detectors.

THE NEW CALIBRATION METHOD

1. Gentec-EO calibrates its THZ12D-3S-VP detector using a stable 10.6 µm laser and a NIST Gold Standard Power Detector.

2. A validation of the detector is made to ensure its good working condition and that its behaviour conforms to the specifications at this wavelength and to other detectors of this type according to the reference absorption curve.

3. Traceable Sensitivity for the THZ12D-3S-VP detectors at ±15% is calculated using the reference absorption curve, as determined by traceable power measurements validation process mentioned in this document. It is then programmed in the EEPROM of the detector for each wavelength between 10 µm to 440 µm (30 THz to 0.70 THz). Beyond 440 µm (0.70 THz) the spectral absorption is estimated.

4. Typical Sensitivity for the THZ9D-20mS-BL and similar Pyroelectric THz detectors is calculated using the typical absorption BL curve. It is then programmed in the EEPROM of the detector for each wavelength between 10 µm to 440 µm (30 THz to 0.70 THz). Beyond 440 µm (0.70 THz), the spectral absorption is estimated. Traceable Sensitivity is only determined at 10.6 µm with NIST Gold standard.

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FUTURE DEVELOPMENTS

Gentec-EO is working with major organizations defining international standards. As soon as one of these organizations will offer a broadband standard in the THz region, we will integrate it into our calibration method and be able to guarantee a calibration uncertainty with traceability.

Gentec-EO THz detectors are being calibrated by recognized international standards laboratory in order to provide a Gold THz standard for calibration services.

We will continue to update you on the state of the art of calibration of our THz Detectors and Instruments as new developments occur.

If you have questions about the calibration and/or spectral response of our "MT" Pyroelectric THz Detectors please contact us at info@gentec-eo.com.

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