Design and construction of an InGaAs transfer standard for absolute calibration of radiation thermometers

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The Centro Español de Metrologia (CEM) in collaboration with the Instituto de Óptica of the Consejo Superior de Investigaciones Científicas (IO-CSIC) are able to calibrate filter radiometers/radiation thermometers with direct traceability to the radiant watt at 650 nm wavelength. This allows CEM to measure thermodynamic temperature in the range from 900 °C to 2500 °C. Currently, some modifications in the calibration set-up are been done to measure at infrared wavelengths (1.6 μm), in order to extend the thermodynamic temperatures measuring range down to 400 °C. In this case, the radiance/irradiance standards are based in InGaAs detectors, instead of the Si ones used in the visible range set-up. The design, construction and characterization of these standards will be described in this work.

INTRODUCTION

The CEM visible calibration set-up has been fully described in [1] and it is based in a supercontinuum laser, a monochromator, an integrating sphere and a Si trap detector. The calibration method is based on the radiance comparison between the Si trap detector and the filter radiometer/radiance thermometer. The signal of the trap is measured with a Keithley 6480 subfemto-amperimeter (with the preamplifier unit close to the detector).

The main modifications needed for using this set-up at 1.6 μm wavelength are: the use of a new grating at the monochromator and a new radiance standard based in InGaAs detectors.

DESIGN OF THE InGaAs STANDARD

The InGaAs standard is based in Hamamatsu G8370-10NA detectors (10 mm in diameter and windowless). The standard main body is cooled with water and it has a precision aperture 5 mm of diameter at the entrance. It is made on aluminium. Nextel® coating has been used to cover all the parts reachable by infrared radiation. The design of the transfer standard can be seen in figure 1.

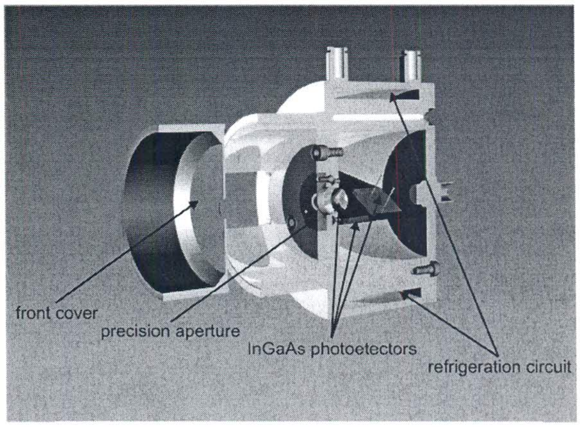

Figure 1. InGaAs transfer standard overview

The instrument allows different configurations:

- one single detector at normal incidence to the incoming light, see figure 2
- three detectors in a trap configuration, see figure 3
- one detector + an interference filter (in the case it is used as a standard filter radiometer) , see figure4

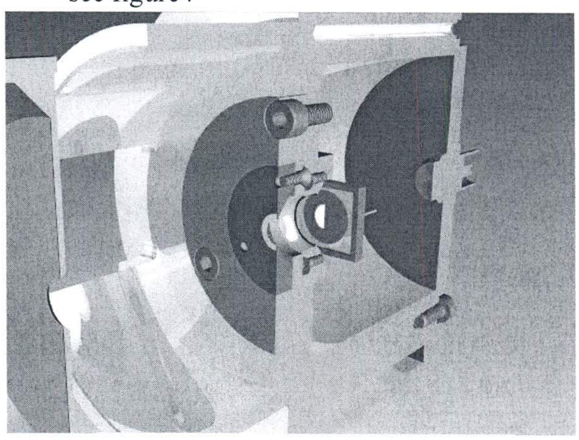

Figure 2. Single detector configuration

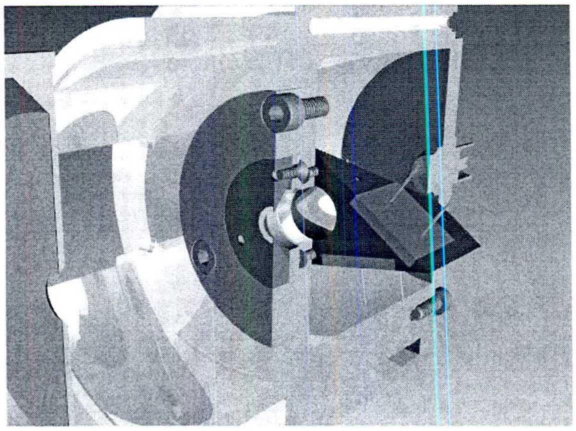

Figure 3. Trap detector configuration

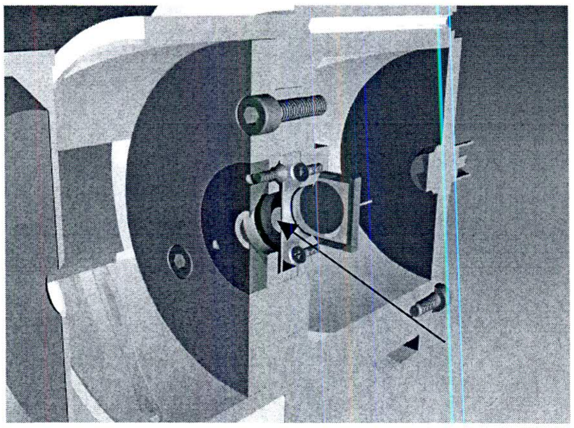

Figure 4. Filter radiometer configuration

InGaAs STANDARD CHARACTERIZATION

Firstly, the homogeneity of the Hamamatsu InGaAs detectors has been measured. The radiation comes out from an optical fiber after a tuneable AOTF filter and a supercontinuum laser (tuned at ≅ 1600 nm, FWHM ≅ 10 nm) has been used. The diameter of this source is ≅ 1 mm. The results are shown in figure 5.

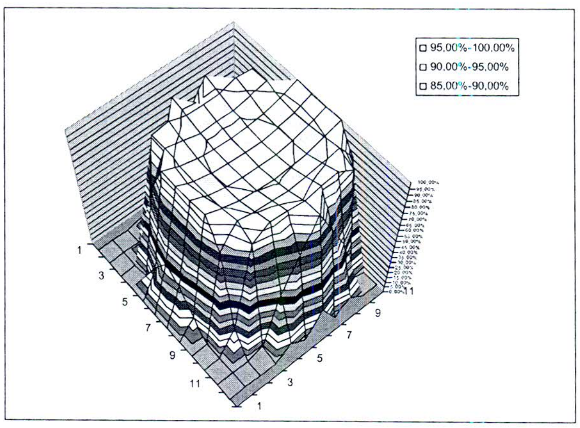

Figure 5. Homogeneity of a InGaAs detector

The poor homogeneity (≅ 5% in the central area) compared with the Si detectors (< 0.5% in the central area) prompts to do the calibration of this standard in irradiance mode. So, the calibration of the standard at IO-CSIC and its use at CEM will be the same and the uncertainty will be reduced.

The signals measured preliminarily with this InGaAs standard at the CEM radiance comparator set-up (before the integrating sphere) are: 12 μA for the single detector configuration and 15.5 μA for the trap detector configuration (both corrected by the dark current).

The advantage of using a single photodiode is that it is possible to work with a larger spot and its alignment is easier, while the disadvantage is the loss of light by reflection. The reverse statement can be said for the trap configuration. It has to be also considered that the impedance decrease in the case of traps when they are connected to the same pre-amplifier. This can be a key point when signals are low (preliminary, after the integrating sphere we measure ≅ 2 nA with both configurations).

After optimization of the InGaAs standard, it will be used to calibrate a radiation thermometer KE-LP5. This thermometer will be used to measure the thermodynamic temperature in the range from 400 °C to 962 °C (variable temperature blackbodies and fixed points) within the project "InK2" [2]

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REFERENCES

1. M. J. Martin, J. M. Mantilla, D. del Campo, M. L. Herranz, A. Pons y J. Campos. Int. J. Thermophys. (Tempmeko 2016 special issues) (submitted, 2016).

2.. Project website http://www.vtt.fi/sites/InK2