Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

Bericht

Report

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Measurement report

SXUV100 Lot 115498 #0003, date of measurement: Week 31, 2025

Description of photodiode

The radiation detector is a silicon photo diode. The detector was electrically connected in such a way that a positive photocurrent was measured. No bias was applied.

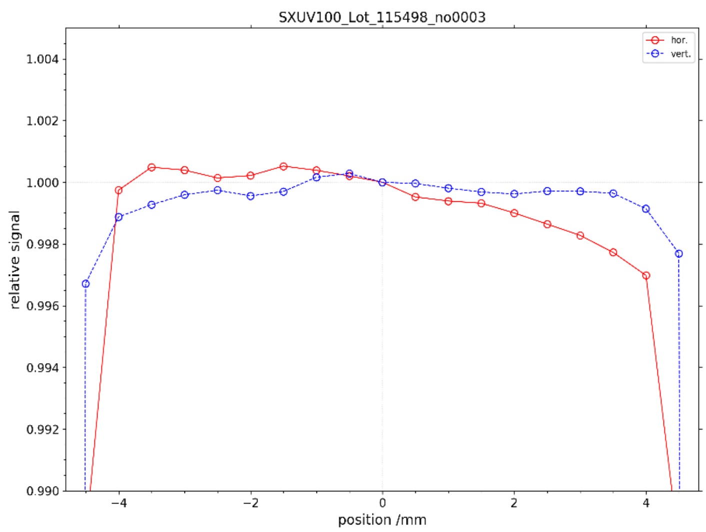
Description of the measuring station

The spectral responsivity of the detector was determined by comparing the photocurrent of the detector with the signal of a reference detector of known spectral responsivity [1]. For this calibration, a photodiode was used as reference detector. This photodiode was calibrated directly against a cryogenic radiometer, which is PTB's primary detector standard for soft X-ray radiation [2]. The measurements were conducted at the soft X-ray radiometry beamline [3] in PTB's radiometry laboratory at the BESSY II electron storage ring.

The detector to be examined was investigated under vacuum conditions. It was fastened to a translation stage which allows linear motion in two perpendicular directions. In this way it is possible to scan over the sensitive area of the detector by means of the X-ray beam. The positioning can be reproduced with an uncertainty of 10 µm. The sensitive area of the detector was directed perpendicular to the photon beam with an uncertainty of 2°. The photon beam had a size of about 2 mm horizontally and 2 mm vertically (FWTM). The typical radiant power used for the measurements was less than 1 µW. The radiation was linearly polarized, with a polarisation degree of better than 95% for wavelengths above 1 nm. It was assumed that the spectral responsivity of the detector is independent of the polarisation of the radiation.

Sample adjustment

The detector was adjusted by means of the linear translations in such a way that the beam impacts the centre of the sensitive area of the detector. These measurements also provide information on the homogeneity of the spectral responsivity, see figure 1.



SXUV100 Lot 115498 #0003

Figure 1 Homogeneity of the spectral responsivity at 13.5 nm.

Measurement

At first, the radiant power at the exit of the monochromator was measured at the selected wavelengths by means of the reference detector. Then, the photocurrent of the detector to be calibrated was measured at the same wavelengths. During the measurement, the radiant power continually decreases due to the decay of the stored electron current. Therefore, the measured detector signals were normalized to the stored electron current. At the end of each measurement cycle, the radiant power was measured once again by means of the reference detector in order to detect any instability that might have been caused, for example, by instabilities of the electron beam position.

Results

The measurement results are presented in table 1. The uncertainty stated is the expanded measurement uncertainty obtained by multiplying the standard measurement uncertainty by the coverage factor $k = 2$. It has been determined in accordance with the “Guide to the Expression of Uncertainty in Measurement (GUM)”. The value of the measurand then normally lies, with a probability of approximately 95 %, within the attributed coverage interval.
The measurement uncertainty encompasses: the uncertainty contributed by the dark current of the detector, the uncertainty which is due to the contribution of radiation of a higher order and scattered radiation in the monochromatized beam, the uncertainty in the spectral responsivity of the reference detector, and the uncertainty of the photon energy scale of the monochromator.
The spectral responsivity stated here was measured in the centre of the sensitive area of the detector by means of the photon beam described above. Therefore, if the detector is used under other radiation conditions than the ones stated here, an additional uncertainty arises which has not been taken into account here.
The uncertainty of the measurement of the radiant power by means of the reference detector is 1 %. The uncertainty contribution due to scattered radiation and higher diffraction orders in the monochromator amounts to 0.4 %.
Uncertainties of the wavelength result from instabilities of the position of the stored electron beam and from uncertainties in the positioning of the optical components of the beamline. The relative uncertainty of the wavelength is less than 0.1 %.
The stated values apply only to the time of calibration. When using the detector, radiation-induced changes in spectral responsivity have to be taken into account [4]. To what extent changes in spectral responsivity occur depends strongly on the type of detector used. Besides, changes in spectral responsivity were observed even for detectors which had been stored only under dry conditions and had not been exposed to radiation [5].

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#0003

wavelength /nm	**spectral responsivity /AW^{-1}**	**uncertainty (k=2) / mAW^{-1}**
11.5	0.1475	2.6618
12.0	0.1603	2.8977
12.2	0.1466	2.6294
12.5	0.2342	4.2927
13.0	0.2343	4.2946
13.5	0.2336	4.2882
14.0	0.2325	4.2754
14.5	0.2314	4.2629
15.0	0.2300	4.2437
15.5	0.2278	4.2126

Table 1 Spectral responsivity of the detector and measurement uncertainty.

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Die Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig und Berlin ist das nationale Metrologieinstitut und die technische Oberbehörde der Bundesrepublik Deutschland für das Messwesen. Die PTB gehört zum Geschäftsbereich des Bundesministeriums für Wirtschaft und Energie. Sie erfüllt die Anforderungen an Kalibrier- und Prüflaboratorien auf der Grundlage der DIN EN ISO/IEC 17025.

Zentrale Aufgabe der PTB ist es, die gesetzlichen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI) darzustellen, zu bewahren und weiterzugeben. Die PTB steht damit an oberster Stelle der metrologischen Hierarchie in Deutschland. Die Kalibrierscheine der PTB dokumentieren eine auf nationale Normale rückgeführte Kalibrierung.

Zur Sicherstellung der weltweiten Einheitlichkeit der Maßeinheiten arbeitet die PTB mit anderen nationalen metrologischen Instituten auf regionaler europäischer Ebene in EURAMET und auf internationaler Ebene im Rahmen der Meterkonvention zusammen. Dieses Ziel wird durch einen intensiven Austausch von Forschungsergebnissen und durch umfangreiche internationale Vergleichsmessungen erreicht.

The Physikalisch-Technische Bundesanstalt *(PTB) in Braunschweig and Berlin is the National Metrology Institute and the supreme technical authority of the Federal Republic of Germany for metrology. The PTB comes under the auspices of the Federal Ministry of Economics and Energy. It meets the requirements for calibration and testing laboratories as defined in DIN EN ISO/IEC 17025.*

The central task of PTB is to realize, to maintain and to disseminate the legal units in compliance with the International System of Units (SI). PTB thus is at the top of the metrological hierarchy in Germany. The calibration certificates issued by PTB document a calibration traceable to national measurement standards.

PTB cooperates with other national metrology institutes - at the regional European level within EURAMET and at the international level within the framework of the Metre Convention - with the aim of ensuring the worldwide coherence of the measurement units. This aim is achieved by an intensive exchange of the results of research work and by comprehensive international comparison measurements.