

The PTB High-Accuracy Spectral Responsivity Scale in the VUV and X-Ray Range

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Abstract. At the electron storage ring BESSY II, the Physikalisch-Technische Bundesanstalt operates ten experimental stations at six synchrotron radiation beamlines for photon metrology in the spectral range from ultraviolet radiation to X-rays. At five beamlines, detector calibration is realized based on cryogenic radiometers as primary detector standards. The current status of instrumentation and measurement capabilities is described. Best measurement capabilities for the calibration of photodiodes vary between 0.4 % and 2.3 %.

Instrumentation

The spectral responsivity scale of semiconductor photodiodes realized with dispersed synchrotron radiation by the Physikalisch-Technische Bundesanstalt (PTB) at the electron storage ring BESSY II covers the wavelength range from 400 nm down to 0.02 nm, i.e. the photon energy range from 3 eV to 60 keV (Fig. 1). For this purpose, three beamlines for bending magnet synchrotron radiation (NIM, SX700, FCM) are operated within the PTB laboratory at BESSY II (Klein *et al.* 2002). In addition, a wavelength shifter (WLS) beamline for hard X-rays is used outside the laboratory. Measurements are routinely performed under ultra-high vacuum conditions with average radiant power values from 10 nW to 50 μ W. The measurement capabilities can be extended also into the regime of single photon counting. Moreover, the use of an excimer laser allows measurements with radiation pulse energies up to 1.5 mJ at the wavelengths of 157 nm and 193 nm.

For absolute measurement of average radiant power, two cryogenic radiometers, SYRES I and SYRES II, are used as primary detector standards, SYRES II being an upgraded version of SYRES I (Rabus *et al.* 1997). Both

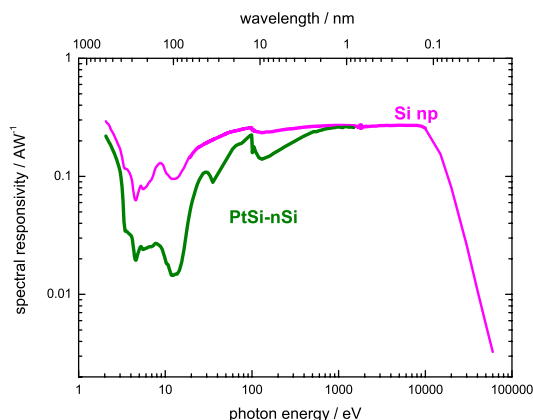


Figure 1. PTB's spectral responsivity scale of semiconductor photodiodes realized with dispersed synchrotron radiation at BESSY II.

systems are optimized for the specific requirements of using spectrally dispersed synchrotron radiation in the μ W regime with a monotonic radiant power decrease of 1 % within a few minutes. For photon energies above 20 keV, a standard ionization chamber is used for detector calibration and dosimetry.

Calibration of Transfer Detector Standards

Different types of semiconductor photodiodes are routinely used as transfer detector standards within the framework of customer calibrations. They are critically selected under aspects of stability, homogeneity, and linearity of their spectral responsivity in order to reduce

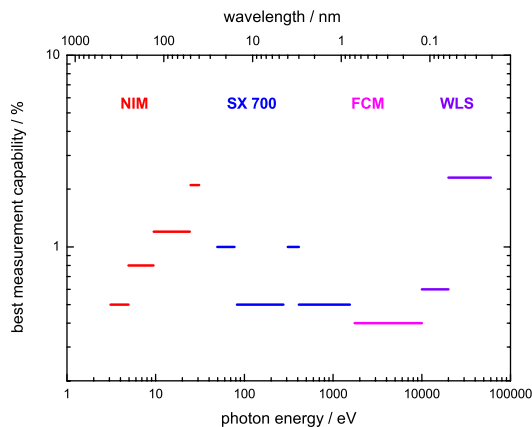


Figure 2. PTB's best measurement capabilities for the calibration of semiconductor photodiodes with synchrotron radiation.

the calibration uncertainties. Important contributions to the uncertainty budgets also arise from spectral impurities of the monochromatized synchrotron radiation. The best measurement capabilities, i.e. the extended ($k=2$) relative uncertainties, for the calibration of semiconductor photodiodes with synchrotron radiation are shown in Fig. 2. The lowest values are achieved within spectral regimes of highest radiant power. Uncertainties for the calibration of, e.g., photocathodes or photon counting devices are generally higher, depending on the individual detector performance. Calibrations performed with excimer laser radiation are, in addition, influenced by the laser instabilities.

References

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