Recent developments in the VUV transfer source calibration based on calculable synchrotron radiation

Annett Barboutis, Roman Klein, Simone Kroth, Wolfgang Paustian, Reiner Thornagel

Physikalisch-Technische Bundesanstalt, Berlin, Germany

Corresponding e-mail address: roman.klein@ptb.de

The spectral radiant intensity of synchrotron radiation can be accurately calculated by the Schwinger formula, thus making electron storage rings primary sources. This fact has been used by PTB at several electron storage rings, which have been optimized to be operated as primary source standards, for the calibration of transfer sources in the spectral range of the UV and VUV for almost 30 years. Currently, we operate the electron storage rings BESSY II and MLS as primary source standards. The transfer sources are compared to the respective primary source standard by means of a suitable, wavelength-dispersive transfer station at each of the storage rings. The spectral region from 7 nm to 400 nm is covered, which is unique in the world. For the dissemination of this radiometric scale in the short wavelength spectral region, PTB operates transfer sources that are based on a hollow cathode discharge. We report on the status of these VUV transfer sources.

INTRODUCTION

Electron storage rings optimized for radiometry can be used as primary radiation source standards, the spectral intensity of which can be accurately calculated within classical electrodynamics by the so-called Schwinger formula [1]. So, using synchrotron radiation for radiometry gives access to the UV, VUV and X-ray spectral region [2, 3] and thus considerably expands the spectral region as compared to that covered, e.g., by blackbody radiators.

Since the late seventies, PTB has been taking advantage of this (besides a multitude of other applications [4]) for the traceable calibration of radiation sources.

CALIBRATION OF TRANSFER SOURCES

Transfer sources are compared to the primary source by means of wavelength-dispersive transfer stations. The transfer station either accepts radiation from the primary source or from the transfer source under test. The source point of either source is imaged into an entrance aperture of a wavelength-dispersive monochromator, which represents the core of the transfer station. In the first orientation, the spectral sensitivity of the transfer device is determined and in the second orientation it is used then for a traceable calibration of the transfer source. PTB operates a transfer station [5] at the electron storage ring BESSY II primary source standard [6] which covers the spectral range from 40 nm to 400 nm and a station at the MLS primary source standard [7], which covers the spectral range from 7 nm to 40 nm [8, 9]. The transfer source can be either characterized in terms of spectral radiance or spectral radiant intensity. In the first case, only a part of the radiating source area is accepted by the entrance aperture of the transfer device. Details of the calibration principle and the uncertainty budget can be found in [8, 9].

At PTB, source-based calibrations in the short wavelength range below 120 nm are mainly performed within scientific co-operations, focusing on the calibration of space instruments [10, 11] and related transfer sources. In this paper we focus at these transfer sources. In the spectral region with wavelengths longer than 116 nm, i.e. the spectral region where the radiometric scale can be straightforwardly disseminated by means of deuterium (D2) lamps as transfer standards, calibrations are handled within the normal PTB calibration service [12].

VUV TRANSFER SOURCES

Currently PTB operates two VUV transfer sources, both of which are based on a hollow cathode of the same kind. These sources have been developed by PTB in the 1980s for the calibration of the CDS spectrometer and SUMER spectrometer of the SOHO mission, respectively. The CDS source uses a Wolter telescope for the collimation of the radiation to a beam with 5 mm in diameter and works in the spectral range from 7 nm upwards. The SUMER source uses an Au coated mirror under NI reflection for collimation. It delivers a beam of 10 mm in diameter, but due to the NI reflection its use has been limited to wavelengths longer than about 50 nm. To benefit from this larger beam diameter also in the shorter spectral range, the Au coated mirror was recently replaced by a multilayer mirror with reflectivity as shown in Fig.1. The comparison of the SUMER source signal before and after the modification is shown in Fig. 2. The short wavelength Ne spectral lines are now also emitted by the source with only moderate less output at the longer wavelength spectral region.

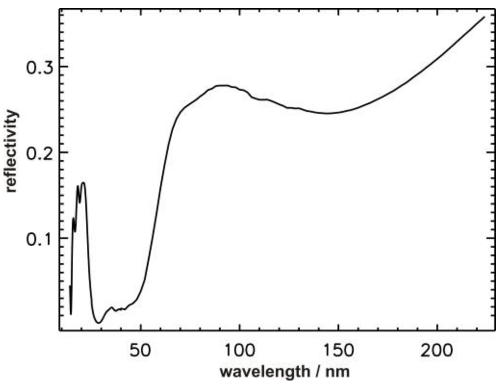

Figure 1. Measured reflectivity of the new SUMER transfer source collimation mirror.

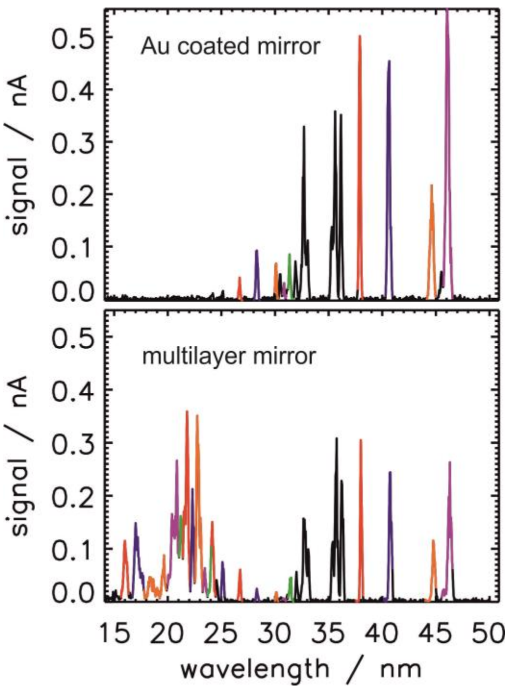

Figure 2. Example for the short wavelength range covered with the SUMER transfer source operated with Ne discharge before (top trace) and after (bottom trace) replacement of the collimation mirror.

After this replacement, the spectral range, which previously could only be covered by the CDS source, now also is served with the SUMER source. This enables the calibration over a wide spectral range with only one source and thus considerable facilitates the calibration procedure.

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