

Synchrotron radiation based irradiance calibration of deuterium lamps from 200 nm to 400 nm at SURF III

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Abstract. Synchrotron radiation, with its very nature of calculability, has long been established as a primary source standard for a broad spectral range from x-rays to infrared [1,2]. In the UV and even shorter wavelength regions, synchrotron radiation stands out as the only standard source available to date since this wavelength region is out of reach to the widely used black body source standard. Transfer UV source standards, such as deuterium lamps, can be readily calibrated against synchrotron radiation. Most recently, such work was reported [3] using the Synchrotron Ultraviolet Radiation Facility (SURF II) at the National Institute of Standards and Technology (NIST) where SURF is a dedicated synchrotron source for radiometry. Since then, SURF has undergone a major upgrade to SURF III where the accuracy of all the storage ring parameters has been significantly improved [4]. A new white light beamline was constructed to direct the calculable SURF III radiation to the user station with minimum obstruction from optical components. Meanwhile, deuterium lamps with improved stability were developed as transfer standards recently [5]. Calibration of these lamps directly against SURF III will yield results with much reduced measurement uncertainty.

We report here the calibration of deuterium lamps by comparing with synchrotron radiation in the wavelength range from 200 nm to 400 nm using the new Facility for Irradiance Calibration Using Synchrotrons (FICUS). The measurements were performed using a 0.25-m monochromator with a cooled photomultiplier tube for radiation detection and an integrating sphere with a precision aperture before the entrance slit to diffuse the incident radiation. The whole assembly was mounted on an x-y translation stage and alternately measured the radiation from synchrotron and the deuterium lamp to be calibrated. Results of the calibration of three deuterium lamps are shown in Fig. 1. The estimated uncertainty is 1.2% at 2σ which is a significant improvement over current UV irradiance scale of NIST. Below we summarize the determination of parameters that could have significant contribution to the uncertainty budget:

1. Storage ring parameters: To calculate the flux of synchrotron radiation, one needs three storage parameters, namely, the electron energy, the radius of the electron

beam orbit, and the electron beam current. The measurements of these parameters and the improvement in accuracy for SURF III are discussed elsewhere [5].

2. Distance of the monochromator assembly relative to the emitting point of the synchrotron radiation: The distance from the emitting point of the synchrotron radiation to the defining aperture of the monochromator assembly was measured by using both an optical technique and direct measurement. Both results agree to within 1 mm out of a distance of more than 6 meters.

3. Positioning of the monochromator assembly relative to the electron orbital plane: Synchrotron radiation is not uniform in the vertical direction or the direction perpendicular to the orbital plane. In order to find the on-orbit position accurately, the monochromator assembly used vertical scan to map the characteristic angular distribution of the synchrotron radiation and deduce the on-orbit position.

4. Window transmittance: Like previous study, the monochromator assembly measured radiation in air and a UV window is required to maintain vacuum of the beamline. The transmittance of the window has to be accounted for in irradiance calculation. Unlike the previous study where the window had to be removed to measure the transmittance, the window transmittance can be measured directly on the beamline with synchrotron radiation and the monochromator assembly to reduce the uncertainty.

5. Characterization of integrating sphere and monochromator: To characterize such quantities as the slit scattering function of the monochromator and the fluorescence from the integrating sphere, we used the UV radiation from the tunable lasers at NIST's facility of SIRCUS. An algorithm was used to correct the measured synchrotron and deuterium spectrum from both the measured monochromator slit function and fluorescence from the integrating sphere.

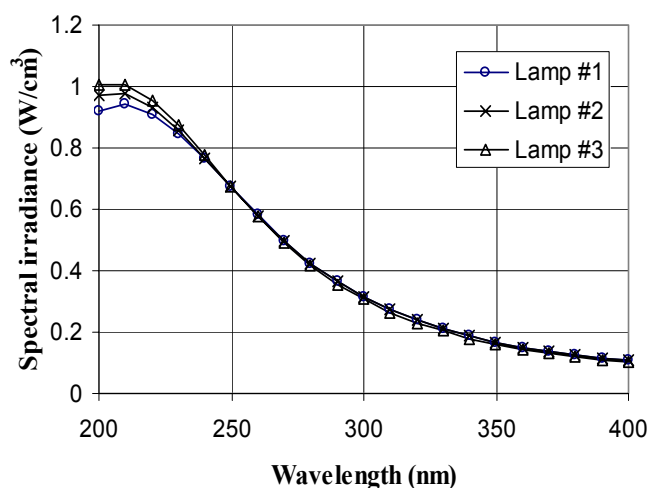


Figure 1. Measured spectral irradiance of three deuterium lamps at 30 cm based on the absolute scale of synchrotron radiation.

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