Characterization of light-emitting diodes in the solar UV spectral range

S. Nowy\textsuperscript{a}, S. Nevas\textsuperscript{a}, P. Blattner\textsuperscript{b}, J. Gröbner\textsuperscript{c}

EMRP ENV03
Traceability for surface spectral solar ultraviolet radiation

\textsuperscript{a.)} Physikalisch-Technische Bundesanstalt, Braunschweig, Germany  
\textsuperscript{b.)} Bundesamt für Metrologie METAS, Bern-Wabern, Switzerland  
\textsuperscript{c.)} Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, Davos, Switzerland
Project Objectives

- Enhance the reliability of spectral solar UV radiation measured at the Earth surface
- Improved traceability, improved methodologies, improved devices
- Uncertainties better than 2% in the wavelength region 300 nm – 400 nm (current state of the art is 5%)
- Develop techniques and devices for using cost-effective array-spectroradiometers for solar UV measurements

Primary Irradiance Standard
Black Body (PTB)

Transfer Standard

Reference Spectroradiometer
QASUME (PMOD WRC)

End-User Devices

Calibrated UV Network
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<th>Active JRP Partners</th>
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<td>Saulius Nevas</td>
<td>PTB, METAS, SFI Davos, VSL, Kipp</td>
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<td>Peter Blattner</td>
<td>METAS, Aalto, LNE, PTB, PMOD/WRC, VSL, REG(IMU)</td>
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<td>Julian Gröbner</td>
<td>PMOD/WRC, All</td>
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WP1 – Spectral Irradiance Traceability

- Task 1.1
  Detector-based traceability chain using an absolute radiometer and tuneable UV laser facility (PTB)

- Task 1.2
  Development of a highly stable portable monitoring source powered by LEDs (PTB, METAS, SFI Davos, Kipp)

- Task 1.3
  Compact laser-induced high-flux UV source as metrology light source for field applications (VSL, Kipp)
Motivation Task 1.2

- Use of spectroradiometers for solar UV measurements requires monitoring sources that are
  - compact
  - portable
  - robust
  - stable

- Tungsten halogen lamps are typically used for this purpose

- Can an alternative be found based on commercially available UV-LEDs?
  - spectral range of 280 nm – 400 nm
  - aging rates of 0.05% / hour or less (drift in irradiance)
  - minimum spectral irradiance of
    - 1 (mW / m²) / nm \( \lambda \leq 330 \) nm
    - 5 (mW / m²) / nm \( \lambda > 330 \) nm
LEDs used in this study

- 12 different types from 285 nm – 437 nm peak wavelength
- 3 LEDs of each type
- package type: TO-18
- emission window: flat

source: http://www.roithner-laser.com
Pre-aging and stability study

Fully automated setup to record:
- current
- voltage
- temperature
- irradiance

Goals:
- find operating conditions
- pre-aging of the devices
- determine stability (drift in irradiance)
- selection of best performing devices

detectors:
Si photodiode array spectroradiometer

temperature stabilized LED holder

computer controlled rotary stages
Aging behavior

peak wavelength
- 285 nm
- 310 nm
- 369 nm

operating time / h
0.4
0.6
0.8
1.0
norm. irradiance
Drift in irradiance after pre-aging

<table>
<thead>
<tr>
<th>name</th>
<th>peak wavelength</th>
<th>pre-aging time</th>
<th>temperature</th>
<th>drift after pre-aging required: 0.05% / h or less</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVTOP 280 #1</td>
<td>285 nm</td>
<td>565 h</td>
<td>25°C</td>
<td>-0.08% / h</td>
</tr>
<tr>
<td>UVTOP 295 #1</td>
<td>299 nm</td>
<td>402 h</td>
<td>25°C</td>
<td>-0.05% / h</td>
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<tr>
<td>UVTOP 310 #1</td>
<td>310 nm</td>
<td>476 h</td>
<td>25°C</td>
<td>-0.05% / h</td>
</tr>
<tr>
<td>UVTOP 315 #2</td>
<td>323 nm</td>
<td>120 h</td>
<td>25°C</td>
<td>+0.02% / h</td>
</tr>
<tr>
<td>UVTOP 325 #2</td>
<td>333 nm</td>
<td>101 h</td>
<td>25°C</td>
<td>-0.03% / h</td>
</tr>
<tr>
<td>UVTOP 335 #3</td>
<td>342 nm</td>
<td>134 h</td>
<td>35°C</td>
<td>-0.04% / h</td>
</tr>
<tr>
<td>UVTOP 345 #2</td>
<td>352 nm</td>
<td>120 h</td>
<td>25°C</td>
<td>-0.02% / h</td>
</tr>
<tr>
<td>UVTOP 355 #1</td>
<td>369 nm</td>
<td>134 h</td>
<td>35°C</td>
<td>-0.01% / h</td>
</tr>
<tr>
<td>LED405 #1</td>
<td>401 nm</td>
<td>120 h</td>
<td>25°C</td>
<td>&lt; -0.01% / h</td>
</tr>
<tr>
<td>LED435 #1</td>
<td>437 nm</td>
<td>120 h</td>
<td>25°C</td>
<td>-0.02 % / h</td>
</tr>
</tbody>
</table>
Expected irradiance levels after pre-aging
Expected irradiance levels after pre-aging

two LEDs with 352nm, 342 nm discarded
- 10 UV-LEDs in series
- distance to measurement plane: 50mm
- 2 PT100 for reference and temperature controller
UV-LED monitoring source

current source
I = 20 mA

20ch DMM
voltages, current, temp.

temperature controller
T = 25°C
Performance of the UV-LED source

Current stability: ± 0.07 µA

Temperature stability: ± 0.003°C
Performance of the UV-LED source

![Graph showing spectral irradiance vs wavelength]

- LEDs in monitoring source
- Levels to be achieved

Measured with reference spectroradiometer QASUME
Field experiments

PMOD started in April on La Réunion

The UV-LED source was and will be tested in the measurement missions with QASUME at European solar-UV network measurement sites during April - October 2013

source: http://de.wikipedia.org/wiki/Réunion
Field experiments

Stability of the UV-LED source
LEDs at 35°C, measurement site: INTA, Spain
Summary

- UV-LEDs selected after pre-aging
- drift in irradiance in desired range (< 0.05% / h) for almost all devices
- prototype of UV-LED monitoring source has been built
- first experiments with prototype successful
- field experiments already in progress and are very promising

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