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The UV Experts

PTB traceable calibrated reference UV radiometer for measurements at high irradiance medium pressure mercury discharge lamps

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Nationales Metrologieinstitut

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aufgrund eines Beschlusses des Deutschen Bundestages

Project results (2010-2012)

Cooperative project KF2303704RR9 between Physikalisch-Technische Bundesanstalt (PTB) and sglux GmbH
„Development of UV calibration standards for UV water disinfection“

This lecture:
PTB traceable calibrated reference UV radiometer for measurements at high irradiance medium pressure mercury discharge lamps

Lecture held by Dr. Peter Sperfeld (PTB) – today 9:40h
Developing and setting calibration facility for UV sensors at high irradiance rates

Lecture held by Dr. Peter Sperfeld (PTB) – tomorrow 11:00h
Traceable measurement of the spectral irradiance of water disinfection plants

sglux GmbH

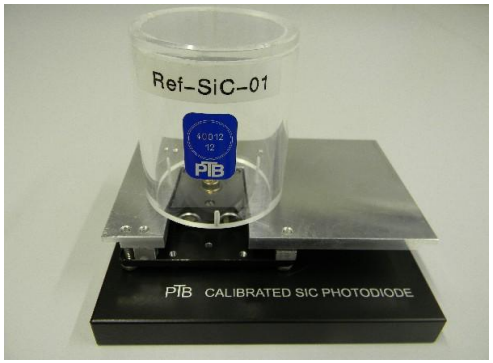
- company’s business objective is scientific development and production of officially assessed UV sensing equipment
- actual project is commercialising a PTB traceable calibrated UV Reference Radiometer
- founded in 2003 as a manufacturer of UV photodiodes
- today 10 employees (6 engineers)
- production within the entire value chain of UV sensing products
- in-house produced SiC photodiode wafers, SiC photodiodes and hybrids, UV probes, UV radiometers, UV controllers and UV calibration standards

Steps to a traceable calibrated UV reference radiometer

1. Characterization of components for high irradiance UV sensors
2. Development and Characterization of a digital reference sensor
3. Development of a displaying unit
4. Determination of calibration conditions
5. Development and characterization of a calibration source
6. Development of a calibration method
7. Validation
8. Calibration

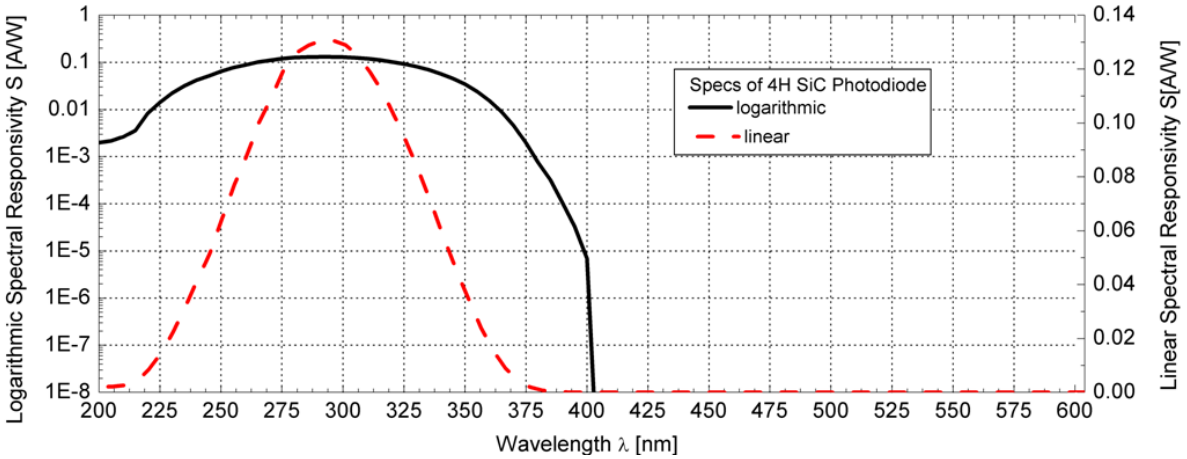
1. Characterization of UV sensor components

UV Photodiodes



Silicon carbide (SiC):
- radiation hard
- visible blind
- low dark current
- low noise

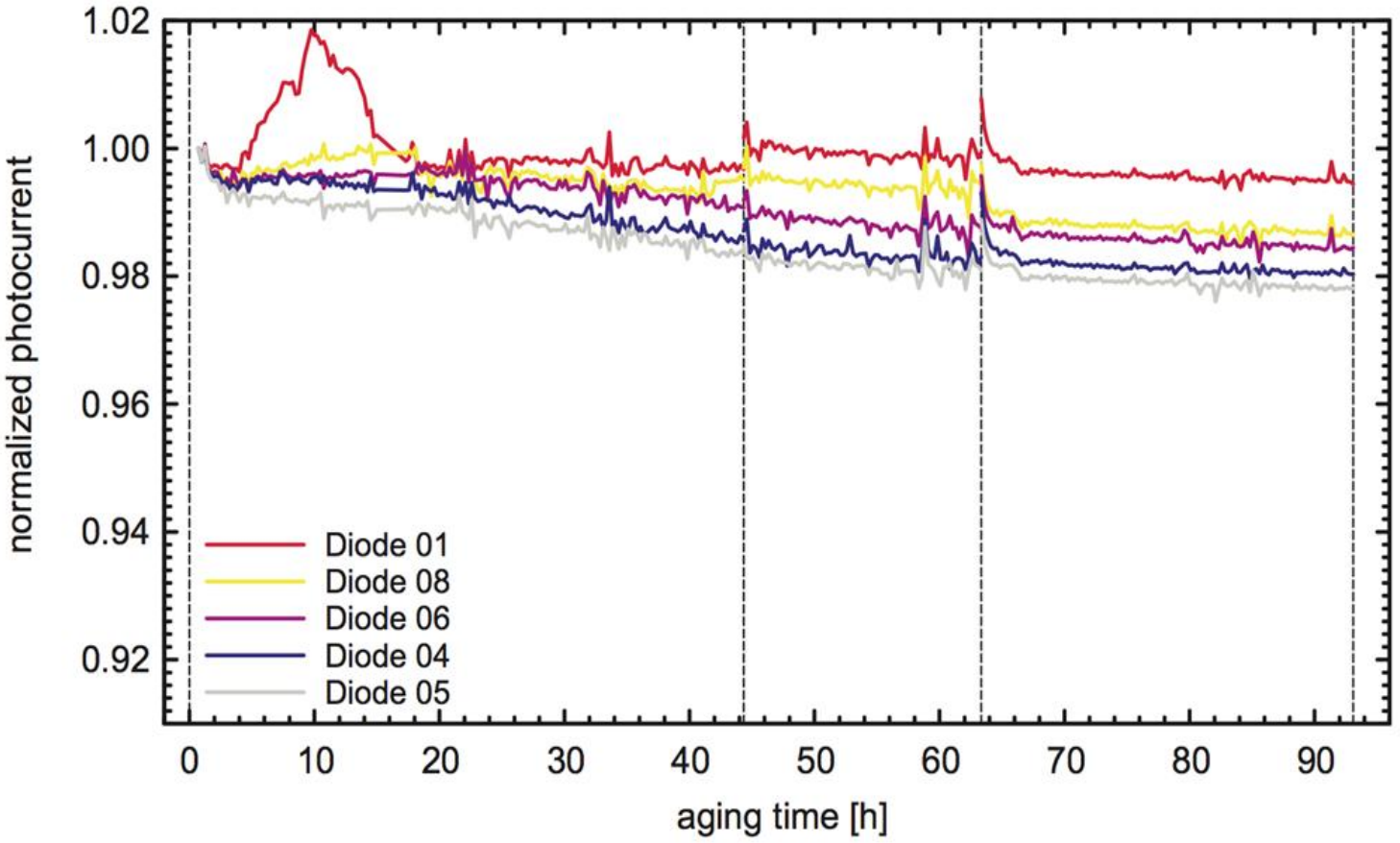
Spectral responsivity



1. Characterization of UV sensor components

UV Photodiodes

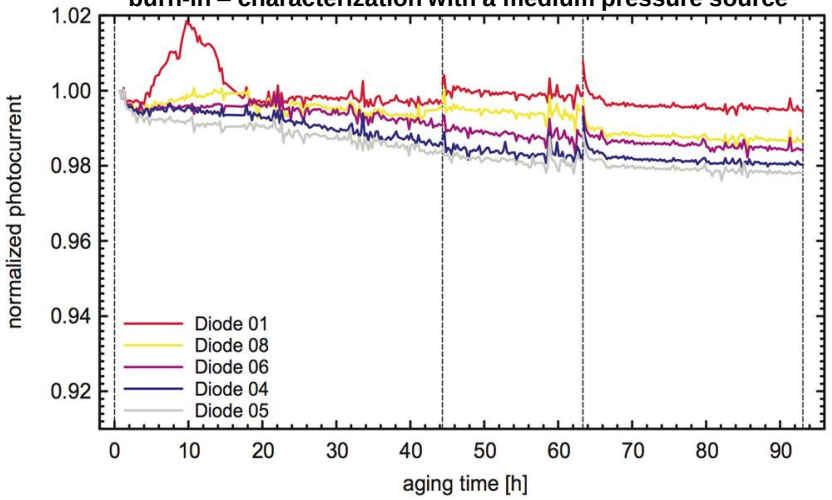
Photodiode behavior during burn-in with 2kW Hg medium pressure source



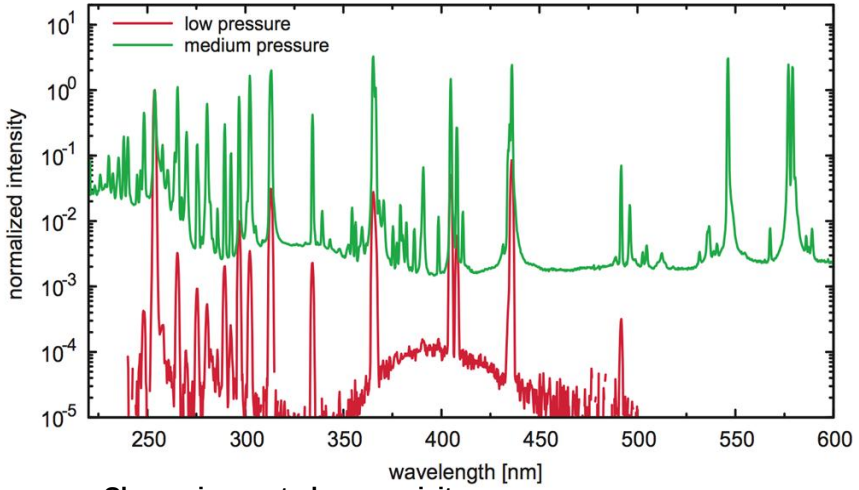
1. Characterization of UV sensor components

UV Photodiodes

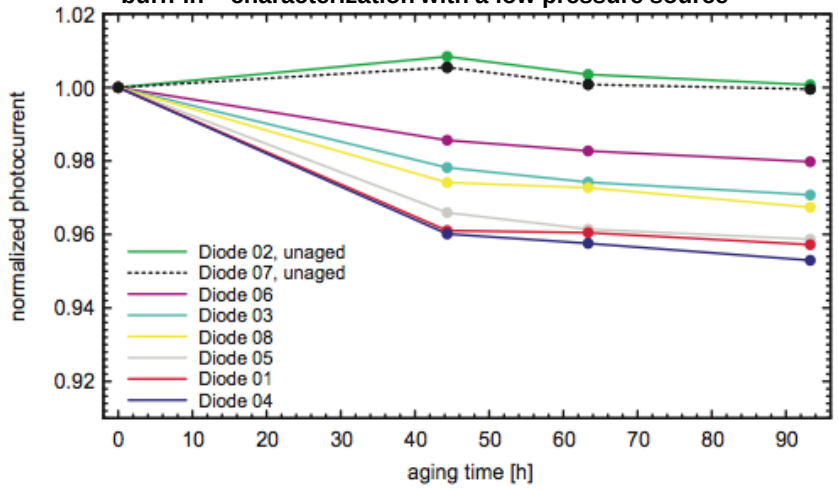
burn-in – characterization with a medium pressure source



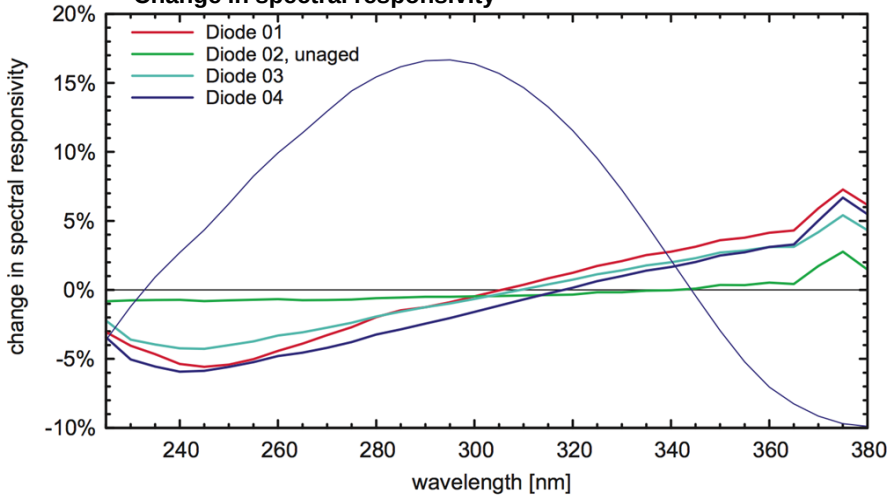
Spectral emission – normalized at 253.75nm



burn-in – characterization with a low pressure source



Change in spectral responsivity

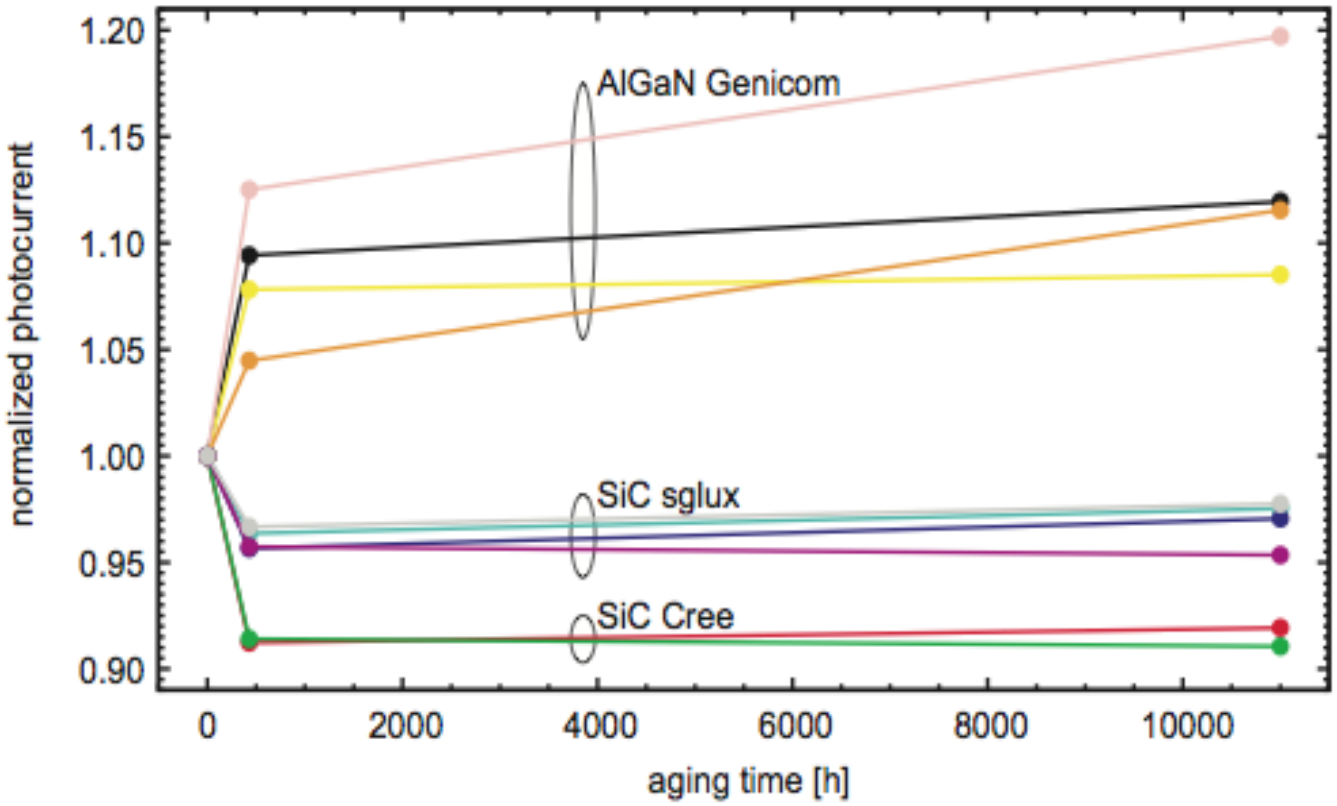


1. Characterization of UV sensor components

UV Photodiodes

Long term stability – at low pressure UVC irradiation

Comparison of AlGaN, SiC (Cree) and SiC (sglux) photodiodes



1. Characterization of UV sensor components

Diffusers

Demands on a suitable diffuser

- Good light scattering properties
- Spectrally flat transmittance
- Temporally stable transmittance
- Insensitivity to high irradiance levels
- Uniform transmittance over the surface

Typical optical diffusers

- PTFE
- Heraeus OM 100 / Primusil / Diffusil

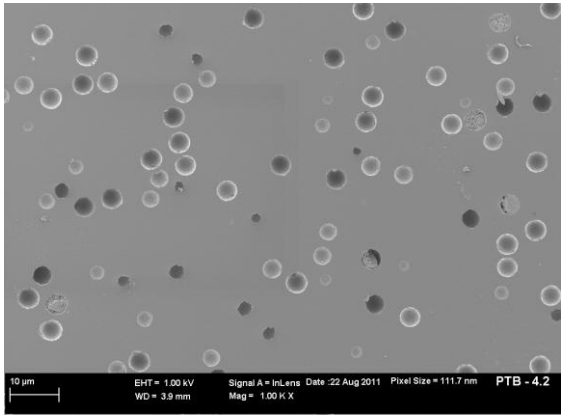
1. Characterization of UV sensor components

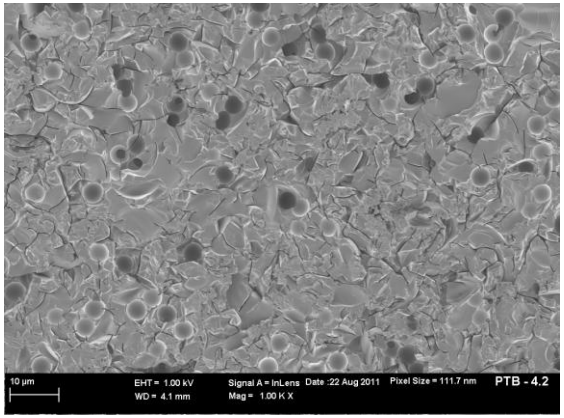
Diffusers

Source: www.silicaglas.com

Primusil / Diffusil

Opaque fused silica diffusers
- Extremely small gas bubbles act as scattering centres
- Gas bubbles are homogeneously distributed
- Bubble size and quantity can be adjusted



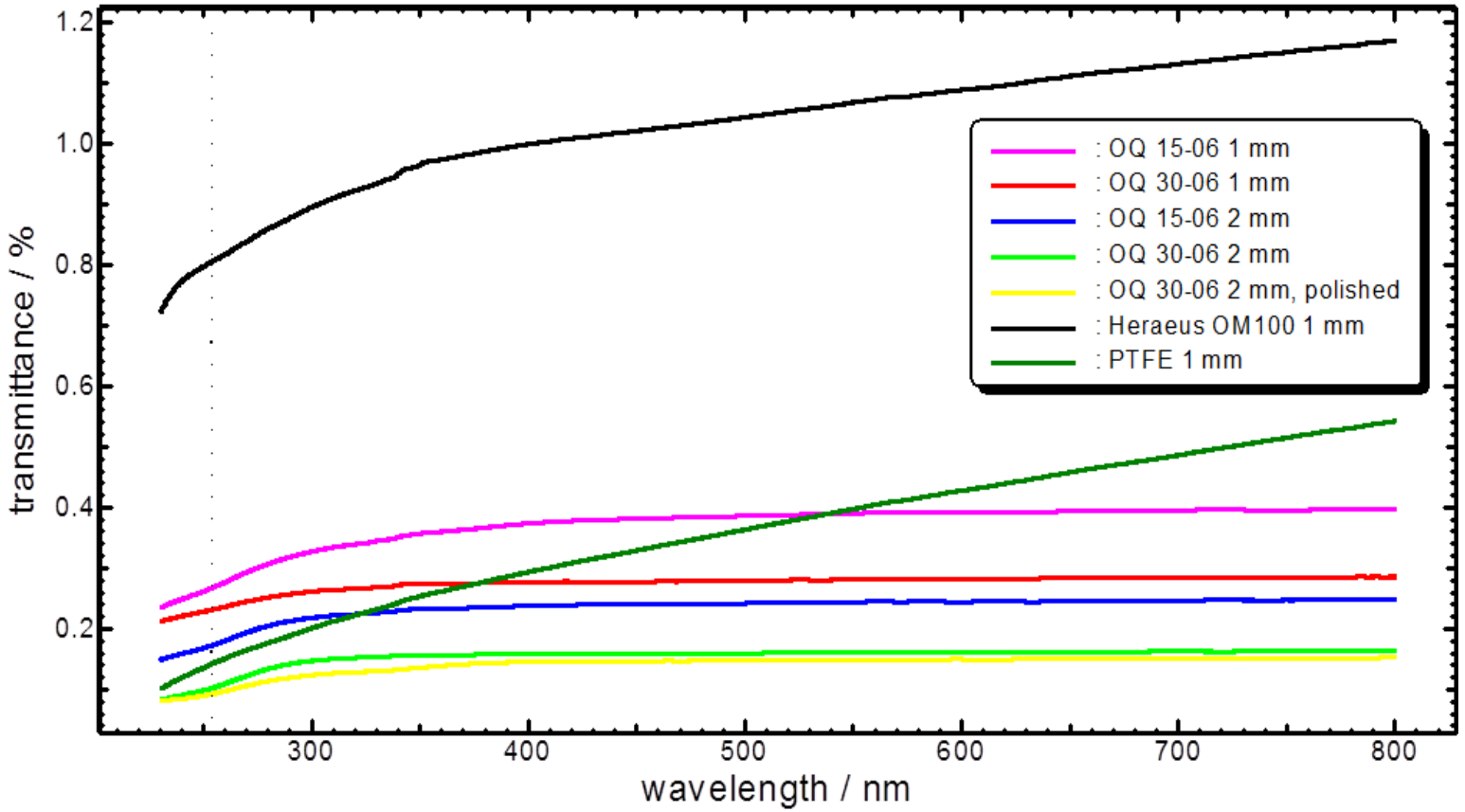


surface of a polished (left) and an unpolished opaque fused silica diffuser (right).

1. Characterization of UV sensor components

Diffusers

Spectral regular transmittance of different diffusers

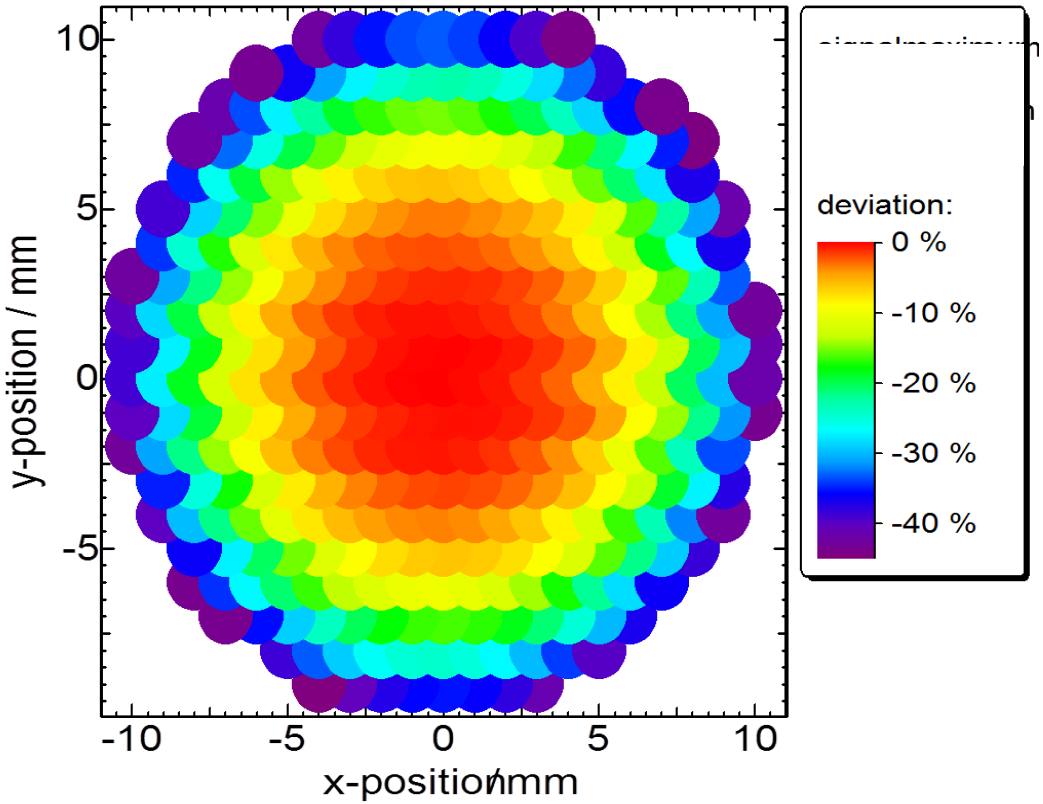


1. Characterization of UV sensor components

Diffusers

Primusil
Surface homogeneity

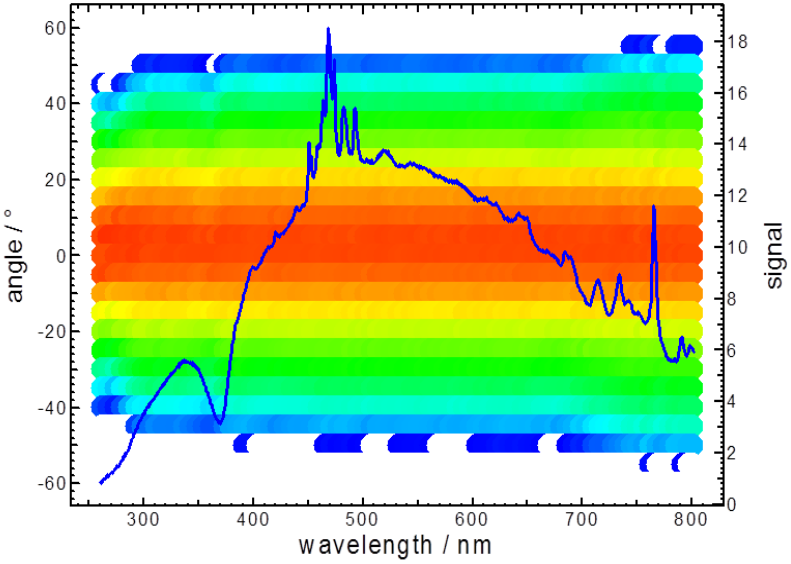
Each diffuser was irradiated by a high UV irradiance level. A silicon photodiode with an aperture of 3 mm scanned the distribution of the transmitted light right behind the diffuser.



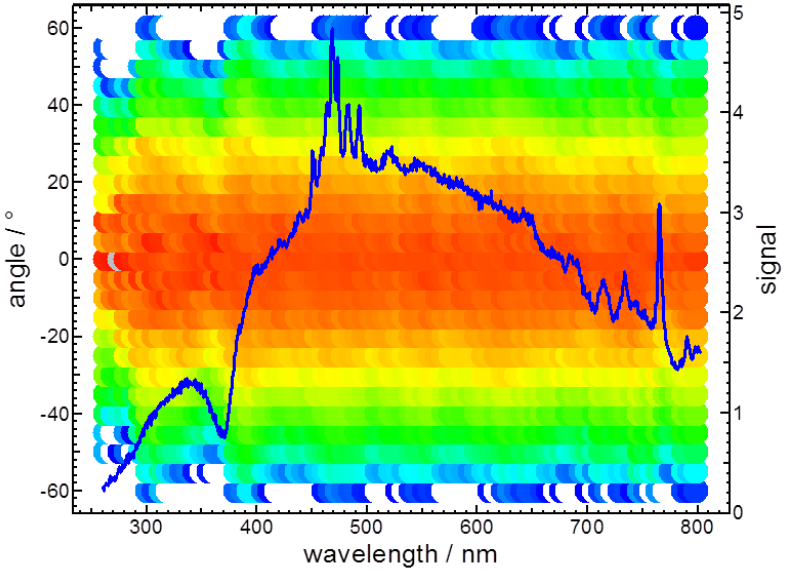
1. Characterization of UV sensor components

Diffusers

Deviation from cosine response as a function of wavelength



OM 100



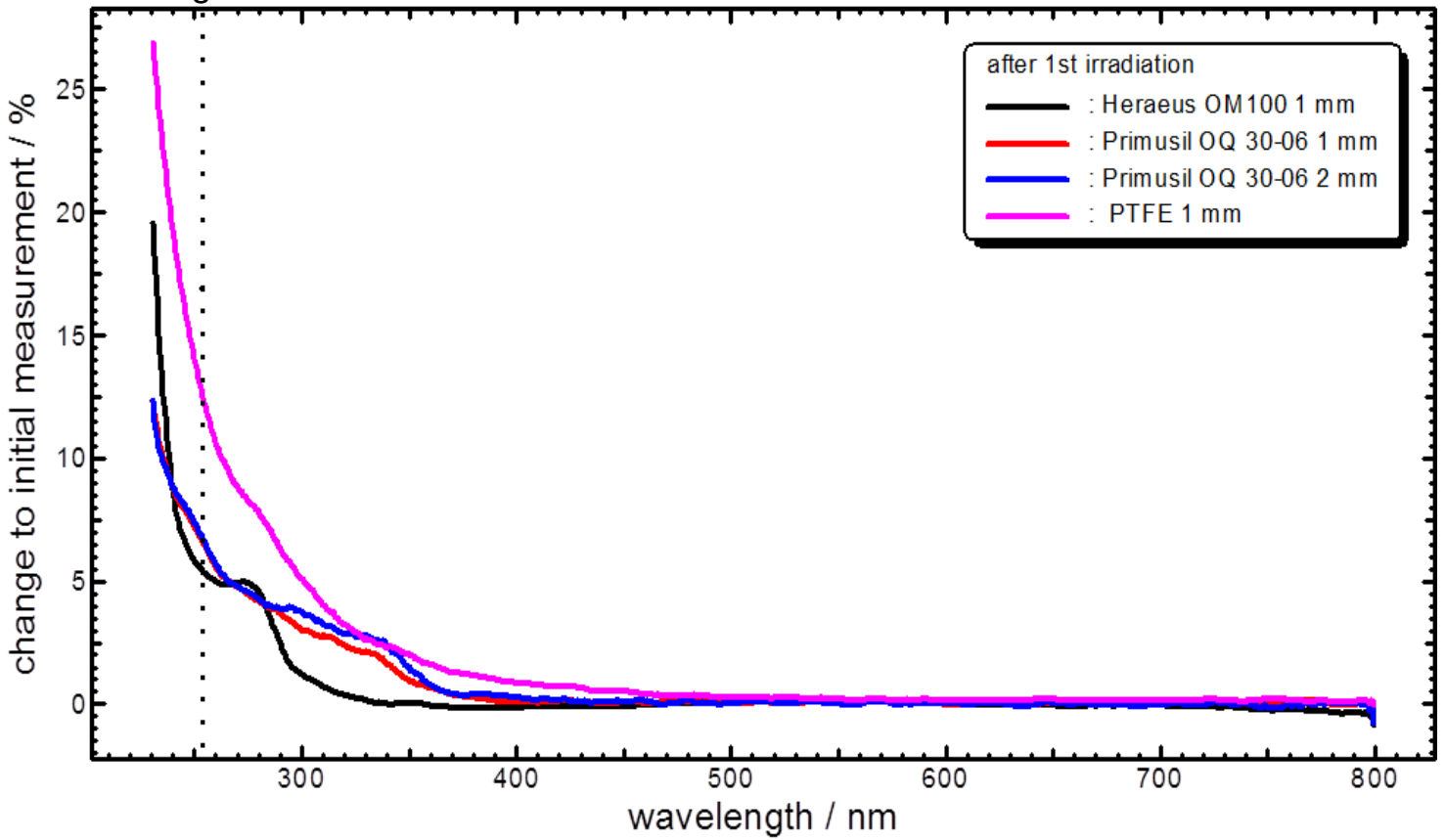
Primusil

1. Characterization of UV sensor components

Diffusers

Diffuser burn-in in front of a 2kW medium pressure source at a distance of 20cm

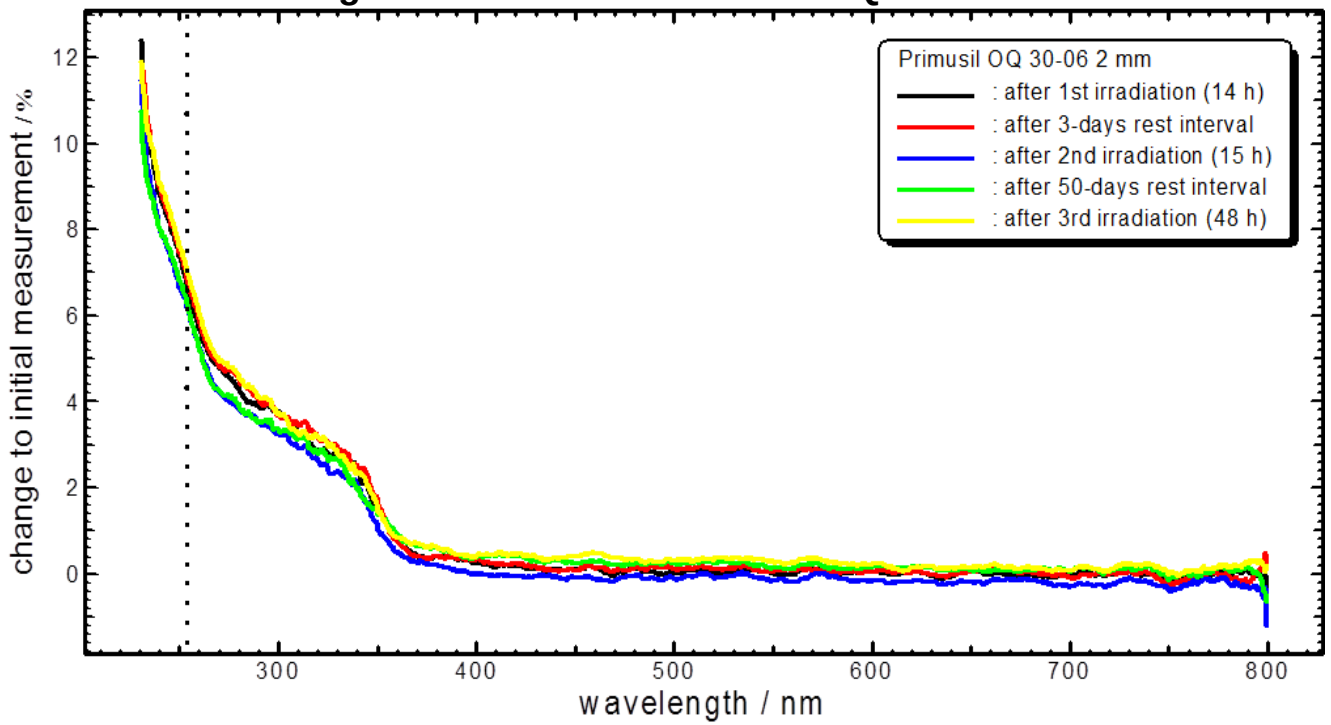
Change of transmittance after 14 hours of irradiation



1. Characterization of UV sensor components

Diffusers

Transmission change after burn-in of Primusil OQ



1. Characterization of UV sensor components

Electronics

Characterization and selection of electronic components for a digital sensor

OP-amps parameters (test quantity = 20)
- low input offset current/voltage
- low temperature coefficient of the offset
- low power consumption
- low noise

AD converter
- high resolution
- low non-linearity

Reference source for AD converter
- low temp coefficient

Feedback resistor
- low temperature coefficient
- low voltage coefficient

2. Development of a reference sensor

Specifications

- Sensor according to DVGW 294-3 specifications
- spectral sensitivity
- FOV
- rotational behavior
- mechanical design

- Integration of selected components

- Digital CAN bus output

- Wide dynamic range for universal use (changing transmission, different lamp types)

- High resolution

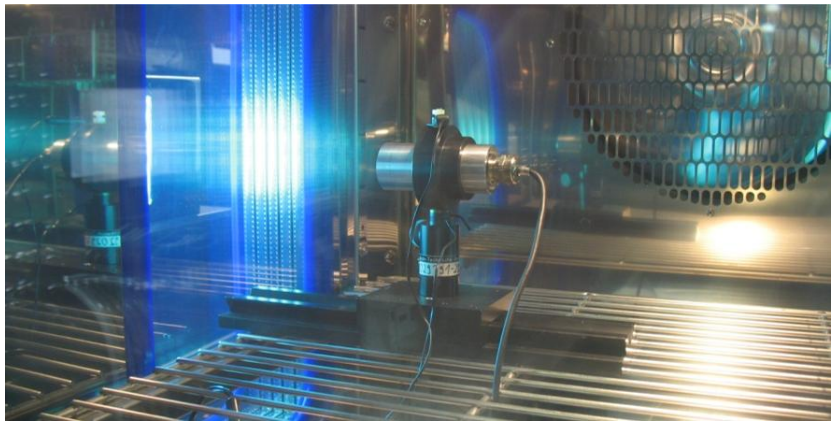
- Integrated temperature sensor

- 5 calibrations storable in the sensor

2. Development of a reference sensor

Characterization of the complete sensor

Temperature behavior



Sensor tempered in a climate chamber between 10° C and 85° C while irradiating with a stabilized low pressure UVC source

Results:

- no signal change between 10° C and 45° C
- signal decrease by 2.5% between 45 and 85° C

➡ necessity of a digital correction between 45° C and 85° C f(E, T)

Further validated were standard parameters like:
- sensor response to non-germicidal radiation (according to W294-3)
- FOV
- rotational signal behavior

3. Development of a handheld displaying unit

UVTOUCH

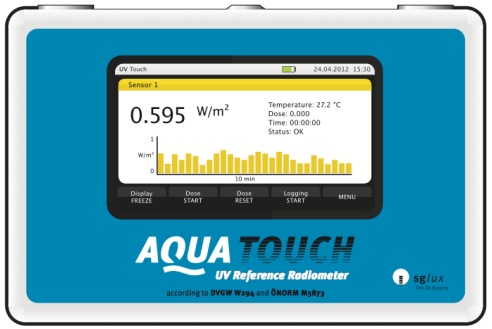
- **CAN-Bus conversation with developed sensors**
- **two measurement channels**
- **dose and intensity measurements**
- **data logging**

Main challenge

- **concept for EMC safety of sensor and handheld (mainly mains-borne disturbance / wire / power supply)**

Future appearance

AQUATOUCH – UV Reference Radiometer incl. sensor according to DVGW W 294-3



7. Validation

Validation and calibration at characterized medium and low pressure calibration sources at the PTB and at sglux

More about the calibration source:

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More about the measurement and calibration method:

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Traceable measurement of the spectral irradiance of water disinfection plants

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Thank you for your attention!