Characterization of SiC photodiodes for high irradiance UV radiometers

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Abstract

For monitoring high UV irradiance, silicon carbide (SiC) based photodiodes are used. In this paper we describe the characterization of novel SiC UV photodiodes in terms of their spectral and integral responsivity. Special attention is paid to the aging behavior of the photodiodes due to high UV irradiance. Artificial aging of the samples is performed by illumination with a high power medium pressure mercury discharge lamp.

Preliminary studies

- comparison of different photodiodes:
  SiC from Cree and sglux
  AlGaN from Genicom
- long term irradiation with a low pressure UVC lamp (Philips PL-L 36W 4P, approx. 4.2mW/cm^2 at peak wavelength)

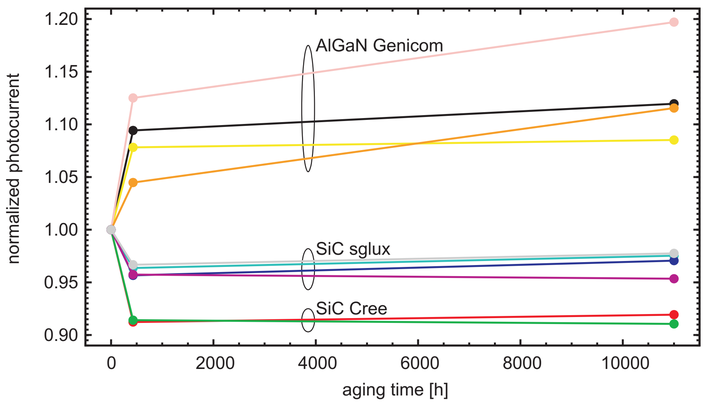

Figure 1: Normalized photocurrent for different types of UV photodiodes during long term irradiation with a low pressure UVC lamp.

- SiC photodiodes loose responsivity in the beginning of the irradiation (Cree: 9%, sglux: 4%), then no further degradation
- AlGaN photodiodes show an increased responsitivity (up to 20%) and a broad scatter

SiC photodiodes used in this study

- 8 novel SiC photodiodes
- manufacturer sglux SolGel Technologies GmbH
- improved visible blindness compared to SiC photodiodes from Cree
- area of the SiC chip: 1mm^2

Measurement setups

1. Artifical aging of the photodiodes

- irradiation with a high power medium pressure Hg discharge lamp
  uv-technik meyer UVH2022-17, spectrum see fig. 2
- operated at about 1.8kW constant electric power
- irradiance level in the beginning approx. 17mW/cm^2
- SiC reference detector for irradiance monitoring
- diodes 01, 03 - 06, 08 are irradiated
- diodes 02 and 07 are not exposed to UV radiation, and used as reference

2. Characterization of the photodidoes

- irradiation with a low pressure Hg discharge lamp Wedeco NLR 1825, spectrum see fig. 2
- UV irradiance approx. 1.04mW/cm^2
- SiC reference detector for irradiance monitoring
- diodes 01 - 08 are characterized

3. Spectral responsivity of the photodiodes

- obtained at PTB's differential spectral responsivity (DSR) facility
- usually used for calibration of solar cells, modified for measurements in the UV range
- diodes 01 - 04 are investigated

Spectral emission from the UV lamps

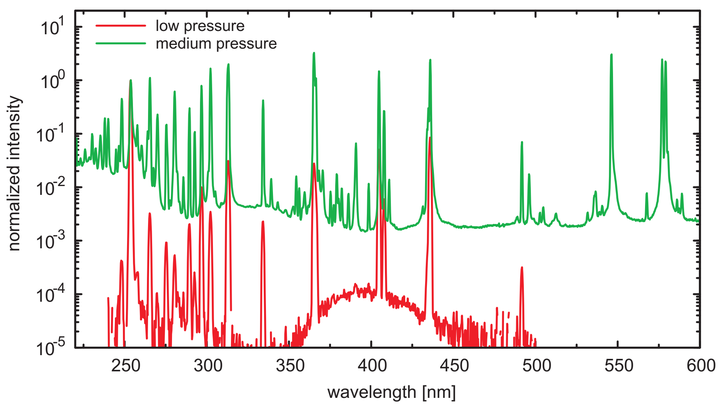

Figure 2: Spectral emission from the low (red line) and medium (green line) pressure lamps. Normalized to 253.75nm.

Photodiode behavior during artificial aging

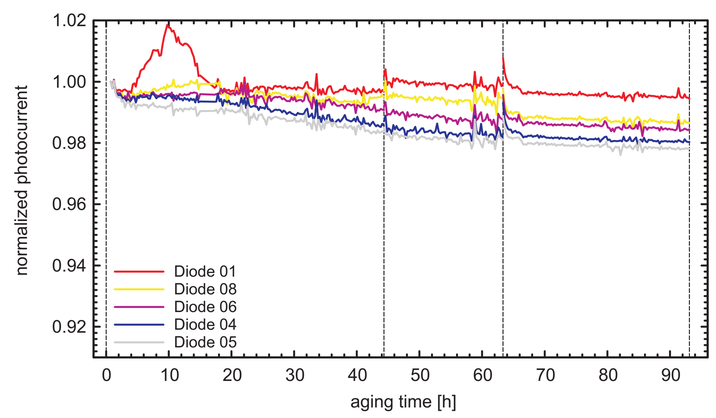

Figure 3: Normalized photocurrent for 5 photodiodes during aging with the medium pressure lamp.

- total aging time approx. 93h
- aging interrupted for characterization with the low pressure Hg lamp (dashed lines)
- decrease in responsivity up to 2.2%

Photodiode characterization

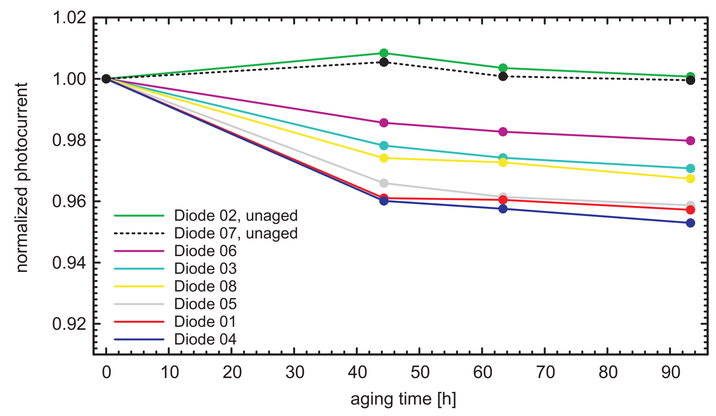

Figure 4: Normalized photocurrent, characterization with the low pressure lamp.

Unaged photodiodes 02 and 07:
- no decrease in photocurrent

Aged photodiodes 01, 03 - 06, and 08:
- decrease in responsivity up to 4.7%
- much larger decrease in responsivity as compared to fig. 3
- aging of the photodiodes mainly in the beginning

Spectral responsivity

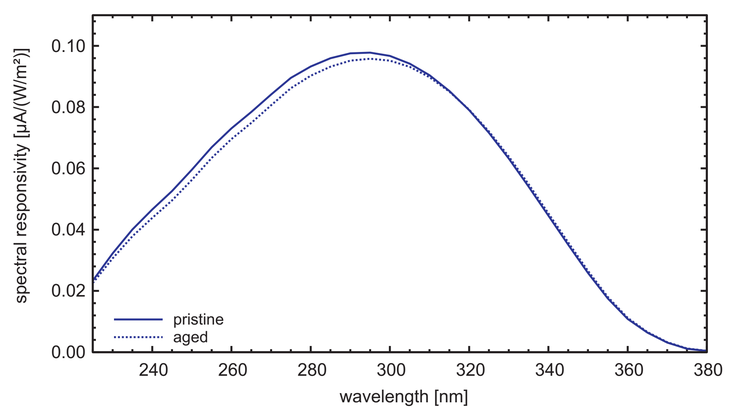

Figure 5: Spectral responsivity of diode 04 in pristine state (solid line) and after 93h of aging (dashed line).

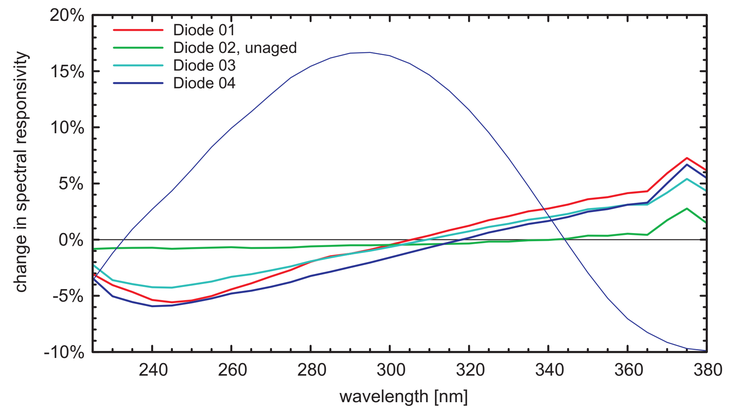

Figure 6: Change in spectral responsivity after aging of diodes 01 - 04. Additionally, the spectral responsivity of diode 04 in pristine state is shown as thin line.

Unaged photodiode 02:
- no change in spectral responsivity

Aged photodiodes 01, 03, and 04:
- change in spectral responsivity is observed
- change is wavelength dependent
- below approx. 310nm: loss in responsivity
- above approx. 310nm: gain in responsivity

Change in integral responsivity

Due to wavelength dependent responsivity:
- integral responsivity depends on the lamp used
- calculation uses spectral responsivity (fig. 6) and spectra of the low and medium pressure lamps (fig. 2)

	low pressure	medium pressure
Diode 01	-4,7%	-1.4%
Diode 02	-0.7%	-0.5%
Diode 03	-3.5%	-1.2%
Diode 04	-5.0%	-2.3%

Calculated values perfectly agree with measurement data from both types of lamps (fig. 3 and fig. 4).

Conclusions

Very recent measurements after additional 120h of irradiation: photodiodes are not aging significantly any further
⇒ after burn-in: SiC photodiodes are very stable

Outlook

- degradation studies of the photodiodes will be continued
- additional photodiodes will be investigated

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