

1 Picture of an integrated 4x4-SiC-UV-Sensorarray

## ION IMPLANTED SiC UV-PHOTODIODES TUNEABLE FOR UV-A/B SUNLIGHT AND VISIBLE BLIND UV-C DETECTION

### Fraunhofer IISB

Schottkystrasse 10  
91058 Erlangen  
Germany

### Contact:

PD Dr.-Ing. Tobias Erlbacher  
Phone: +49 9131 761 319  
Fax: +49 9131 761 360  
tobias.erlbacher@iisb.fraunhofer.de

[www.iisb.fraunhofer.de](http://www.iisb.fraunhofer.de)



### General description

- A p+n-junction formed by ion implantation in epitaxially grown n-layer on highly n-doped 4H-SiC-substrate
- Strong photon absorption in the desired UV range
- No absorption of visible light, e.g. from artificial sources

### Advantages

- Visible-blind design (excellent rejection of artificial light sources)
- Higher sensitivity without cooling compared to silicon
- Less intrinsic noise compared to silicon sensor devices
- EQE up to 60% (next generation EQE > 75% expected)
- Compatible with ams "multi-sensor platform chip" from EU-FP7 MSP project (no. 115495) and MPW service

### Features

- Wide bandgap of 4H-SiC (3.26 eV) offers possibility of visible blind UV-detection without additional optical filters
- Selectivity to sunlight can be adjusted by the sensor design
- Low intrinsic carrier concentration - very low dark current
- Ion implantation technology offers possibility of very shallow emitters
- Reduced process effort and higher homogeneity compared to fabrication using epitaxy
- Integrated two-dimensional sensor arrays feasible

### Benefits

- Higher turnover from new applications and increased sensitivity
- Cost reduction from room temperature operation (no sensor cooling required)

2 Integrated 2x2 SiC-UV-sensor arrays

**Spectral responsivity**

- Tunable maximum, e.g. at 260 nm: 110 mA/W
- Near-constant responsivity from 270-300 nm achievable
- Typical peak external quantum efficiency of 55%

**Reverse IV-characteristics (typ.)**

- Dark current < 1 nA/cm<sup>2</sup>
- Typ. SNR > 57 dB
- Cap. typ. 20 nF/cm<sup>2</sup> at 0 V

**Temperature characteristics**

- Operation up to 200 °C (limited by packaging, usability of SiC chip at higher temperatures)
- Even higher photocurrent at higher temp. (up to 200 °C), especially for longer wavelengths
- No measurable increase of dark current (Fig. 2)

**Application examples**

- UV water purification (typ. 254 nm) - Fig. 1
- Flame and heat detection (several peaks) - Fig. 3
- Sunlight UV (280 – 380 nm) monitoring - Fig. 4 & 5

**Device dimensions**

- Die size x (typ.): 1.5 mm\*
  - Emitter-size y: 1.3 mm\*
  - Optical area (typ.): 1.6 mm<sup>2</sup>\*
  - Bond pad area b (typ.): 0.25 x 0.25 mm\*
- \*others on request

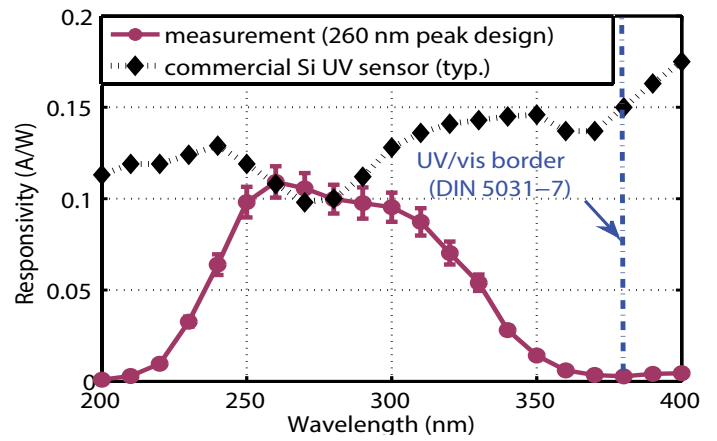
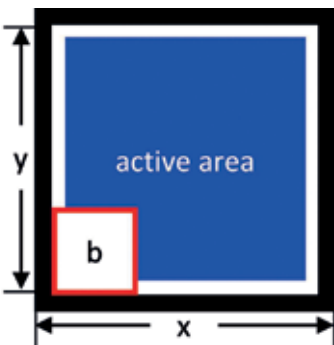


Fig. 1: Measured responsivity of a 260 nm peak device in comparison to a commercially available UV sensitive Si-photodiode

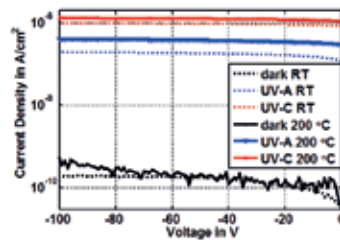


Fig. 2: Typical reverse IV-curve with UV-A (broad-band) and UV-C lamp (254 nm peak) turned on and off @RT and 200 °C

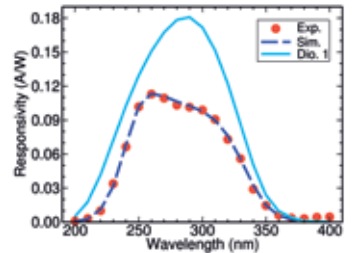


Fig.3: TCAD simulation of new 290 nm peak design with EQE > 75% (green), sim. model for old design (see Fig. 1) shown for verification

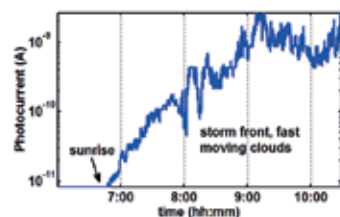


Fig. 4: Photocurrent vs. time during storm 'Niklas' in Germany in 2015

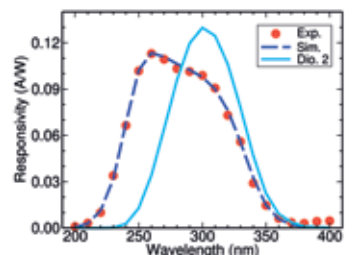


Fig. 5: TCAD simulation of new solar UV design (green) in Germany in 2015