

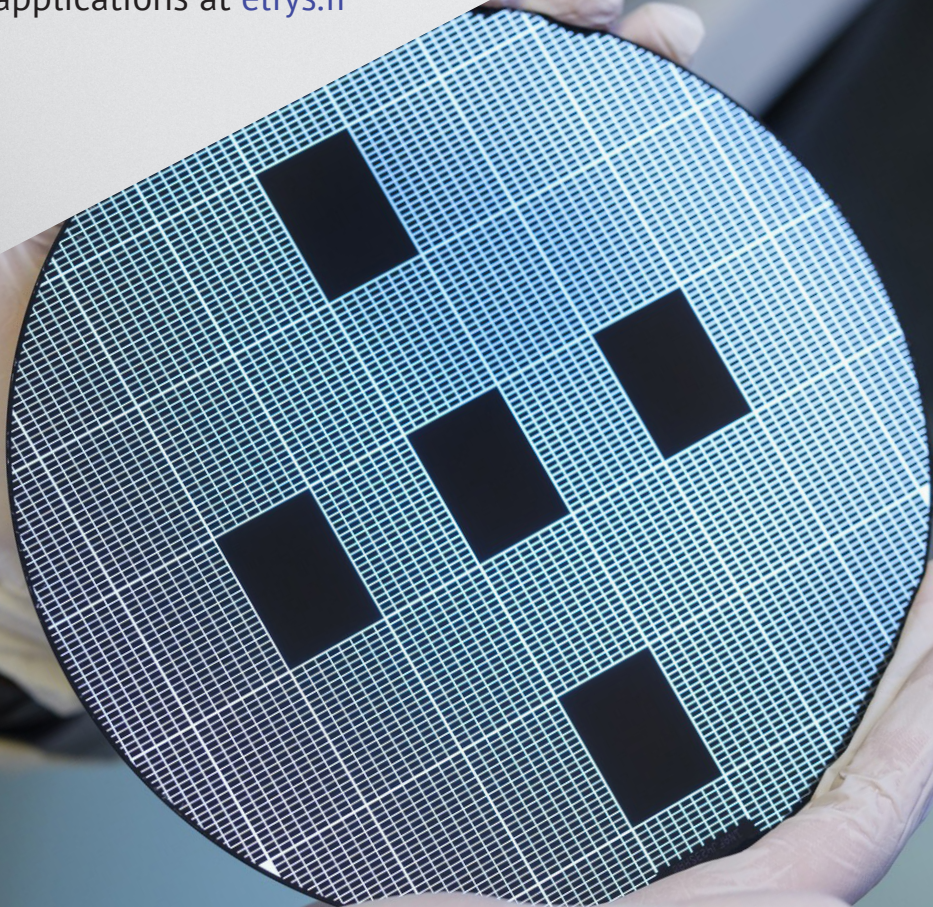


# BLACK SILICON PHOTODIODES: THE ULTIMATE ADVANTAGE

Capturing every ray of light

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## LIMITLESS APPLICATIONS FROM SAFETY AND SECURITY TO MEDTECH AND WEARABLES

Where innovation meets the demanding applications

ELFys provides advanced photodetector products and services based on innovative black-silicon induced-junction technology. We support our customers to evaluate photodetector performance for proof-of-concept. We design and develop tailored photodetector solutions with our in-depth know-how. We manufacture and supply photodetector products with small volume and mass production.

### We offer

#### Standard product portfolio

- ◆ Photodetector products with different sizes and packaging options
- ◆ Samples for quick demonstration and evaluation of the photodetector technology
- ◆ High-volume production capability

#### Customized solutions with production

- ◆ Customized photodetector design
- ◆ Prototyping and validation in small volume
- ◆ High-volume production capability

#### Black silicon induced junction technology and semiconductor processing services

- ◆ Core know-how technology available for outsourcing or licensing
- ◆ Black silicon and photodiode processing services

### Manufacturing

ELFys has two manufacturing sites at its disposal. The company utilizes the state-of-the-art processing facilities at Micronova Nanofabrication Center in Finland: 2600 square meters of CMOS compatible facilities suitable for both R&D and semi-mass production. For high-volume mass production, ELFys has partnered with an external, European semiconductor partner.



### About us

ELFys, Inc. was founded in autumn 2017 and is located in Espoo, Finland. The company is based on long-term research work at Aalto University. Our core team consists of former senior researchers, engineering leaders and business professionals. 40 % of ELFys staff are women, and we speak 7 languages at native level.

ELFys provides light sensors with better sensitivity than anything seen before, literally catching every ray of light. The technology greatly improves any light sensing application ranging from health monitoring to analytical instrumentation, space and defence. The superior performance of ELFys photodetectors is based on an inventive combination of modern MEMS nanotechnology and atomic layer deposition. The core technologies are patented and in the possession of the company.

### Contact

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## THE MOST SENSITIVE PHOTODETECTOR FOR UV-VIS-NIR PRODUCT AND TECHNOLOGY OFFERING

### Standard photodiode product portfolio

We help our customers to evaluate our advanced photodetector technology in their applications. The purpose is to prove the design concept at initial stage, and to verify the intended performance. This provides an easy, fast and low-risk approach for product development.

#### We offer

- ◇ Photodetector technology support and consultation
- ◇ Demonstration photodetector chips and evaluation samples of standard form factor and configuration
- ◇ Demonstration photodetector performance characterization and measurement report

Delivery time: 2 weeks

### Custom solution

We provide tailored photodetector solutions based on our advanced technology for the customer's applications. The purpose is to create an optimized solution with unmatched performance and quality for each individual use case. We design and prototype product samples with the customer's specification, enabling the customer to quickly verify the new solution on a system level, and guaranteeing a short time-to-market.

#### We offer

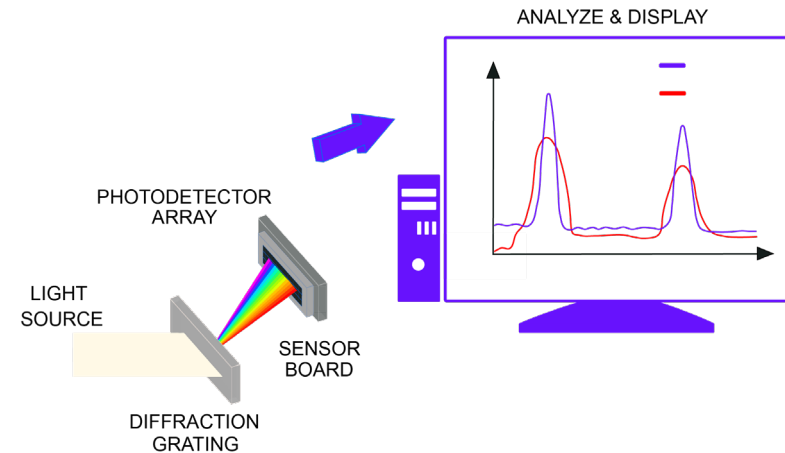
- ◇ Customized photodetector chip design based on specifications
- ◇ Customized photodetector packaging design based on specifications
- ◇ Manufacturing prototypes in small volume
- ◇ Comprehensive testing for quality verification

Delivery time: 3 - 4 months

### Continuous delivery

We build long-term relationships with our customers. We promise to provide products and services to our customers consistently. We actively manage our product life-cycle in the best interest of our customers. We apply the lean production principles to our future production efficiency development. **We offer small batch delivery as well as mass production.**

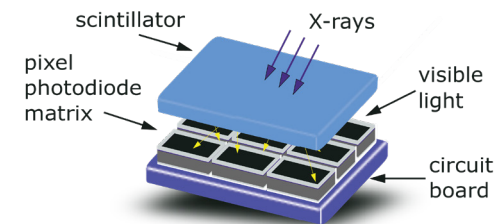
## APPLICATIONS



ELFys photodetectors, spanning from ultraviolet to near-infrared, are designed to provide a competitive edge in various applications:

- ◇ Health Monitoring
- ◇ Defence & Space applications
- ◇ Analytical Instrument

Our photodetectors are available with different designs and can be **customized** for your use.



# PHOTODETECTOR PRODUCTS

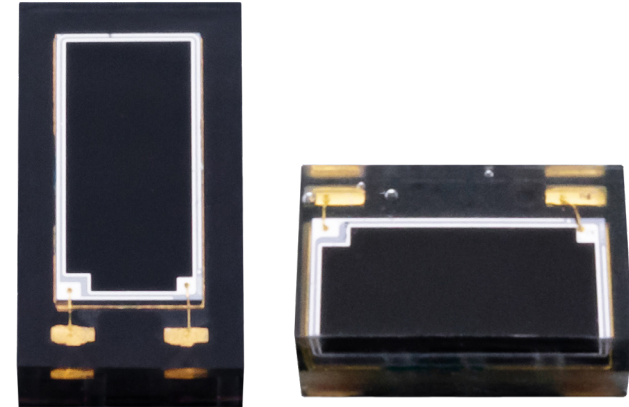
## SM PRODUCT LINE

### Key benefits

- ◇ Superior photosensitivity at multiple wavelengths: Green, Red, and NIR
- ◇ Low dark current
- ◇ Compact SMD packaging

### Key applications:

- ◇ Health monitoring
- ◇ Wearable electronics
- ◇ and more



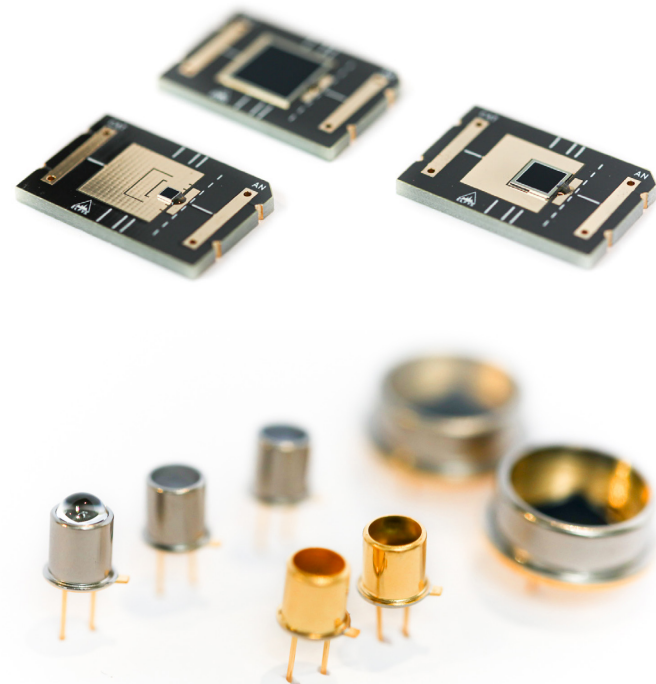
## PD PRODUCT LINE

### Key benefits

- ◇ Enhanced photosensitivity with wide spectrum: UV, Vis and NIR
- ◇ Optimized electrical properties
- ◇ Maximum environmental protection with TO-can packaging

### Key applications:

- ◇ High precision photometry
- ◇ Analytical instruments
- ◇ and more



## SM AND PD SPECIFICATIONS

Product line	Product name	Bias voltage - Max.	Photosensitive area	Dark current @ -10mV - Max	Capacitance @ 0 V, 100 kHz	Responsivity		Default packaging*
		[V]				[mm <sup>2</sup> ]	[pA]	
SM	SM322	6	3.22	40	60	0.71	970	SMD
	SM446		4.46	50	80	0.71	970	SMD
PD	PD1sM	10	1	12	20	0.80	1010	TO-46
	PD1sH		1	255	11	0.81	1040	TO-46
	PD4sM		4	15	65	0.80	1010	TO-46
	PD25sM	20	25	30	370	0.80	1010	TO-8
	PD25sH		25	700	110	0.81	1040	TO-8
	PD100sM		100	60	1200	0.80	1010	PCB
	PD100sH		100	1500	340	0.81	1040	PCB
	PD5sMG		5	15	105	0.80	1010	PCB
	PD5sHG	5	400	30	0.81	1040	PCB	
	PD25sMG	100	25	30	370	0.80	1010	PCB
	PD25sHG		25	700	110	0.81	1040	PCB
	PD100sMG		100	60	1200	0.80	1010	PCB
	PD100sHG		100	1500	340	0.81	1040	PCB

\*Customized packaging is available for all products upon customer request, bare chip is available off-the-shelf for all products.

Visit [www.elfys.fi](http://www.elfys.fi) to view datasheets

# PHOTODETECTOR PRODUCTS

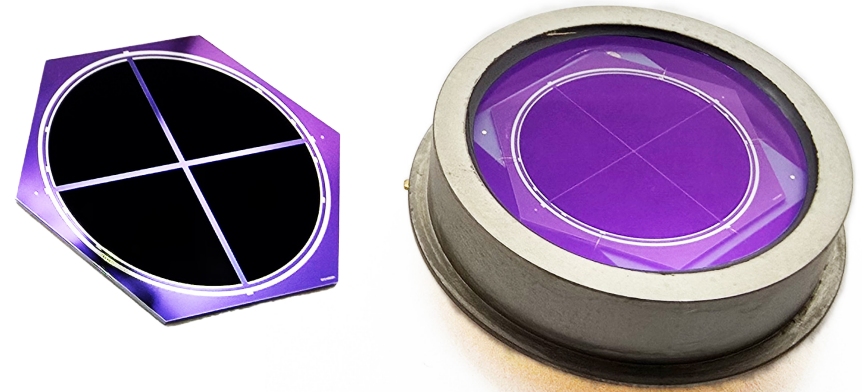
## FOUR-QUADRANT PHOTODIODE (QPD) PRODUCT LINE

### Key benefits

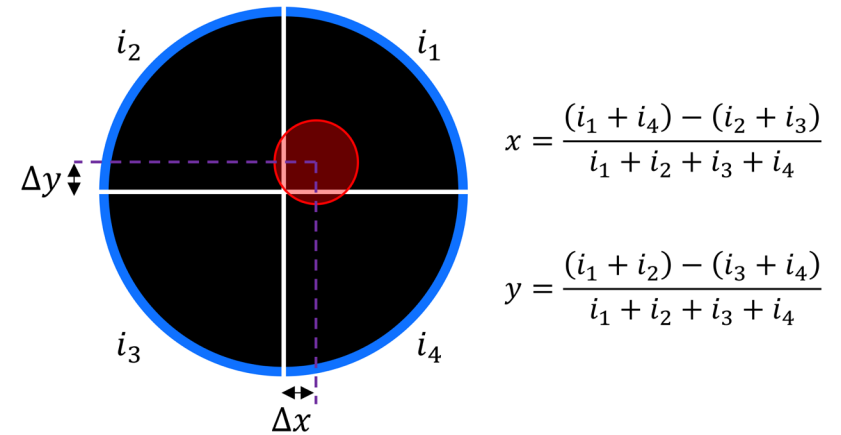
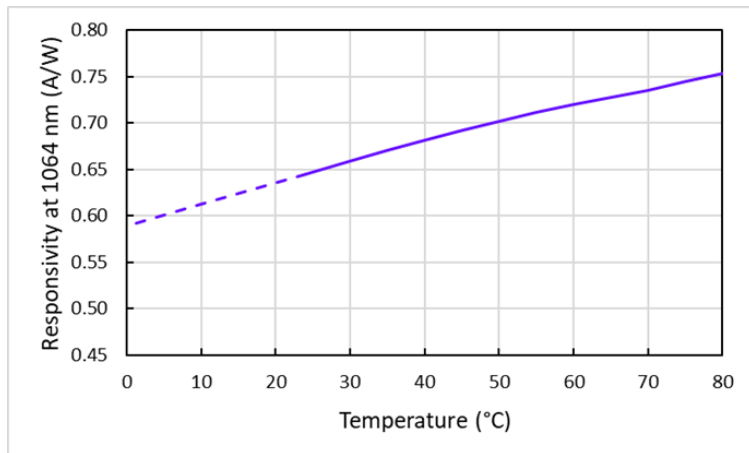
- ◆ Exceptional sensitivity 0.64A/W @1064nm in NIR
- ◆ Accurate positional information on incident light
- ◆ High responsivity with low dark current and fast response times

### Key applications:

- ◆ YAG laser (1064 nm) systems
- ◆ Laser beam tracking/alignment
- ◆ Atmospheric/space optical communication
- ◆ Autocollimator
- ◆ Defence Applications
- ◆ and more



Responsivity as a function of temperature at 1064 nm



A 4-quadrant detector can determine the position of a laser beam on the detector surface by comparing the output currents between the quadrants.

## QPD SPECIFICATIONS

Electro optical characteristics at 25 °C

Parameter	Condition	Min	Typ	Max	Unit
Active area ( per element )			38.5		mm <sup>2</sup>
Overall active area diameter			14		mm
Case bottom to active surface distance			5.0		mm
Active surface to glass window distance			200		μm
Gap	between elements		70		μm
Dark current	bias 140 V, per element		5	30	nA
Dark current temperature coefficient	bias 140 V, per element		1.11		times/ °C
Responsivity	bias 140 V, wavelength 1064 nm	0.5	0.64		A/W
Breakdown voltage	reverse current 2 μA	250			V
Capacitance	bias 140 V, per element		16	22	pF
Rise time	bias 140 V		15		ns
Crosstalk	bias 140 V, load resistance 1000 Ohm, wavelength 1064 nm		2		%
Heating resistor*			40		Ω
Temperature sensor resistance*			1 000		Ω
NEP			6.30E-14		W/ √Hz
FOV			±75		°

\*11-pin TO-can with heater, model QPD-385-YH

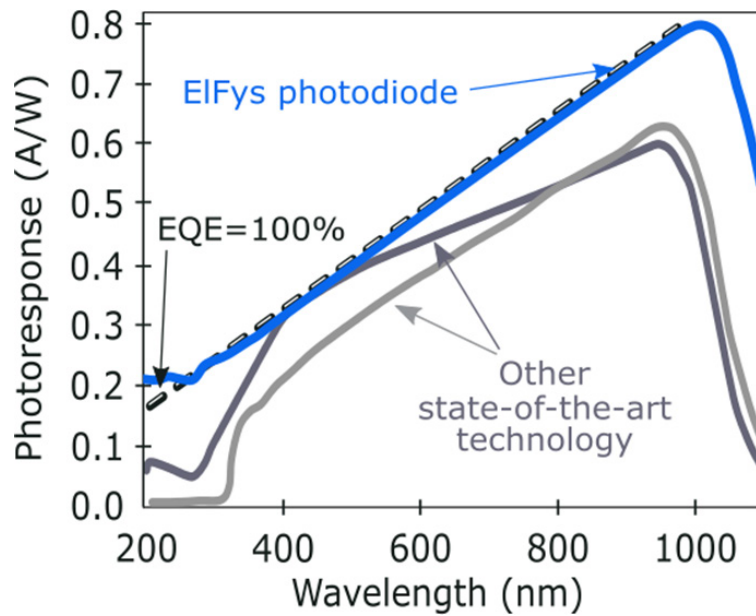
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## KEY BENEFITS

### Key benefits for your applications

- ◇ High responsivity (> 96% EQE) over entire optical spectrum range (200 nm to 1050 nm)
- ◇ Ultra wide sensing angle with extremely high absorbance (> 95% @ 60°)
- ◇ Superior responsivity in ultraviolet wavelength range (no signal losses in the photodetector surface layer)
- ◇ Customized design with optimal electrical properties

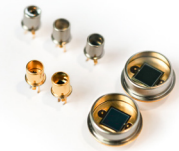
### Data certified by PTB - Physikalisch-Technische Bundesanstalt



## INNOVATIONS

### Core technology: Black Silicon Induced Junction

- ◇ Nano-engineered surface structure
- ◇ Defect-free induced junction
- ◇ Advanced ALD passivation

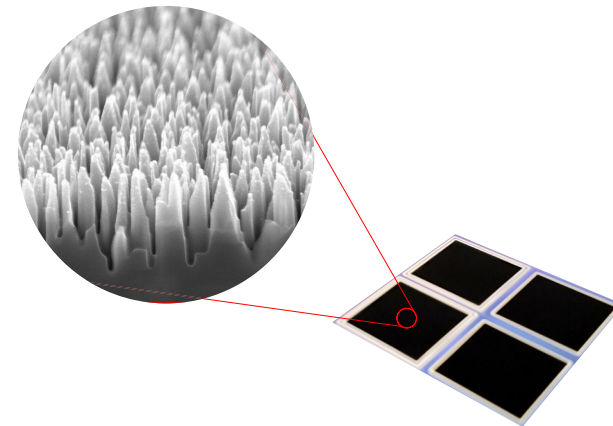


### Patents

Our photodiode technology is protected by our patent families worldwide

### Scientific publications

- ◇ M.A. Juntunen et al, Nature Photonics, 2016, 10, 777-781
- ◇ M. Garin et al, Physical Review Letters, 2020, 125, 117702
- ◇ J. Heinonen et al, IEEE Transactions on Electron Devices, 2020, 67 (4)
- ◇ T. Tsang et al, Optics Express 2020, 28,13299
- ◇ J. Heinonen et al, Nuclear Instruments and Methods in Physics Research A, 2020, 977, 164294



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