Instruction manual and data sheet SPCA-4Pi-05-3000-1060-x

Broadband photoconductive antenna with 4 π logarithmic spiral structure
for laser wavelengths λ ~ 500 nm … 1100 nm

PCA – Photoconductive Antenna

SPCA-4Pi-05-3000-1060-0	- unmounted antenna chip 4 mm x 4 mm with 2 bond contact pads
SPCA-4Pi-05-3000-1060-h	- mounted antenna on hyperhemispherical silicon substrate lens
SPCA-4Pi-05-3000-1060-a	- mounted antenna on aspheric focusing silicon substrate lens
SPCA-4Pi-05-3000-1060-c	- mounted antenna on aspheric collimating silicon substrate lens

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1. PCA application

The PCA can be used in a time-domain terahertz spectrometer as emitter and detector antenna in the frequency region from 0.05 to 1 THz.

- Laser excitation wavelength 500 nm … 1060 nm

2. Antenna design

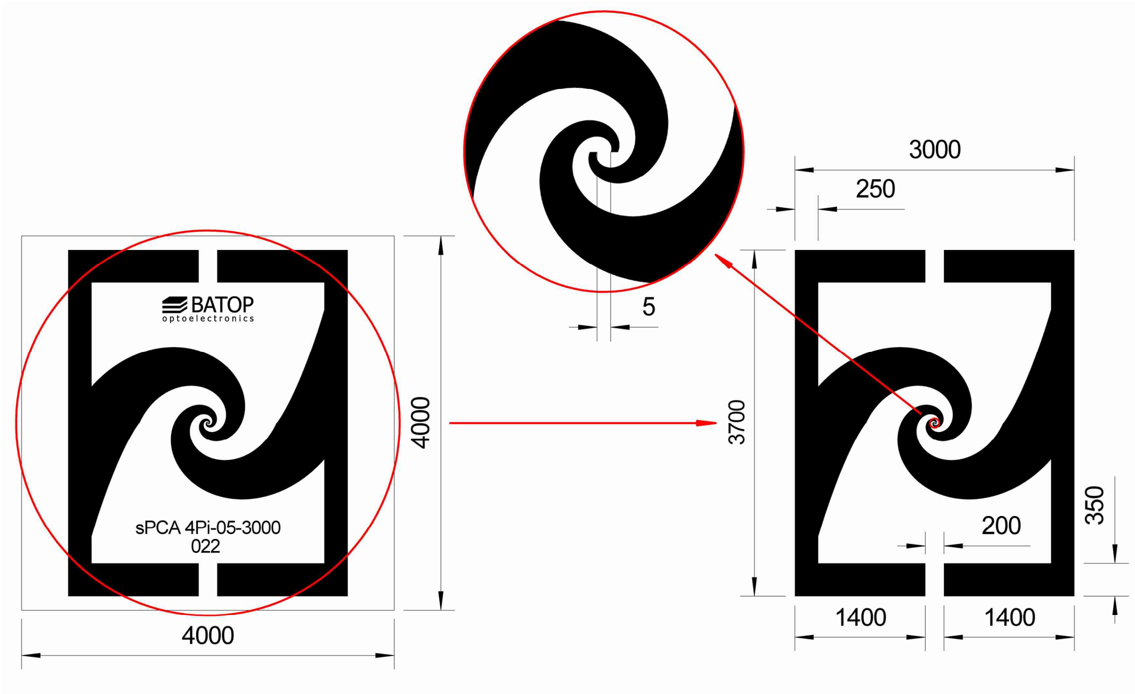


Photo SPCA-4Pi-05-3000 (survey)

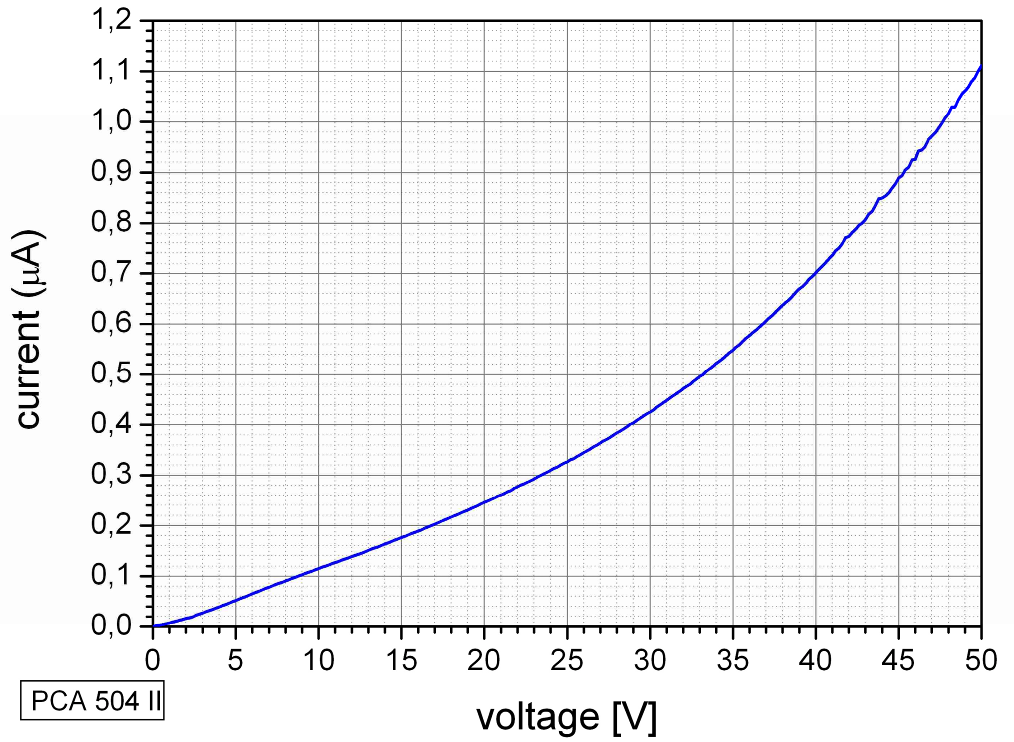
Photo SPCA-4Pi-05-3000 (detail)

Dielectric cover

3. Antenna parameters

Electrical parameters	***Values***
Dark resistance	80 MΩ
Dark current @ 10 V	120 nA
Maximum voltage	20 V

Dark current voltage characteristic of SPCA-4Pi-05-3000-1060



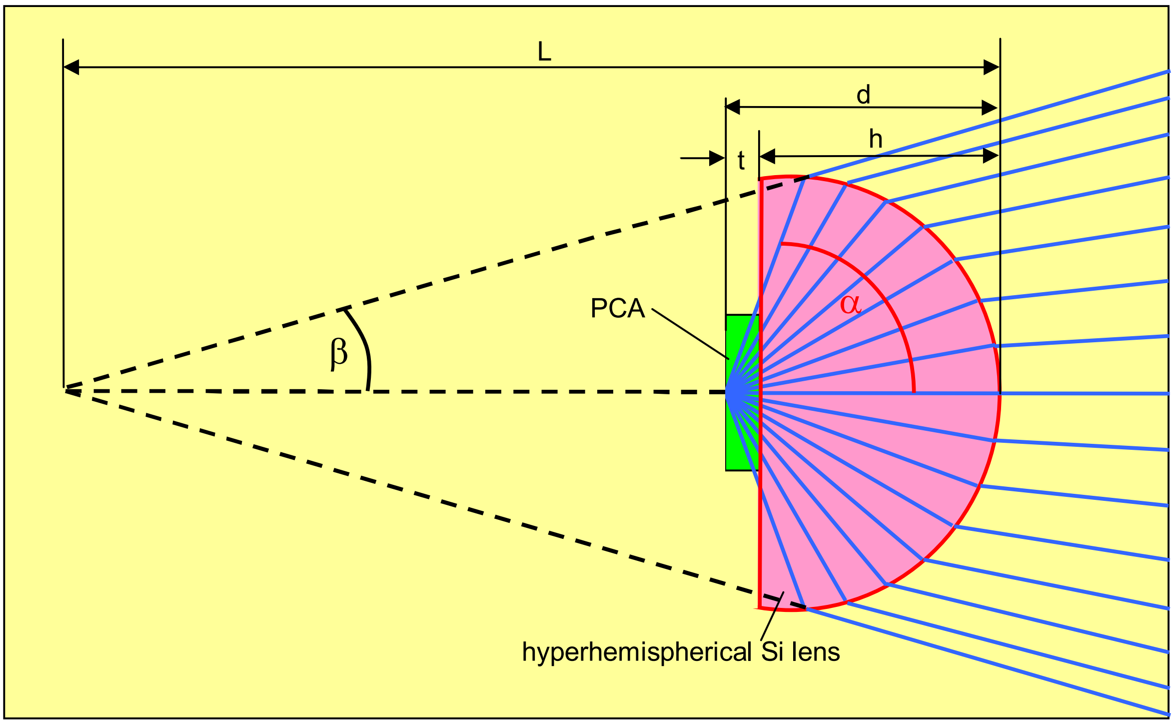
Optical excitation parameters	***Values***
Excitation laser wavelength	500 - 1060 nm
Optical reflectance @ 1060 nm	~ 10 %
Optical mean power	10 – 20 mW
Carrier recovery time	250 fs

4. Mounted PCA on hyperhemispherical silicon substrate lens: SPCA-4Pi-05-3000-1060-h

Photoconductive antenna	substrate	semi-insulating GaAs
	chip area	4 mm x 4 mm
	thickness t	600 µm

Hyperhemispherical lens	material	undoped HRFZ-silicon,
	specific resistance ρ	>10 kΩcm
	refractive index n	3.4
	diameter	12 mm
	height h	7.1 mm
	distance d	7.7 mm

Terahertz beam	collection angle α	57°
	divergence angle ß	15°
	virtual focus length L	26.4 mm

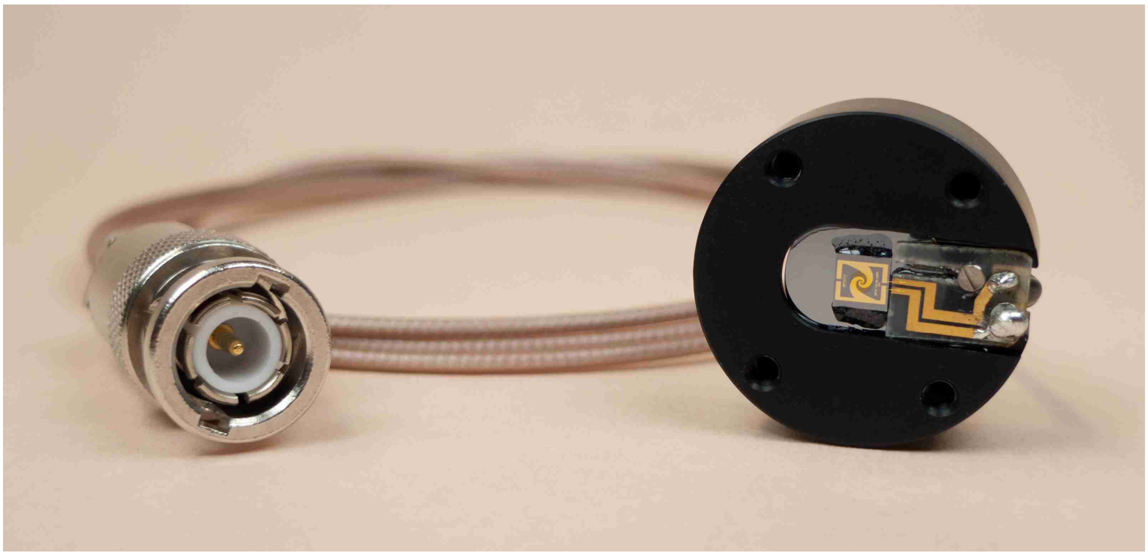


Aluminum mount	25.4 mm diameter, 6 mm thick
Coaxial cable	type RG178 B/U, impedance 50Ω, capacitance 96pF/m, 1 m long
Connector type	BNC or SMA

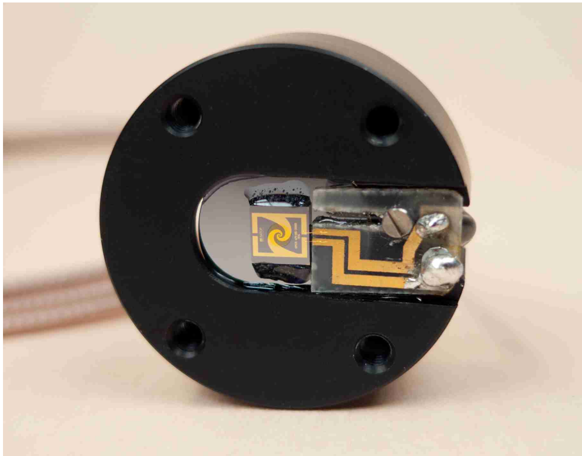
- The PCA chip is optically adjusted and glued on the hyperhemispherical silicon lens with a thermal conducting glue.

- The silicon lens is fixed on the aluminum mount with a thermal conducting glue.
- The two antenna contacts are wire bonded on a printed circuit board, which provides the connection to a 1m long coaxial cable with BNC or SMA connector
- A central hole in the aluminum mount allows the Terahertz radiation to escape from the hyperhemispherical silicon lens

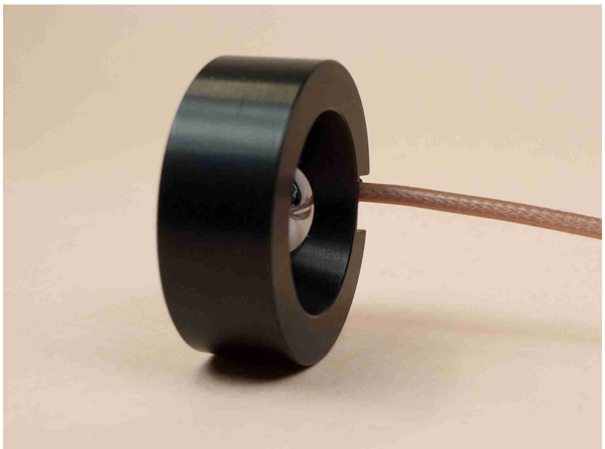
PCA with hyperhemispherical silicon lens, coaxial cable RG 178 and BNC connector



Front view on mounted PCA (laser side)

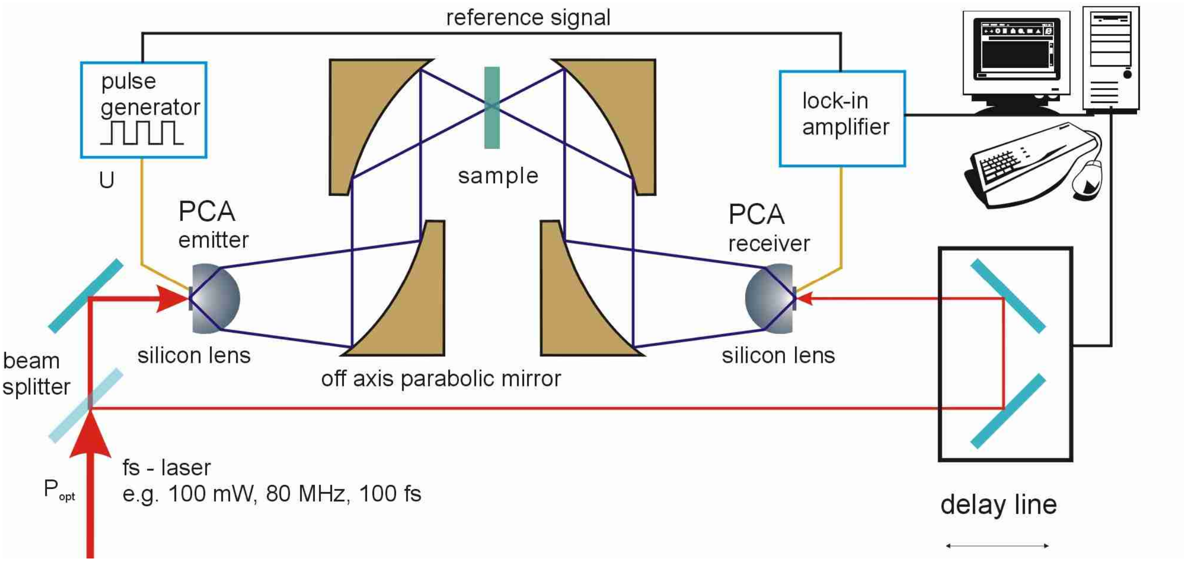


Back view on mounted PCA (THz side)



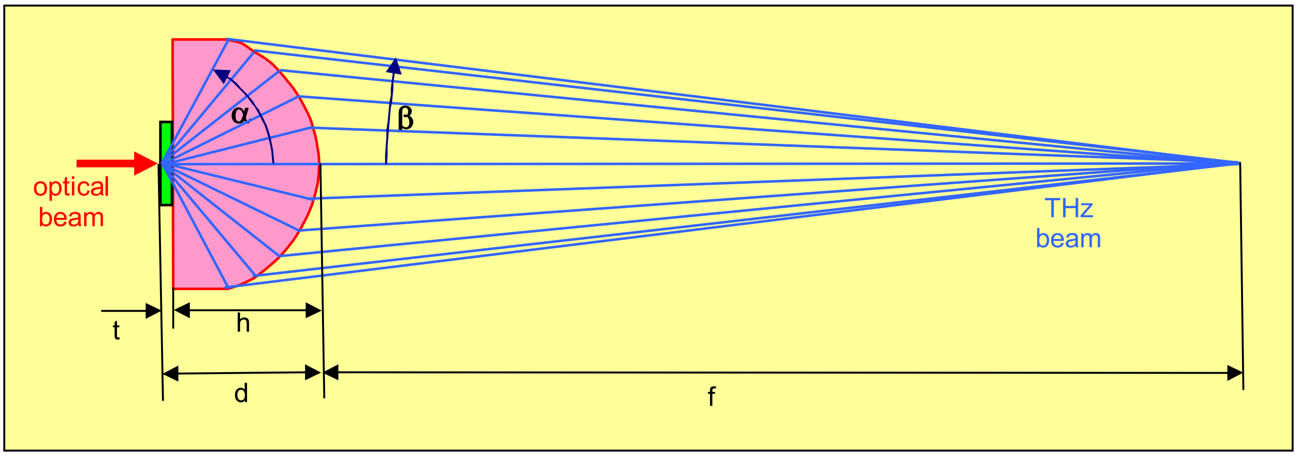
The antenna can be used as terahertz emitter or detector in pulsed laser gated broadband THz measurement systems for time-domain spectroscopy (see schematic below).

Schematic of a time-domain spectroscopy setup



5. Mounted PCA on aspheric silicon substrate lens: SPCA-4Pi-05-3000-1060-a

Photoconductive antenna	substrate	semi-insulating GaAs
	chip area	4 mm x 4 mm
	thickness t	600 µm
Aspheric lens	material	undoped HRFZ-silicon
	specific resistance ρ	>10 kΩcm
	refractive index n	3.4
	diameter	12 mm
	height h	8 mm
	distance d	8.6 mm
	rough AR surface	
Terahertz beam	focal length f	50 mm
	collection angle α	57.6°
	convergence angle ß	6.8°
Airy disc diameter	at 300 GHz	5 mm
	at 1 THz	1.5 mm
	at 3 THz	0.5 mm



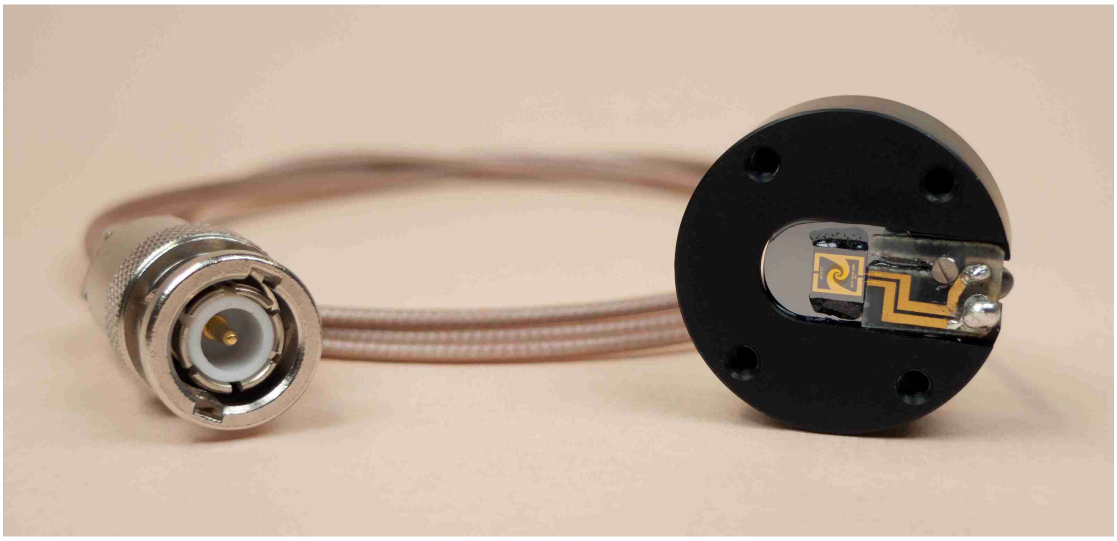
Aluminum mount	25.4 mm diameter, 6 mm thick
Coaxial cable	type RG178 B/U, impedance 50Ω, capacitance 96pF/m, 1 m long
Connector type	BNC or SMA

- The PCA chip is optically adjusted and glued on the aspheric silicon lens
- The silicon lens is glued on the aluminum mount.

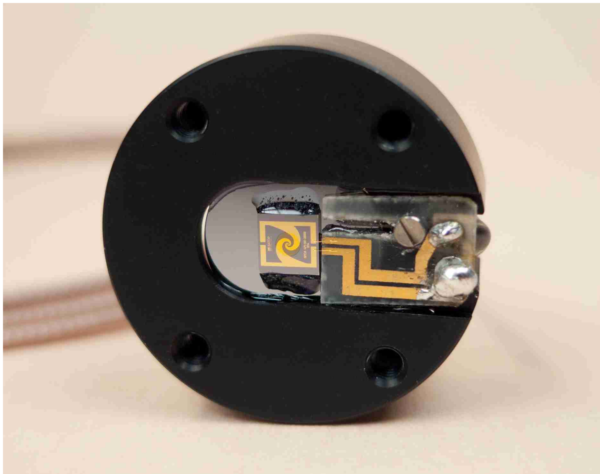
- The two antenna contacts are wire bonded on a printed circuit board, which provides the connection to a 1m long coaxial cable with BNC or SMA connector

A central hole in the aluminum mount allows the Terahertz radiation to escape from the aspheric silicon lens as a collimated beam with a focus 50 mm away and an Airy disc diameter dependent on the THz frequency.

PCA with aspheric silicon lens, coaxial cable RG 178 and BNC connector

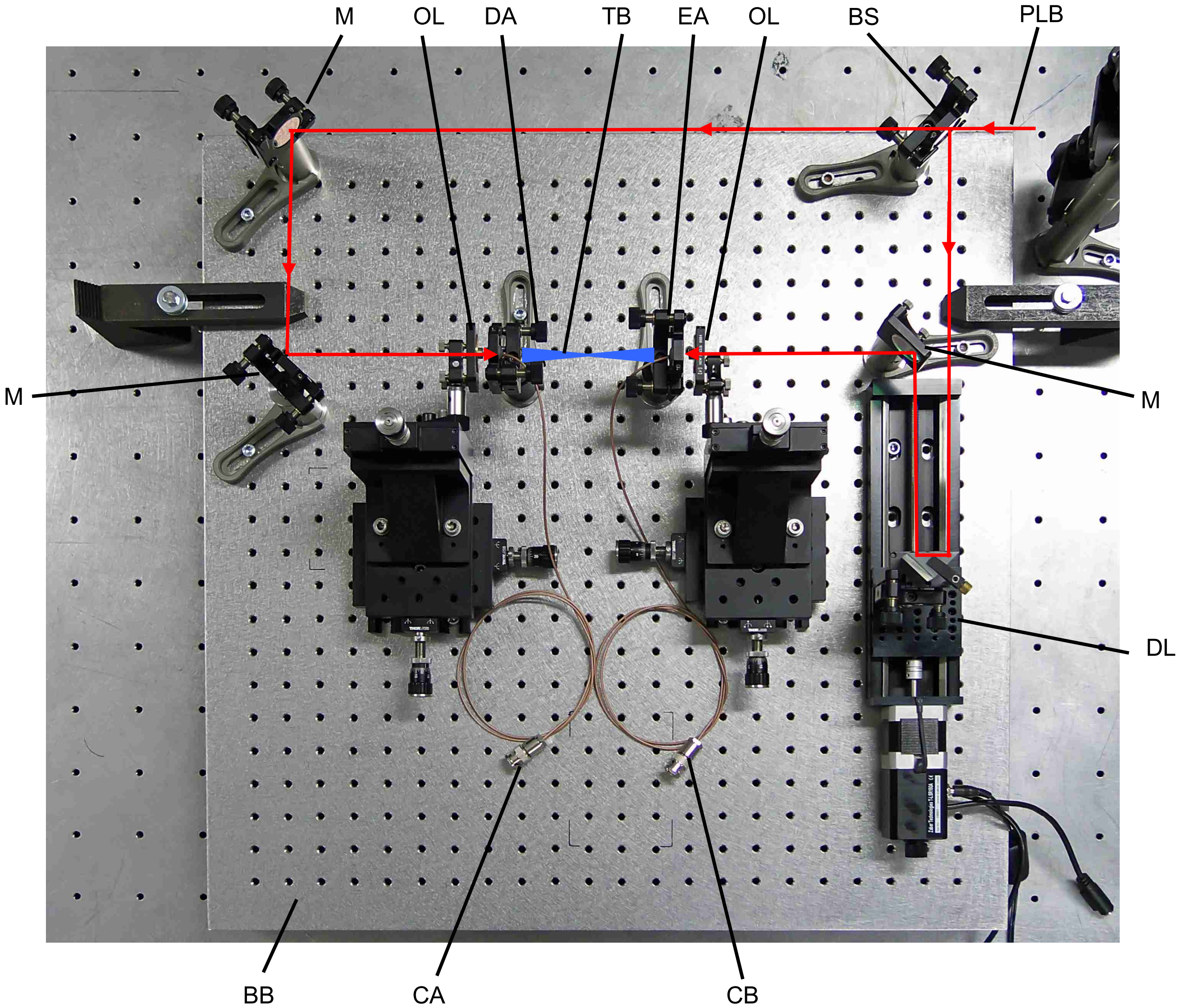


Front view on mounted PCA (laser side)



Back view on mounted PCA (THz side)

Terahertz time-domain spectrometer with two photoconductive antennas on aspheric lenses



Components of the THz time-domain spectrometer:
BB – breadboard, BS – beam splitter, CA – connector to amplifier, CB – connector to bias, DL - delay line, DA – detector antenna, EA – emitter antenna, M – mirror, OL – optical lens, PLB – pulsed laser beam, TB – Terahertz beam

6. Instructions for use of the SPCA-4Pi-05-3000-1060-x

Emitter:

The pulsed laser beam has to be focussed onto the antenna gap using an appropriate lens or objective with a beam diameter of about 5 - 8 µm to bridge the gap with photo-excited carriers within the semiconductor. At the same time a voltage U of ~ 15 V (maximum 20 V peak voltage) has to be supplied on the antenna by connecting the BNC connector cable to a voltage source. The recommended optical mean laser power P_{opt} is 15 mW.

Receiver:

The pulsed laser beam has to be focussed onto the antenna gap using an appropriate lens or objective with a beam diameter of about 5 µm to bridge the antenna gap with photo-excited carriers within the semiconductor. The phase of the laser beam with respect to the beam on the emitter site has to be adjusted by using of an optical delay line in such a way, that the measured value of the THz field on the antenna meets a maximum of the optical beam. By changing the phase difference between the emitter and receiver antenna the time-dependent shape of the THz field can be measured.

The cable with the BNC connector must be connected with a sensitive electronic current amplifier.

Attention: Please be sure, that the focusing lens or the lens mounting parts does not touch the antenna chip or the tiny gold contact wires between the antenna chip and the PCB. See figure “front view on mounted PCA (laser side)” above.

Lock-in detection

Because of the very small detector signal a lock-in detection scheme is recommended. The following two possibilities for lock-in detection can be used:

- An optical chopper can be used in front of the emitter antenna to chop the optical beam with a frequency ~ 1 kHz. The result is a chopped emitted THz signal, which meets the detector antenna. The output of the detector antenna is than a chopped current, which can be amplified using an ac amplifier and rectified using a standard lock-in system. The disadvantage of this system is the loss of 50 % of the optical excitation power on the emitter antenna.
- A square wave voltage generator with an output voltage U of maximum +/- 20 V and a frequency of some kHz can be used as supply for the emitter antenna. The result is an emitted alternating THz signal, which meets the detector antenna. The output of the detector antenna is than an alternating current, which can be amplified using an ac amplifier and rectified using a standard lock-in system. This setup is shown in the figures above.

7. Order information

SPCA-4Pi-05-3000-1060-**x** logarithmic spiral photoconductive antenna

spiral angle	$4\ \pi$
gap distance	g = 5 µm
diameter of the spiral antenna	l = 3000 µm
laser wavelength	λ = 1060 nm

x denotes the type of mounting as follows:

x = 0	unmounted chip 4 mm x 4 mm with 4 bond contact pads 400 µm x 750 µm
x = h	mounted on an Al disc with 25.4 mm ∅ and **h**yperhemispherical silicon substrate lens, 1m coaxial cable with BNC connector
x = a	mounted on an Al disc with 25.4 mm ∅ and **a**spheric focusing silicon substrate lens with 50 mm focus length, 1m coaxial cable with BNC connector
x = c	mounted on an Al disc with 25.4 mm ∅ and aspheric **c**ollimating silicon substrate lens with 12 mm diameter, 1m coaxial cable with BNC connector