TeraFlash smart

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Ultrafast Time-Domain Terahertz Platform

Time-domain terahertz (TD-THz) techniques have opened up new possibilities across a wide range of applications, from fundamental science to non-destructive testing of plastic composites and paint layers, and from security screening of mail envelopes to semiconductor inspection. Most of the TD-THz spectrometers developed thus far accommodate a mechanical delay stage for waveform sampling. System performance notwithstanding, the delay has remained a bottleneck in terms of measurement speed.

TOPTICA's TeraFlash smart utilizes a proprietary scheme dubbed ECOPS ("electronically controlled optical sampling"). The approach employs two femtosecond lasers rather than just one, eliminating the need for a mechanical delay altogether. The terahertz transmitter and antenna are driven by a separate laser each. By means of a fast feedback loop, the repetition rate of the "slave" laser is phase-locked to that of the "master". An additional modulation varies the phase difference between the two pulse trains, and therefore, the pulses of the "slave" are periodically accelerated or delayed. The net effect is equal to that of a conventional, mechanical delay stage, yet data acquisition is roughly 100 times faster!

The TeraFlash smart incorporates highly mature fiber laser technology: the two femtosecond lasers make use of robust telecom components. Carefully designed optical fibers guide the pulses to two InGaAs-based photoconductive switches, which generate and detect the terahertz pulses.

The fiber-coupled arrangement greatly facilitates handling. The length of the tethers from the photoconductive antennas to the main station – 10.5 meters – allows the use of the system in numerous industrial settings, including robot-based assemblies.

The software control permits a flexible setting of the scan range between 700 ps @ 200 traces/s and 150 ps @ 1600 traces/s. In a single-shot measurement, the system achieves a time-domain dynamic range of > 50 dB, and a spectral bandwidth of 3 THz. Within one second of averaging, the time-domain dynamic range increases to > 80 dB and the bandwidth spans 4 THz.

The TeraFlash smart enables terahertz-based thickness measurements at unprecedented speed. The system thus lends itself to measurements on rapidly moving samples, e.g. conveyor belts, papermaking machines, or extrusion lines. Other potential applications include measurements under rapidly changing environmental conditions, "hundred-percent" inspection in industrial quality control, and high-speed terahertz imaging.

Applications

· Non-contact layer thickness measurements (polymers, paint layers, glue)
· Quality control: Hundred-percent inspection
· Material research
· High-speed terahertz imaging

Key Features

· Enables fastest terahertz-based thickness measurements to-date
· Proprietary ECOPS technology
· Robust design, no mechanical delay line
· High measurement speed: 1600 pulse traces / sec
· Time-domain dynamic range: > 50 dB single-shot, > 80 dB in 1 s
· Frequency-domain dynamic range: Typ. 35 dB single-shot, 60 dB in 1 s
· Spectral bandwidth: 3 THz single-shot, 4 THz in 1 s
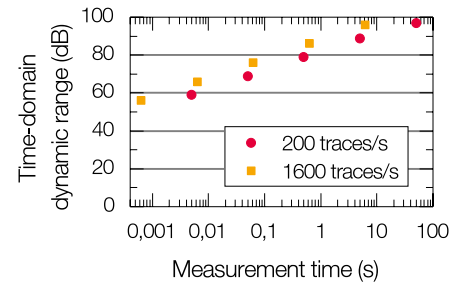· Fiber-coupled emitter and receiver antennas

TOPTICA PHOTONICS

TeraFlash smart

Class 1 Laser Product EN 60825-1:2014.
Invisible laser radiation.

Specifications*

Specifications*	
Components	2 synchronized femtosecond lasers SM/PM fiber delivery 2 InGaAs photoconductive switches Electronics for data acquisition
Laser wavelength	1560 nm
Laser pulse width	< 100 fs (80 fs typ.)
Laser repetition rate	80 MHz
Fiber delivery	Included
Terahertz emitter	InGaAs/InP photoconductive switch with 100 µm strip-line antenna #EK-001123: fiber length = 0.3 m
Terahertz receiver	InGaAs/InP photoconductive switch with 25 µm dipole antenna, 10 µm gap #EK-001125: fiber length = 0.3 m
Antenna package	Cylindrical, ∅ 25 mm, integrated Si lens and SM/PM fiber pigtail
Delay stage	Electronic delay (ECOPS)
Scan range	> 700 ps @ 200 Hz > 400 ps @ 800 Hz > 150 ps @ 1600 Hz
Terahertz spectral range	Typ. 3 THz single-shot, 4 THz in 1 s
Average terahertz power	Typ. 30 µW
Time-domain dynamic range	> 50 dB single-shot, > 80 dB in 1 s
Peak dynamic range of spectrum	Typ. 35 dB single-shot, 60 dB in 1 s
Useable terahertz path length	10 - 180 cm, adjustable via software control
Frequency resolution	< 1.5 GHz @ 700 ps scan range < 7 GHz @ 150 ps scan range
Maximum measurement speed	1600 pulse traces/s
Relative timing jitter	< 50 fs (100 Hz – 100 kHz)
Fiber length of antennas	10.5 m outside main unit, + 0.3 m antenna pigtails
Computer interface	Ethernet and USB; data streaming via USB
Computer software	Labview-based GUI, included
Size (H x W x D)	200 x 450 x 440 mm
System weight	20 kg
Operating voltage	24 V / 8 A, power supply included

*) Subject to change without notice

Time-domain dynamic range as a function of the measurement time. Red and orange symbols denote measurement speeds of 200 traces/s and 1600 traces/s, respectively. The graph shows how the dynamic range increase with trace averaging.
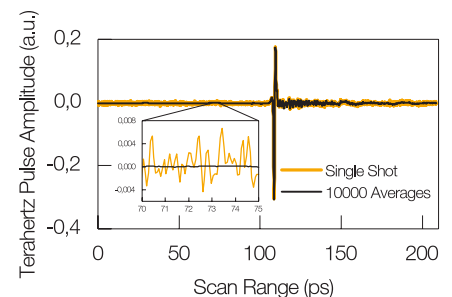
Terahertz waveforms measured in transmission, without a sample in place. Orange: Single-shot measurement obtained at a rate of 1600 traces per second, black: Average of 10000 consecutive waveforms. Inset: Magnification of the pre-pulse background signal.
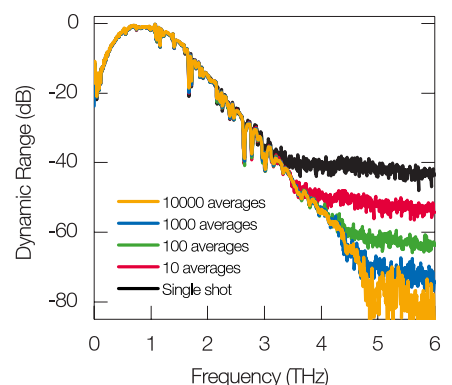
Dynamic range of the terahertz power for a single-shot measurement (black trace), and for 10 (red), 100 (green), 1000 (blue) and 10000 (orange) terahertz waveforms averaged.

Literature

R.J.B. Dietz, N. Vieweg, T. Puppe, A. Zach, B. Globisch, T. Göbel, P. Leisching, M. Schell:
All fiber-coupled THz-TDS system with kHz measurement rate based on electronically controlled optical sampling; Opt. Lett. 39:22 (2014) 6482-6485.

M. Yahyapour, K. Dutzi, B. Schmauss, P. Leisching, N. Vieweg, A. Deninger:
Extremely fast thickness measurements with an ECOPS-based TD-THz system;
Proc. IRMMW-THz (2018).

Technical drawings not available yet