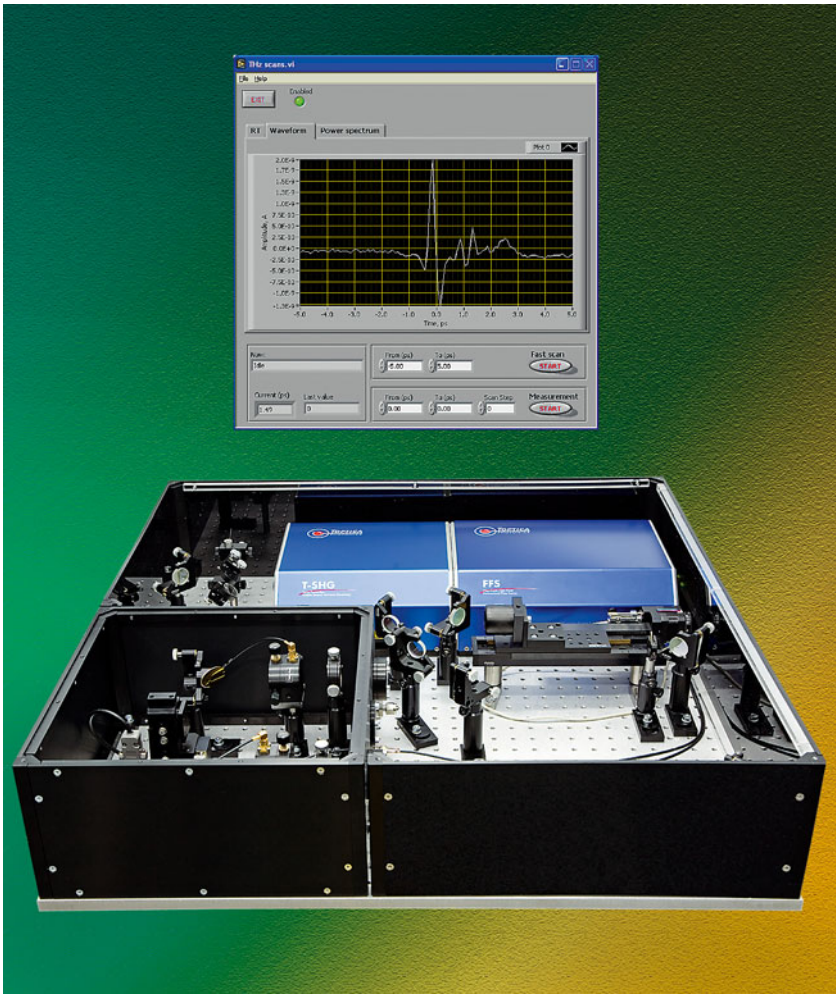


# THz SPECTROMETER

## Terahertz Spectroscopy System

The terahertz (THz) and sub-THz frequency region (100 GHz – 10 THz) of the electromagnetic spectrum bridges the gap between the microwaves and infrared. Terahertz absorption or reflection spectroscopy, imaging of biological and other objects, THz tomography, ultrafast pump-THz probe spectroscopy are hot topics on most scientific conferences with possible applications in semiconductor, medical or security industries.

EKSPLA's Terahertz Spectroscopy System is a versatile tool for researchers who are interested in extending existing systems capabilities into THz frequency region.

### FEATURES

- Spectral range **0.2–3 THz**
- Amplitude signal to noise ratio **1000:1** @0.6 THz
- Spectral resolution better than **15 GHz**
- Optional reflectance measurements
- Optional optical pump – THz probe configuration

### APPLICATIONS

- THz transmission spectroscopy
- THz reflectance spectroscopy
- THz imaging
- Optical pump – THz probe spectroscopy

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## THz Time Domain Spectroscopy

The typical THz Time Domain Spectroscopy (THz-TDS) setup is shown in *Fig. 1*. Sub-picosecond pulses of THz radiation are detected after propagation through a sample and an identical length of a free space. A comparison of the Fourier transforms of these pulse shapes gives the absorption spectra of the sample under investigation.

The system includes ultrafast pumping laser, photoconductive antenna THz emitter and detector, pump laser beam guiding optics, motorized delay line with controller, THz beam guiding mirrors, sample holder, lock-in amplifier and personal computer with Labview based software for data acquisition.

Typical examples of data collected are shown in *Fig. 2*. The THz pulse waveform and its Fourier spectrum were measured without sample inserted between emitter and detector in ambient air atmosphere.

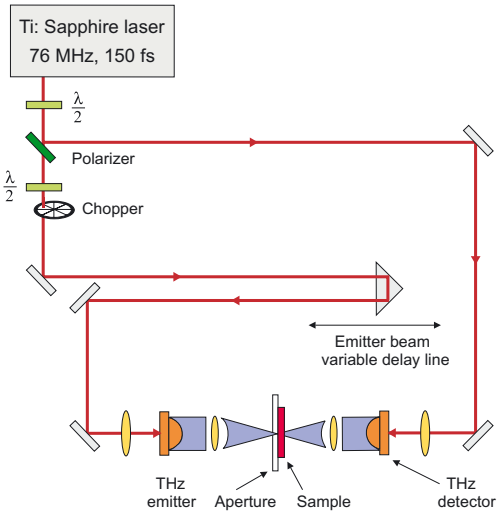


*Fig.1.* Optical layout

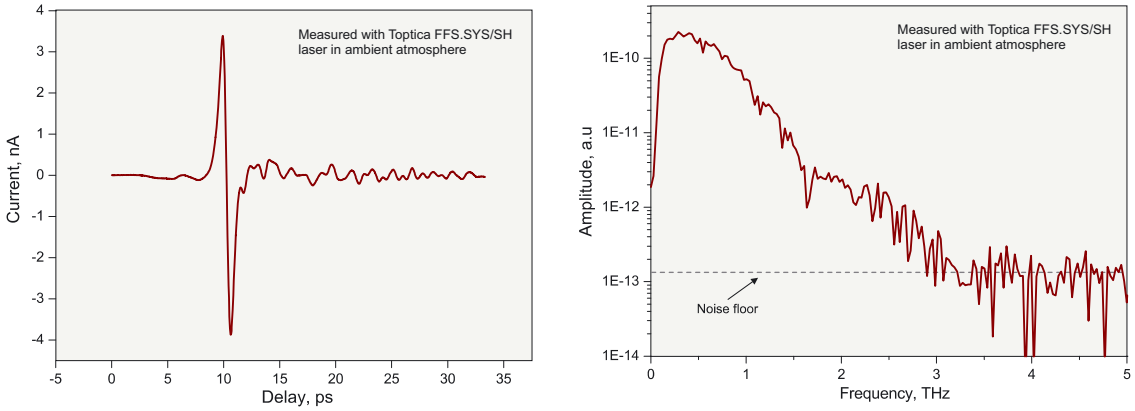


*Fig.2.* THz pulse waveform and Fourier-transform spectra

## Versatile

The configuration of the system can be easily modified. Ekspla offers four configurations of the system optimized for transmission, reflection, imaging or pump-probe measurement.

The basic (and simplest) configuration is for transmission measurements. The other optional configurations can be ordered at a later time as an upgrade.

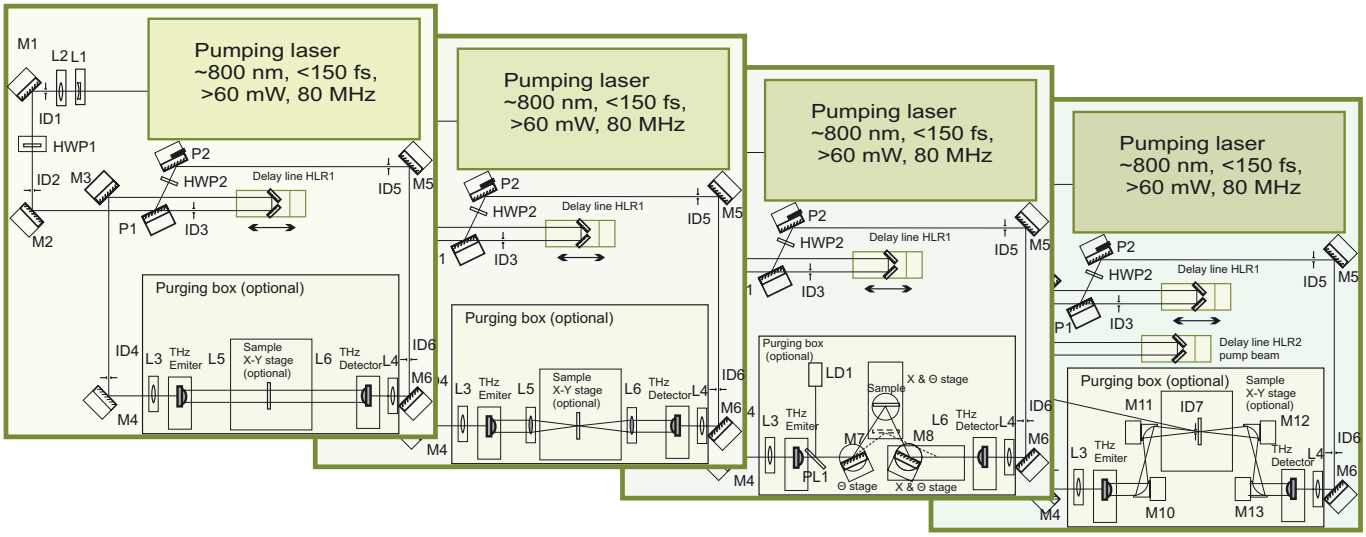


*Fig. 3.* Transform Your system for transmission, reflectance, imaging or optical pump-THz probe measurements

## THz reflectance option

For security applications like non destructive materials inspection or remote vapor trace detection it is important to investigate reflectance spectra. Reflectivity of various materials in THz range can be recorded with optional reflectance measurements configuration. The incidence angle of THz radiation can be adjusted in 30–50 deg range. The red guiding beam facilitates guiding of THz radiation to the sample and orientation of sample surface. Since our THz emitter provides polarized output, the system can be configured for vertical or horizontal polarization measurements.

## Pump-probe THz Experiments option

Femtosecond lasers let to investigate ultrafast nonequilibrium dynamics in semiconductors. For this aim, optical-pump-optical-probe techniques are usually employed. In such experiments, an intense optical pump pulse is used to excite free carriers in a sample, while a weaker probe beam monitors changes in its optical properties. In contrary to the optical probe, terahertz probe pulses are non-resonant with the band gap of semiconductor under investigation and, because of this, can be used as direct probes of free-carrier dynamics avoiding numerous experimental artefacts typical for optical-pump-optical-probe systems.

## THz Imaging option

THz radiation has an ability to penetrate deep into many organics materials, which makes THz imaging attractive for imaging of biological samples. Image of the sample can be obtained by raster-scanning of the sample trough the focused THz beam. Spatial resolution of approx. 1 mm can be obtained.

## Software

Labview based software for data acquisition is supplied. The software allows measurement of reference spectra and calculation of transmission coefficient. The raw data can be saved to the hard disk and later analyzed by optional third-party specialized software. Separate virtual instruments facilitates THz system setup, allows to control lock-in amplifier and other equipment.

Notebook computer featuring 1.6 GHz Pentium 4 class microprocessor and two USB ports is used for system control.

As option we can provide Labview source code for easy integration or modification.

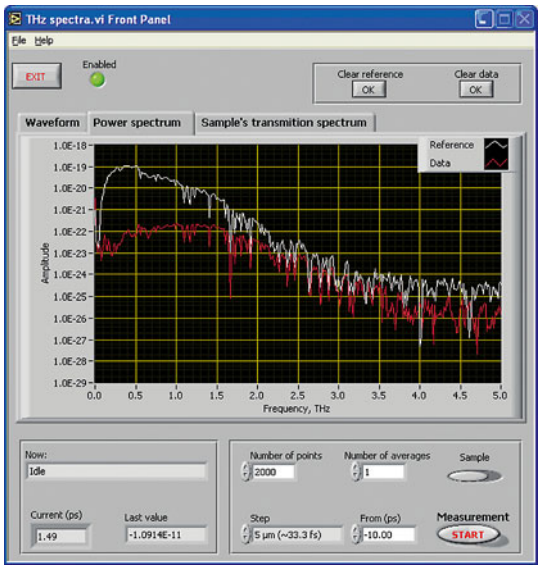


*Fig. 4.* THz Spectroscopy measurement window

## THz Components

The key components for any THz system is THz radiation emitter and detector. Ekspla produced THz emitter and/or THz detector consists of a microstrip photoconductive antenna fabricated on low-temperature grown GaAs (LT-GaAs) substrate. THz radiation is collected and collimated by integrated Si lens, mounted on X-Y stage. Performance of photoconductive antenna, used as THz emitters and detectors, depends on carrier mobilities and their trapping times in semiconductor layers of the antenna. LT-GaAs is one of the best materials for THz applications because of high carrier mobility, fast carrier capture time, high breakdown voltage and high resistivity. A technology of LT-GaAs grow allows to control the photo-excited carrier lifetime within a very wide region: from less than ~100 fs to 100 ps. Photoconductor antennae geometry, parameters of the Si lens, as well as the properties of LT-GaAs epitaxial layers were optimized for highest THz radiation output efficiency while preserving optimal bandwidth. As a result, typical emitted THz radiation power exceeds 10 µW when pumped by mode-locked ultrafast laser with 100 mW output power and 150 fs pulse duration. FWHM bandwidth of detection system exceeds 700 GHz with usable spectral range of 0.1–3 THz.

## SPECIFICATIONS

| Parameter | Value | Notes |
|---|---|---|
| **PUMP LASER** | | |
| Output power, mW | >60 | |
| Pulse duration, fs | >50 | optional 20 fs version |
| Wavelength, nm | 760–840 | |
| Pulse repetition rate, MHz | 50–100 | inquiry for other PRR |
| **SPECTROSCOPY** (transmission mode) | | |
| Spectral range, $cm^{-1}$ | 6–100 | or 0.2–3 THz |
| Spectral Resolution, GHz | >15 | for 70 ps scanning window |
| Accuracy, % | ±2 | @ 0.6 THz |
| Dynamic range | >1000:1 | electrical field amplitude @ 0.6 THz |
| Scan range, ps | 300 | inquiry for longer scan ranges |

*Specifications are subject to changes without advance notice.*

## Options

- Purging box option — *Removes water vapor absorption in 1.5–3 THz range*
- Reflectance measurement option — *Allows measurement of reflected spectra*
- Optical pump-THz probe option — *Allows ultrafast pump-probe spectroscopy of semiconductor and other materials*
- 2D sample imaging option — *Allows acquisition of sample image*
- Real-time spectra acqusition option — *Fast optical delay line for real-time spectra recording*
- Labview source code option

**Requests for custom-made version are welcome !**

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