Hatteras

Femtosecond Pump - Probe Transient Absorption System

Principles of Operation:

The Hatteras is first professional system on the market for ultra fast transient absorption pump - probe spectroscopy. Two linear image sensors (multichannel detection) or two photodiodes (single-channel detection) are placed behind an imaging spectrometer to measure probe and reference pulses, originating from a femtosecond white light (continuum) generator or from an optical parametric amplifier. As a result, photoinduced absorbance (optical density) changes OD are calculated as:

$$OD = -\lg ((E_{probe} / E_{ref})^* / (E_{probe} / E_{ref})),$$

where $(E_{probe} / E_{ref})^*$ is a ratio of probe and reference energies at a given wavelength, measured after the sample excitation, and (E_{probe} / E_{ref}) is a corresponding ratio for the unexcited sample. Please, note that it is always important to use the reference beam to get the best signal-to-noise (S/N) ratio in optical density changes measurements!

The optical delay between the probe and excitation (pump) pulses is scanned with a delay line, and the 3D transient spectral image OD (,t) is recorded for the multichannel detection, or the transient absorption kinetics at the given wavelength is measured for the single-channel detection.

Attempts to design a turn-key ultra fast pump - probe system, which could be acceptable everywhere, have been made not once during the recent three decades, but different scientific interests and fields of applications require a variety of options and configurations. We try to satisfy all requirements introducing a wide range of Hatteras optical configurations and options.

The System Configuration:

The basic optical unit contains all the optical and mechanical components, installed on the breadboard, for pump-probe measurements in the transmission and reflection configurations, including a computer controlled optical delay line, a femtosecond continuum generator, optics for anisotropy measurements, a rotating sample cell, a holder for solid samples and thin films, photodetectors for pump energy control and system synchronization.

The CDP2022i imaging spectrometer is a part of the standard configuration and is shown together with the mounted multichannel detector head. Probe and reference beams are delivered to the entrance slit of the spectrometer with silica fiber leads (the basic configuration) or with steering mirror optics (an optional configuration).

The multichannel detector head contains two linear image sensors. The single-channel detector head (an optional configuration) contains two photodiodes placed behind the variable slit of the spectrometer (not shown). The single-channel detection is often used with white light probe pulses for precise transient absorption kinetic measurements.

The single-channel detector head can be placed inside the optical unit when the wavelength tunable optical parametric amplifier is used to get probe and reference pulses (an optional configuration).

Infrared configurations are available when two InGaAs multichannel or single-channel detectors are used for the detection of the probe and reference pulses.

The Hatteras control unit (not shown) is used for the probe, reference and pump data acquisition, for the chopper or shutter control and for the delay line control. One multichannel and two single-channel detector heads can be connected to the unit simultaneously. The control unit is connected to a computer via USB port.

ExciPro 2.4 software is used for data acquisition, continuum chirp correction, 3D and kinetic analysis.

CDP Systems

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The System Specifications:

Input Pulse Requirements:

- Standard pulse source: femtosecond Ti: sapphire amplifier
- Required pulse duration: <150 fs
- Required pulse repetition rate: 10 Hz - 1 kHz (10 Hz - 5 kHz for single-channel detection)
- Required pulse energy: >0.3 mJ / pulse

Excitation:

- Optional second harmonic (SH) generator placed inside the oprtical unit is used for the sample excitation at 380 nm - 420 nm. Fundamental wavelengths (760 nm - 840 nm) can be used for the excitation also.
- Optional CDP2017 optical parametric amplifier together with SH generation and frequency mixing give tunable sample excitation within 480 nm - 800 nm spectral range.
- Optional TOPAS or OPerA Solo optical parametric amplifier together with harmonics generation and frequency mixing are used as the excitation pulse source controlled with ExciPro 2.4 software.

Probe & Reference:

- White light generation in sapphire plate installed inside the Hatteras optical unit is used for pump and probe pulse generation and multichannel detection with visible or infrared detectors.
- Computer controlled optical parametric amplifier is used as a pump and probe pulse source for single-channel kinetics measurements with visible or infrared detectors.

Anisotropy Measurements:

- Berek's variable wave plate gives a possibility to get any state of polarization for the excitation pulse at any wavelength.
- Two single-channel detector heads (each head contains two photodiode sensors) are used simultaneously for one-scan anisotropy kinetics measurements (optional configuration).

Chopper & Shutter:

- Synchronized chopper and shutter are used for pump light modulation. At 1 kHz pulse repetition rate the chopper operates from 1:1 to 10:10 chopping ratio. The 1:1 chopping ratio (one pump pulse is open, next one is closed) gives best S/N ratio and shortest data acquisition time. The 1:1 ratio is always used in the single-channel detection. In the multichannel detection higher ratios are used in case of weaker probe and reference signals.
- The shutter operates from 10:10 to 50:50 chopping ratio.

CDP2022i Imaging Spectrometer:

- Focal length: 200 mm
- F-number: 3.6
- Four-grating turret to provide automatic grating switching
- First grating: 330 nm - 1000 nm spectral range with 206 nm detection range
- Second grating: 1000 nm - 1700 nm spectral range with 206 nm detection range
- Third and fourth gratings are installed optionally
- Connected to a computer via serial or USB port

Optical Delay Line Specifications:

- Delay line travel: 2.0 ns (4.0 ns in the optional double pass configuration)
- Delay line minimum step: 0.78 fs (1.56 fs in the optional double pass configuration)

Visible Multichannel Detector Specifications:

- Type of sensors: two NMOS linear image sensors
- Number of pixels for each sensor: 1024
- Spectral response range: 200 nm - 1000 nm
- Dynamic range: > 5,800
- Pulse repetition rate: up to 1 kHz

IR Multichannel Detector Specifications:

- Type of sensors: two InGaAs linear image sensors
- Number of pixels for each sensor: 256
- Spectral response range: 900 nm - 1700 nm
- Dynamic range: > 5,000
- Pulse repetition rate: up to 1 kHz

Visible Single-channel Detector Specifications:

- Type of sensors: two Si photodiodes
- Sensitive area: 3 mm diameter
- Spectral response range: 320 nm - 1060 nm
- Dynamic range: > 20,000
- Pulse repetition rate: up to 5 kHz

IR Single-channel Detector Specifications:

- Type of Sensors: two InGaAs photodiodes
- Sensitive area: 2 mm diameter
- Spectral response range: 900 nm - 1700 nm
- Dynamic range: > 20,000
- Pulse repetition rate: up to 5 kHz

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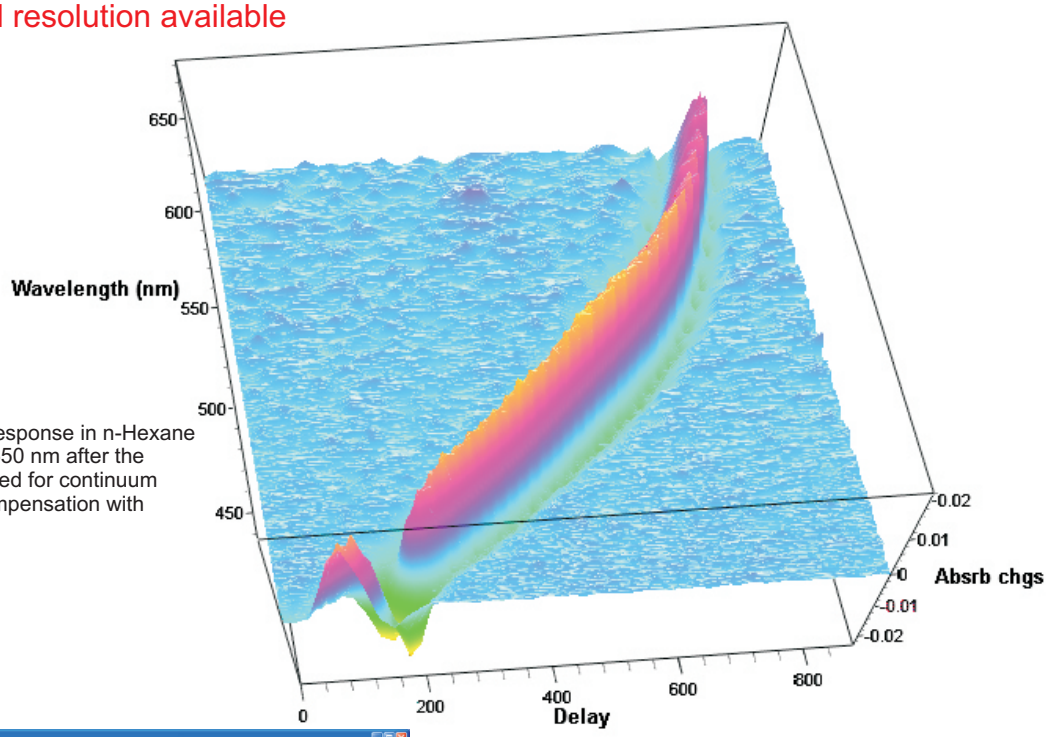
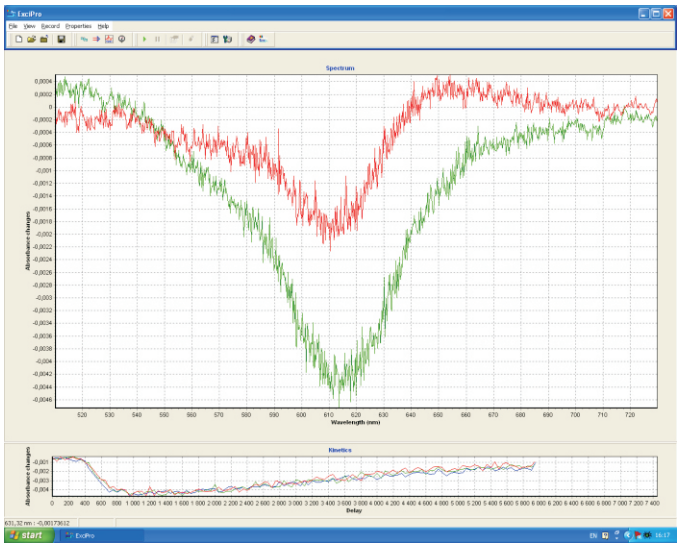
- ♦ All reflective continuum generation
- ♦ Chirp compensation
- ♦ <0.0001 OD RMS noise
- ♦ <100 fs temporal resolution available



3D image of femtosecond response in n-Hexane measured within 450 nm - 650 nm after the excitation at 400 nm and used for continuum chirp measurement and compensation with ExciPro software.



Transient absorption spectra measured with Malachit Green dye solution and multichannel detection at 520 nm - 720 nm. The peak of 0.3 mOD is clearly seen at 660 nm (red spectrum) and demonstrates the Hatteras excellent sensitivity.

Dimensions:

- Hatteras optical unit: 760(L) x 600(W) x 200(H) mm
- CDP2022i spectrometer: 320(L) x 200(W) x 160(H) mm
- Control unit: 250(L) x 250(W) x 100(H) mm

CDP Systems

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