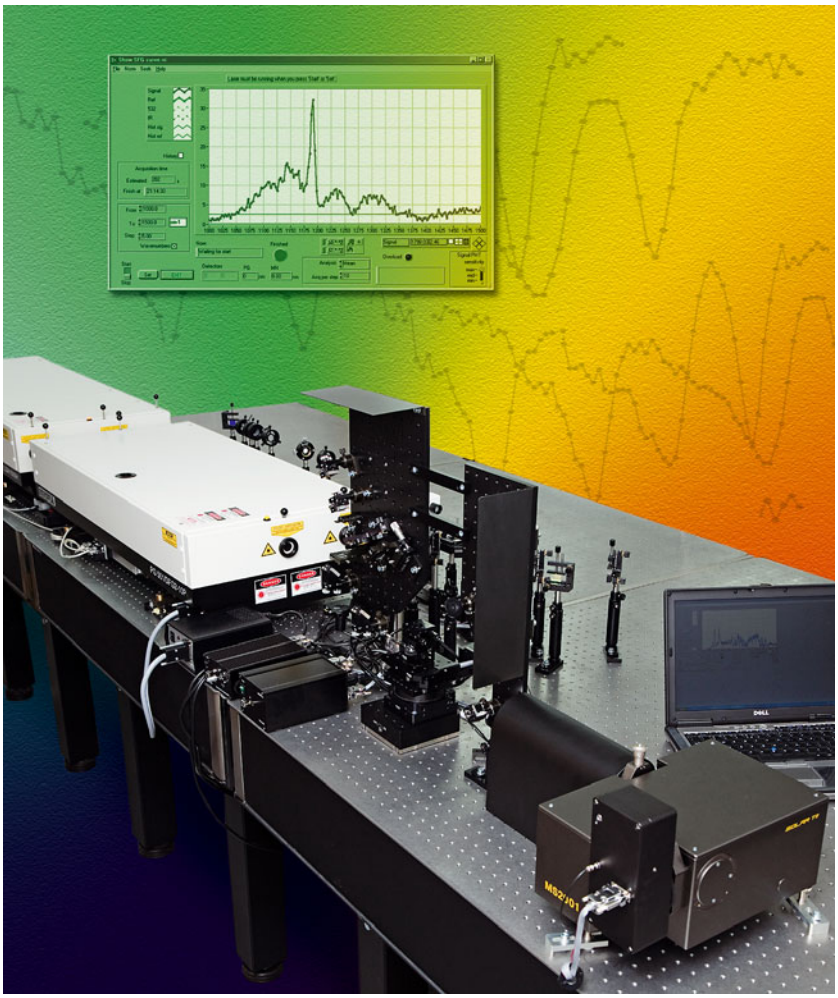
SFG SPECTROMETER

Picosecond Vibrational Sum Frequency Generation Spectrometer



Powerful and versatile tool for *in-situ* investigation of surfaces and interfaces:

- ✔ Intrinsically surface specific
- ✔ Selective to adsorbed species
- ✔ Sensitive to submonolayer of molecules
- ✔ Applicable to all interfaces accessible to light
- ✔ Nondestructive
- ✔ Capable of high spectral and spatial resolution

APPLICATIONS

- Investigation of surfaces and interfaces of solids, liquids, polymers, biological membranes and other systems
- Studies of surface structure, chemical composition and molecular orientation
- Remote sensing in hostile environment
- Investigation of surface reactions under real atmosphere, catalysis, surface dynamics
- Studies of epitaxial growth, electrochemistry, material and environmental problems
- Your application is welcome...

FEATURES

- High S/N ratio due to the superb laser source stability
- Better than 6 cm^{-1} spectral resolution
- Cost-effective picosecond system approach
- Complete PC control
- Acquisition of SFG spectra in wide wavelength range: 4300 – 625 cm^{-1}
- Monitoring of surface dynamics
- Azimuth scan, XY-mapping of the sample (optional)
- Models with 10, 20 or 50 Hz pulse repetition rate
- Double resonance SFG model with tunable visible beam

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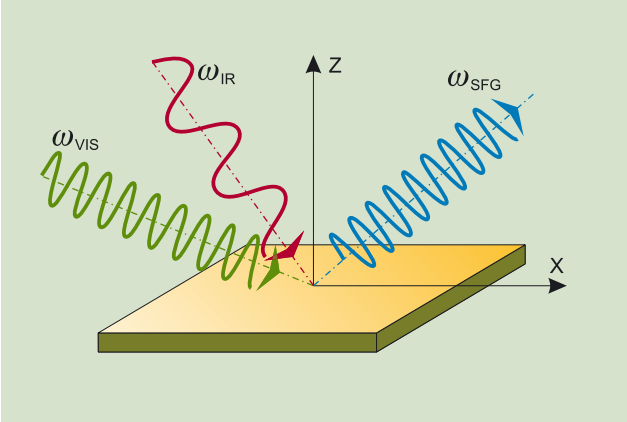
BASIC OPERATION PRINCIPLES

In SFG experiment a pulsed tunable infrared IR (ω_{IR}) laser beam is mixed with a visible VIS (ω_{VIS}) beam to produce an output at the sum frequency ($\omega_{SFG} = \omega_{IR} + \omega_{VIS}$).



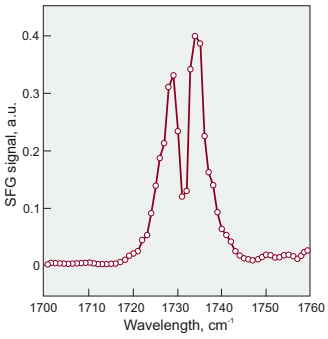
SFG is second-order nonlinear process, which is allowed only in media without inversion symmetry. At surfaces or interfaces inversion symmetry is necessarily broken, that makes SFG highly surface specific.

As the IR wavelength is scanned, active vibrational modes of molecules at the interface give a resonant contribution to SFG signal. The resonant enhancement provides spectral information on surface characteristic vibrational transitions. Different combinations of input and output beam polarizations allow the determination of surface symmetry or molecular orientation.

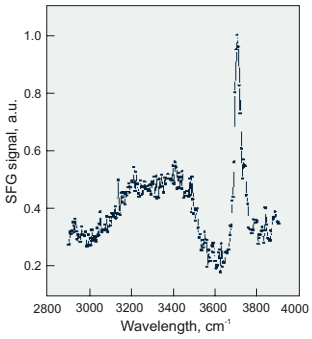
SFG detects vibrational modes, which are rather localized to specific groups of atoms within the molecules. Information about relative orientation of different groups within the same molecule maybe obtained, and, hence, the molecular structure can be deducted.

Referring to the SFG signal phase measurements, information about the absolute orientation of molecule in respect to the surface can be obtained.

EXAMPLES OF SFG SPECTRA



SFG spectra of monoolein surface
1 cm^{-1} scan step, 200 acquisitions per step.
Courtesy of EKSPLA Ltd.



Water-air interface spectra
200 acquisitions per step.
Courtesy of University of Michigan

DESIGN OF THE SPECTROMETER

SFG SPECTROMETER INCLUDES:

- Picosecond Nd:YAG laser
- Optical parametric generator / amplifier / difference frequency generator (OPG/OPA/DFG)
- Beams delivery optics
- Monochromator
- PMT or CCD signal detectors
- Data acquisition system
- Control software
- Guiding beam for system alignment

OPTIONAL ACCESSORIES:

- Reference channel
- Six axis sample holder (manual or three axes (X, Y and θ) PC controlled)
- Sample area purge box

Sum frequency excitation system is based on picosecond pump laser and optical parametric generator/amplifier/difference frequency generator (OPG/OPA/DFG).

Solid state mode-locked Nd:YAG laser featuring high pulse duration and energy stability is used to pump the system. Second harmonic (532 nm) of laser fundamental radiation is used as VIS pump beam for sum frequency generation.

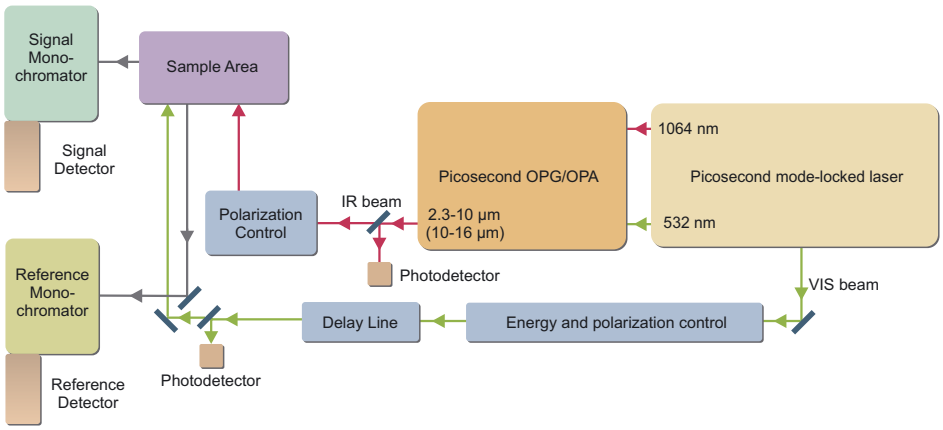
Tunable IR radiation is generated in three stage optical parametric generator / amplifier / difference frequency generator. Spectral and spatial filtration of OPG seed beam provides narrow bandwidth and low divergency of mid-IR radiation. Beam walk-off compensation design ensures overlaping pump beams over the full wavelength range.

VIS beam delivery optics includes: spatial filter for homogenous beam profile, energy and polarization control system for smooth adjustment of pulse energy and polarization direction, delay line for temporal overlap of VIS and IR pulses.

IR beam delivery optics include mirror based polarization control and beam delivery systems.

The energy of both the VIS and IR beams is monitored by photodetectors for SFG signal normalization.

Optional 6 axis (three translational and three rotational) including PC controlled X ,Y and θ axes stage enables sample mapping and investigation of molecules orientation.
SF guiding optics includes steering mirrors, focusing lens, polarization analyser and holographic notch filter for scattered VIS light rejection.
Detection system consists of monochromator and gated PMT based SF signal detector. Low power laser diode guiding beam is integrated for alignment convenience.
Optional reference channel improves the signal/noise ratio for samples with high non-resonant background.



SFG spectrometer optical layout

BUILDING OR UPGRADING YOUR OWN SFG SYSTEM?

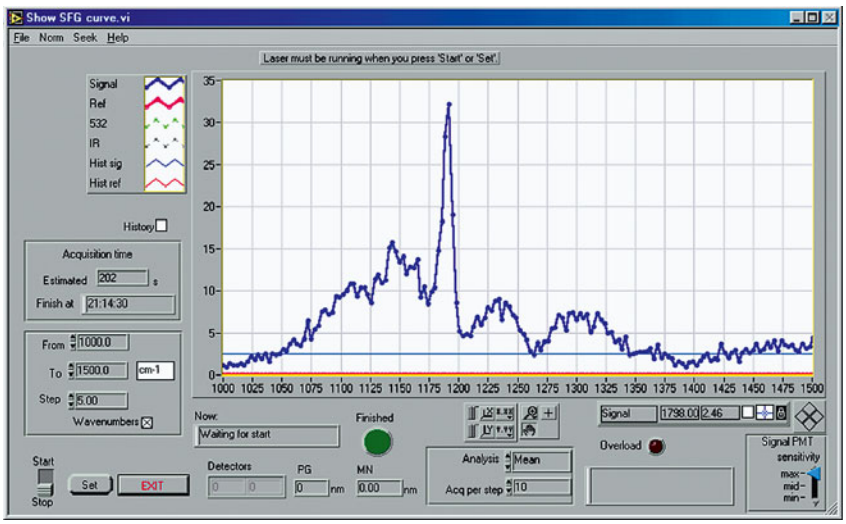
Take advantage of our more than 12 years experience. EKSPLA offers:

- Highly qualified consultations and assistance
- Picosecond Nd:YAG lasers with outstanding stability
- Picosecond OPO/OPG/DFG
- Laser accessories and components
- Photonics components, beam delivery optics

DOUBLE RESONANCE MODEL

Both IR and VIS wavelengths are tunable in double resonance SFG option. This two-dimensional spectroscopy is more selective than single resonant SFG and applicable even to media with strong fluorescence. Double resonant SFG allows investigation of vibrational mode coupling to electron states at a surface.
In double resonance SFG spectrometer model second OPG/OPA is used to generate tunable VIS beam in 210 – 680 nm range.

SOFTWARE



All the spectrometer units (laser, optical parametric generator / amplifier / difference frequency generator (OPG/OPA/DFG), monochromators, photodetectors) are controlled from computer using LabVIEW™ environment. Spectrometer software features SFG spectra acquisition, azimuth scan, XY-mapping, surface dynamics investigation. OPG/OPA/DFG and monochromator calibration options are available.

SPECIFICATIONS

GENERAL	SFG classic	SFG double resonance	SFG rapid
Operation wavelength		2.3 – 10 μm (4300 – 1000 cm^{-1}) [1]	
Spectral resolution, cm^{-1}	< 6	< 10	< 6
Data acquisition rate, Hz	10/20	10/20	50
VIS BEAM			
Wavelength, nm	532 [2]	(210–340), (370–419), 420–680	532 [2]
Linewidth, cm^{-1}	< 2	< 6 [3]	< 2
Pulse energy, mJ	~ 1 [2]	0.1 – 1	~ 1 [2]
Pulse duration, ps		20 – 30	
Polarization		Linear; selectable s or p; purity >1:100	
IR BEAM			
Wavelength, μm		2.3 – 10 [1]	
Linewidth, cm^{-1}		< 6	
Pulse energy, μJ			
2.3 μm		> 200	
4 μm		> 260	
6 μm		> 200	
8 μm		> 100	
10 μm		> 40	
12 μm		> 75	
14 μm		> 45	
16 μm		> 40	
Polarization		Linear; selectable s or p; purity 1:100	

[1] *Optional down to 16 μm (625 cm^{-1}) upgrade is available*
[2] *Optional upgrade with additional VIS@1064 nm is available*
[3] *<10, for spectral range 210-419 nm*

Specifications are subject to changes without advance notice.

SFG SPECTROMETER OPTIONS

SPECTRAL RESOLUTION DOWN TO 2 cm^{-1}

Using narrowband OPO/OPA/DFG with synchronously pumped parametric oscillator decreases SFG spectral resolution down to 2 cm^{-1}.

SECOND HARMONIC GENERATION (SHG) SPECTROMETER

Second harmonic generation (SHG) is an effective tool for surface probing. The monolayer adsorbtion may be detected by SHG. With different input/output beam polarizations SHG yield information on the average orientation of molecular adsorbates. The surface symmetry measurements can be performed by rotation of the sample around the surface normal. By using tunable lasers, SHG establishes itself as powerfull tool for surface-specific electronic transitions spectroscopy.
SHG spectrometer is available as accessory to the SFG spectrometer or stand-alone system.

Requests for custom made products are welcome !

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