

ELIAS Spectrometers

Interaction of light and matter –
induced and analyzed with lasers
and measuring systems of LTB

ELIAS* Emission Line Analyzing Spectrometer



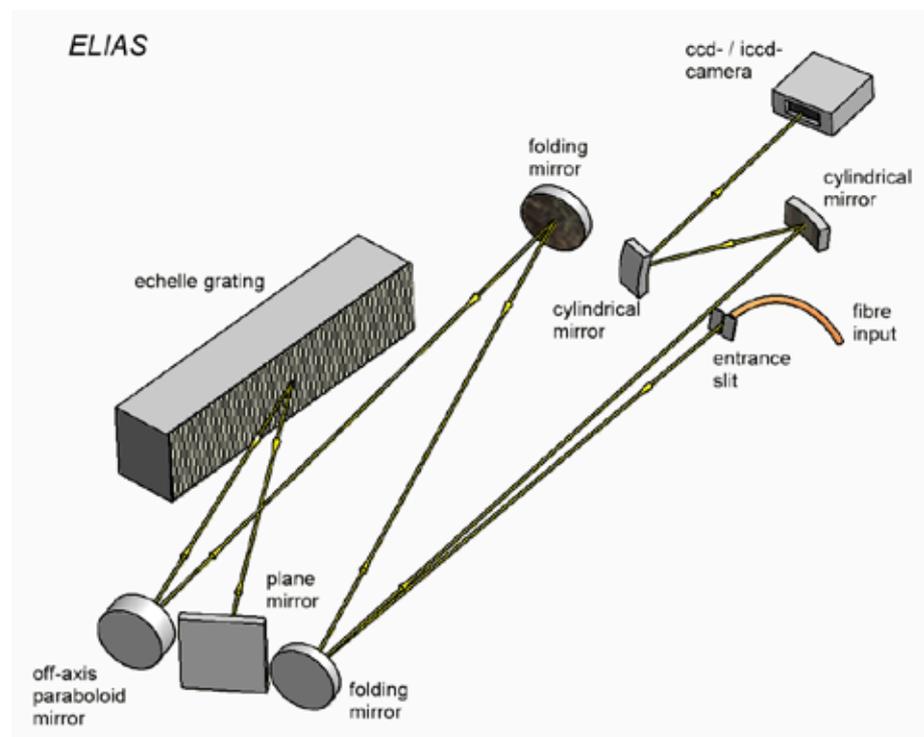
- Highest spectral resolution
Intensity dynamics of up to 4 orders
- High imaging quality
- Industrial use

ELIAS is an echelle spectrometer with an extremely high resolution capability. It is used for the highly resolving spectral measurement of emission and absorption lines, particularly of laser lines. The line profiles can be detected simultaneously within their spectral vicinity with a signal-to-noise ratio of up to 40,000 by means of a CCD. Besides the high-resolution spectral measuring of laser lines, the intensity dynamics of up to 4 orders is of the utmost importance. This makes it possible to quantitatively analyze the wings and the spectral vicinity of the laser lines, other than with Fabry-Perot spectrometers.

The main area of application of the ELIAS-Spectrometer is the excimer laser lithography. Because of their chromatic aberrations, the refraction objectives in the wafer steppers require an extremely high spectral purity of the radiation sources. A strong competitive advantage can be realized by a laser manufacturer who can offer radiation sources with the lowest spectral width. Further application areas are the measuring of the spectral and temporal stability of diode lasers, solid-state lasers and emission lines of lamps.

Spectrometer concept

Optic arrangements using echelle gratings achieve an extremely high theoretical resolution capability through the diffraction of the light in a multitude of high interference orders. To be able to use the theoretical resolution capability of the echelle grating, the optical system of the spectrometer must meet two requirements.

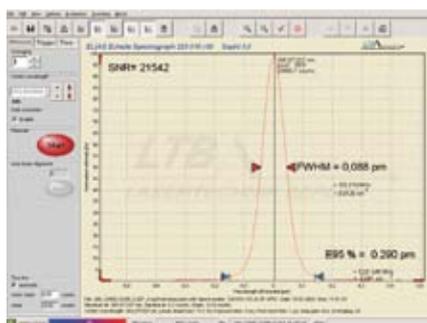


Optical set-up

Spectrometers

First, a nearly diffraction-limited imaging has to be achieved. Second, the linear dispersion must be sufficiently high so as to be able to resolve the halfwidths of the lines with 5-10 pixels considering the typical pixel widths of the line-array detector. In the ELIAS, a 360 mm wide echelle grating within a Littrow arrangement can be used alternatively in a double or single pass. This makes it possible, through motor-controlled software, to work either with an extremely high resolving capability for profile characterization or with a reduced resolving capability but larger inspection range and higher sensitivity. By a 2.5 m off-axis paraboloid and the accompanying anamorphic magnification optics with a tangential image reproduction scale of 4:1, a camera focal distance of 10 m is attained.

The system is extremely thermally and mechanically stable. The complete motorization allows a very simple operation as well as the automatic focusing and positioning of the spectrum on the detector. By exclusively applying reflection optics with broadband UV layers, chromatic aberrations are avoided and there are no limitations in choosing the measurement wavelengths. The coupling into the spectrometer is realized via a SMA fibre coupling or optionally via pure reflection transfer optics.



Operating software

The ELIAS spectrometers are provided in different configurations:

The standard version is the **ELIAS I**. The basic optical set-up of all ELIAS spectrometers is identical with the standard version. The controlling and evaluation software Sophi controls all spectrometer and detector functions. A scan mode allows the sequential measuring of a larger wavelength range – larger than the free spectral range at a time. An optional LabView driver allows the remote control of the ELIAS and the integration into complex test stands.

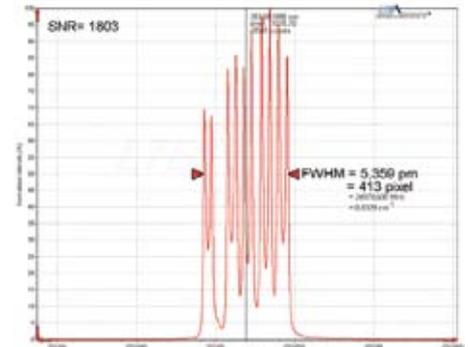
The **ELIAS II** has a much higher spectral resolving capability. The high-resolution detector system and the incorporation of a fast shutter enable an improved time-resolved measurement. A better cooling of the detector system reduces the background noise of the detector and hence improves the signal-to-noise ratio significantly.

The **ELIAS III** is an enhanced development of the ELIAS II. An integrated retroreflector allows to use the echelle grating four times. This doubles the spectral resolution of the ELIAS II.

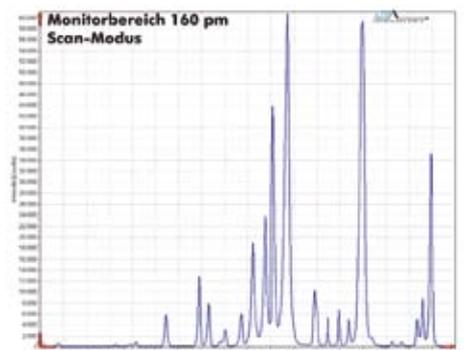
The **ELIAS-LD** does not resolve the halfwidths of the lines with 5 to 10 pixels, instead the free spectral range could be trebled without considerably decreasing the spectral resolving capability.

For the measuring of F2 lasers (157 nm), a vacuum-suited version, the **ELIAS-VUV**, was developed.

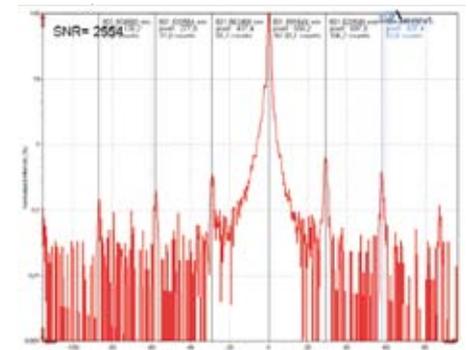
For the mobile use of the spectrometer, an **ELIAS-Portable** version was designed, the damping of which even allows a transport under "rough" conditions without affecting the optical alignment of the spectrometer.



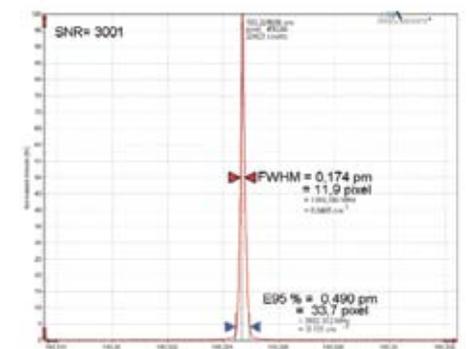
Resonance line of a Hg lamp 253.652 nm



Spectrum of a LTB nitrogen laser 337 nm



Mode spectrum of a diode laser 800 nm



Spectrum of an excimer laser ArF 193 nm

Spectrometers

Specifications

| | |
|---|---|
| Detector | CCD line array detector ELIAS I: 1,024 pixels; ELIAS II/III: 2,048 pixels |
| Dynamic range | 16 Bit A/D conversion, effectively approx. 33,000:1 |
| Signal-to-noise ratio | at level 40,000 better than 10,000 / 40 dB |
| Exposure time min | ELIAS I: 18 ms ELIAS II/III: 2 ms |
| Integrated mechanical shutter | |
| Coupling via fibre, except for ELIAS-VUV (mirror optics) | |
| Wavelength calibration by integrated mercury lamp (253.652 nm) | |
| Absolute accuracy when calibrating with the internal Hg lamp better than ± 5 pm | |
| Rel. pixel dispersion error depending on the wavelength, for 193 nm double pass ≤ 0.2 fm | |
| Industrial PC with Windows | |
| Software | Sophi, LabView driver optional |
| Dimensions ELIAS Standard (L x W x H) (inclusive cart, PC, accessories) | 1,400 x 500 x 1,300 mm |

| | Wavelength [nm] | ELIAS-LD | | ELIAS I-Standard, VUV, Portable | | ELIAS II | ELIAS III |
|--|--------------------|----------|--------|------------------------------------|--------|----------|----------------|
| | | double | single | double | single | double | quadru- ple |
| Pass | | | | | | | |
| Simultaneous Inspection- Range [pm] | 157 | 49 | 152 | 14 | 45 | - | - |
| | 193 | 52 | 170 | 15 | 48 | 16.4 | 8.4 |
| | 248 | 71 | 227 | 20 | 64 | 22.5 | 11.5 |
| | 266 | 92 | 275 | 25 | 73 | 29.7 | 15 |
| | 532 | 185 | 551 | 49 | 146 | 59.4 | 29.9 |
| | 766 | 293 | 846 | 82 | 244 | 92.5 | 47.5 |
| | 1,064 | 626 | - | 98 | 292 | 200 | 101 |
| Spectral resolution: Narrowest spectrally resolvable line FWHM [pm] | 157 | 0.1 | 0.31 | 0.083 | 0.254 | - | - |
| | 193 | 0.11 | 0.34 | 0.086 | 0.283 | 0.060 | 0.022 |
| | 248 | 0.15 | 0.46 | 0.117 | 0.376 | 0.082 | 0.032 |
| | 266 | 0.19 | 0.55 | 0.147 | 0.428 | 0.112 | 0.042 |
| | 532 | 0.37 | 1.1 | 0.294 | 0.856 | 0.225 | 0.084 |
| | 766 | 0.59 | 1.7 | 0.482 | 1.4 | 0.339 | 0.130 |
| | 1,064 | 1.25 | - | 0.588 | 1.711 | 0.450 | 0.165 |

Subject to technical changes