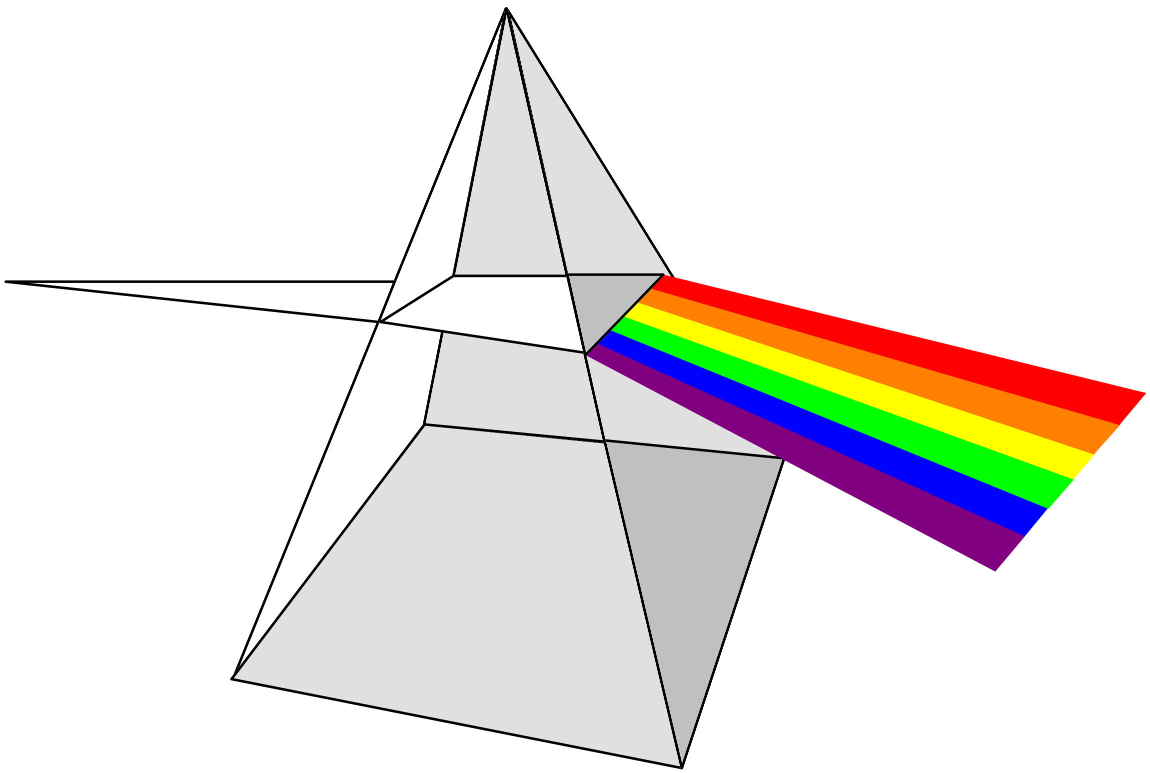
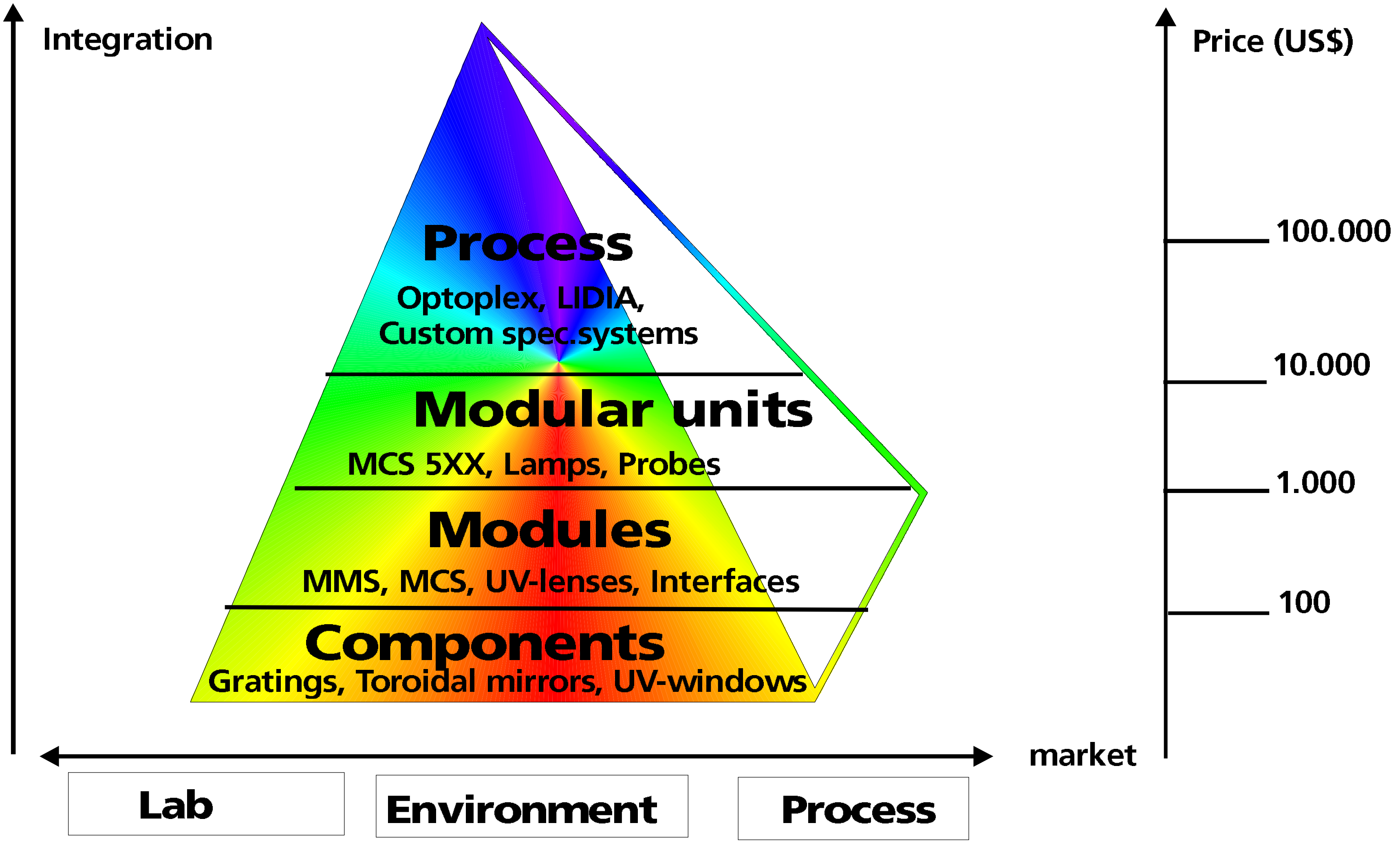
Spectral Sensors



Spectral Sensors



Spectral Sensors

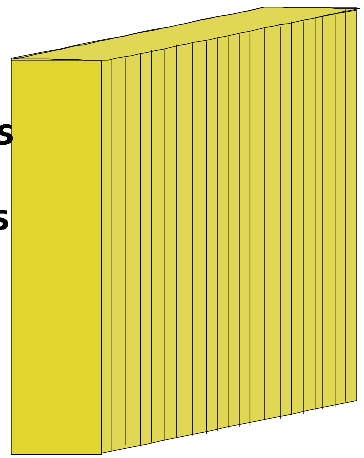
Gratings

Plane gratings

Concave gratings

Flatfield gratings

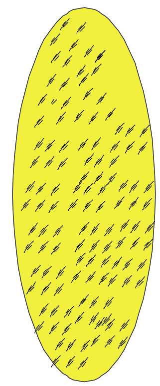
Laser gratings



mechanically ruled
holographically exposed
10-6000g/mm

blazed
sinusoidal
laminar

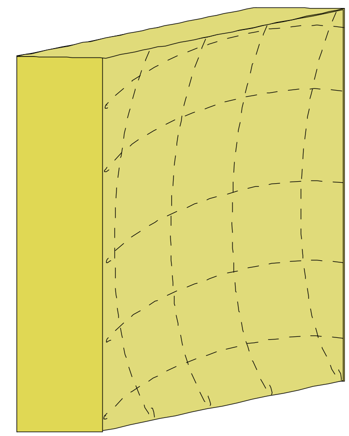
UV lenses



CaF2
MgF2
Quartz

plane
spherical

Mirrors



flat
concave
toroidal

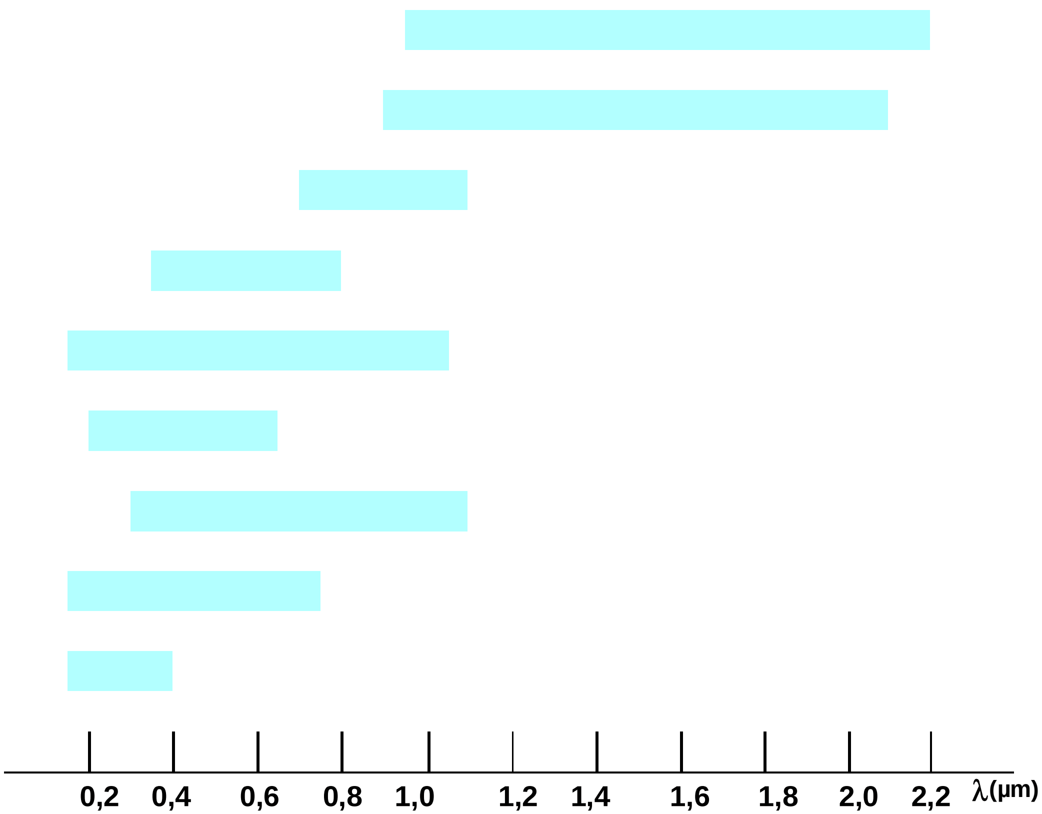
Al pure
Al ptotected
Al+MgF2
Au
Ag enhanced

Spectral Sensors

Features MMS Family

- Compact, permanently aligned system
- Robust and thermally stable
- Use for diverse measuring tasks
- Monolithic design

Spectral Sensors

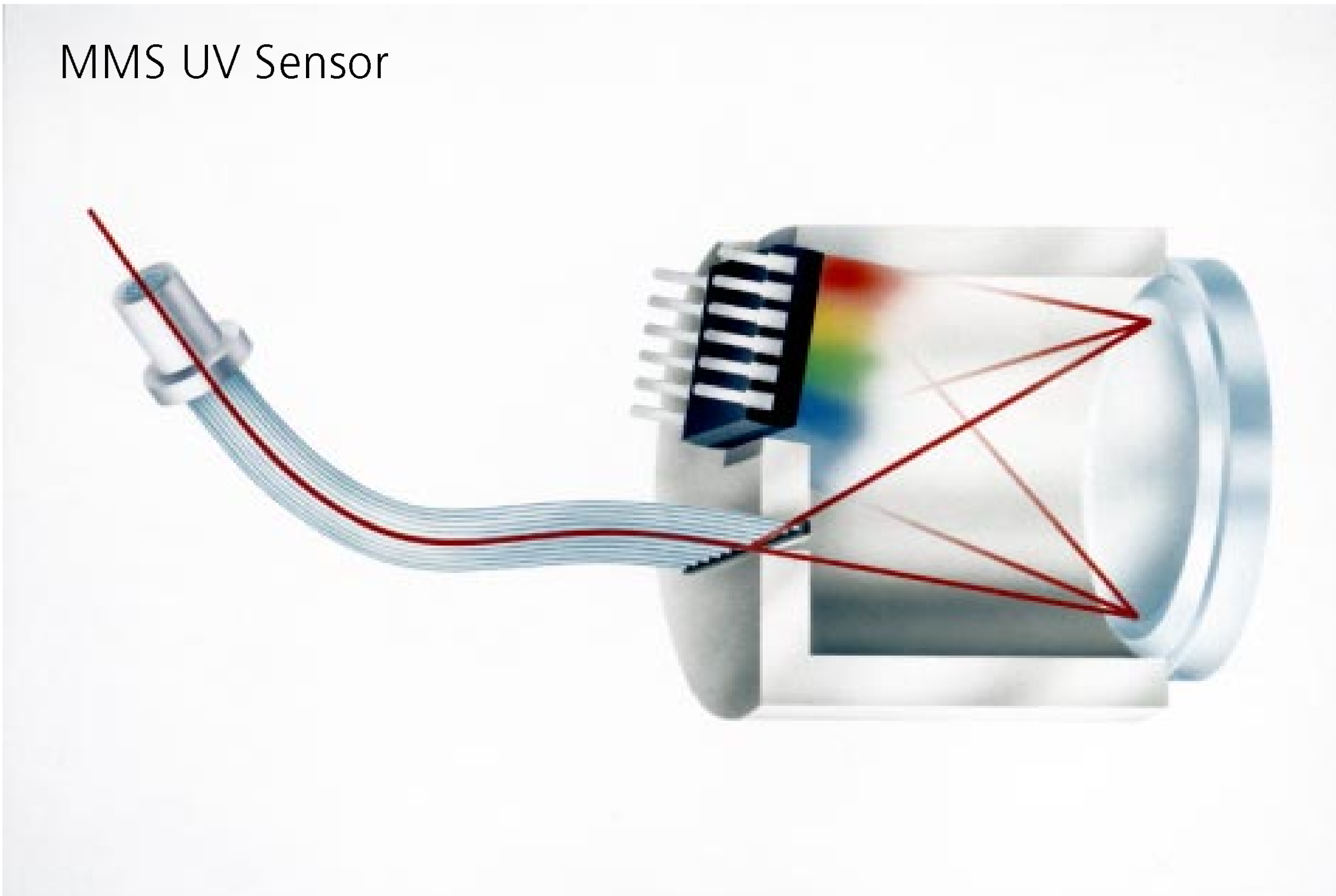


	Price	Straylight/ Noise	Optical resolution	Sensitivity
MMS IR PbS* (0,91-2,2 µm)			< 20 nm	
MMS IR InGaAs* (0,6-2,1 µm)			< 20 nm	
MCS 551 NIR (0,7-1,1 µm)			2.5 nm	
MCS 551 VIS (0,36-0,78 µm)			2.5 nm	
MCS 501 UV-NIR (0,19-1,015 µm)			2.5 nm	
MCS 551 UV (0,20-0,62 µm)			2.5 nm	
MMS 1 (0,30-1,1 µm)			< 10 nm	
MMS UV-VIS (0,19-0,74 µm)			< 7 nm	
MMS UV (0,19-0,4 µm)			< 3 nm	

Spectral Sensors

	Spectral range	Accuracy	Resolution
MMS 1	305...1150 nm specification for the range 360---900 nm	0.3 nm	10 nm
MMS UV	200...400 nm specification for the range 220---400	0.2 nm	3 nm
MMS UV VIS	305...1150 nm specification for the range 360---900 nm	0.2 nm	7 nm

Spectral Sensors



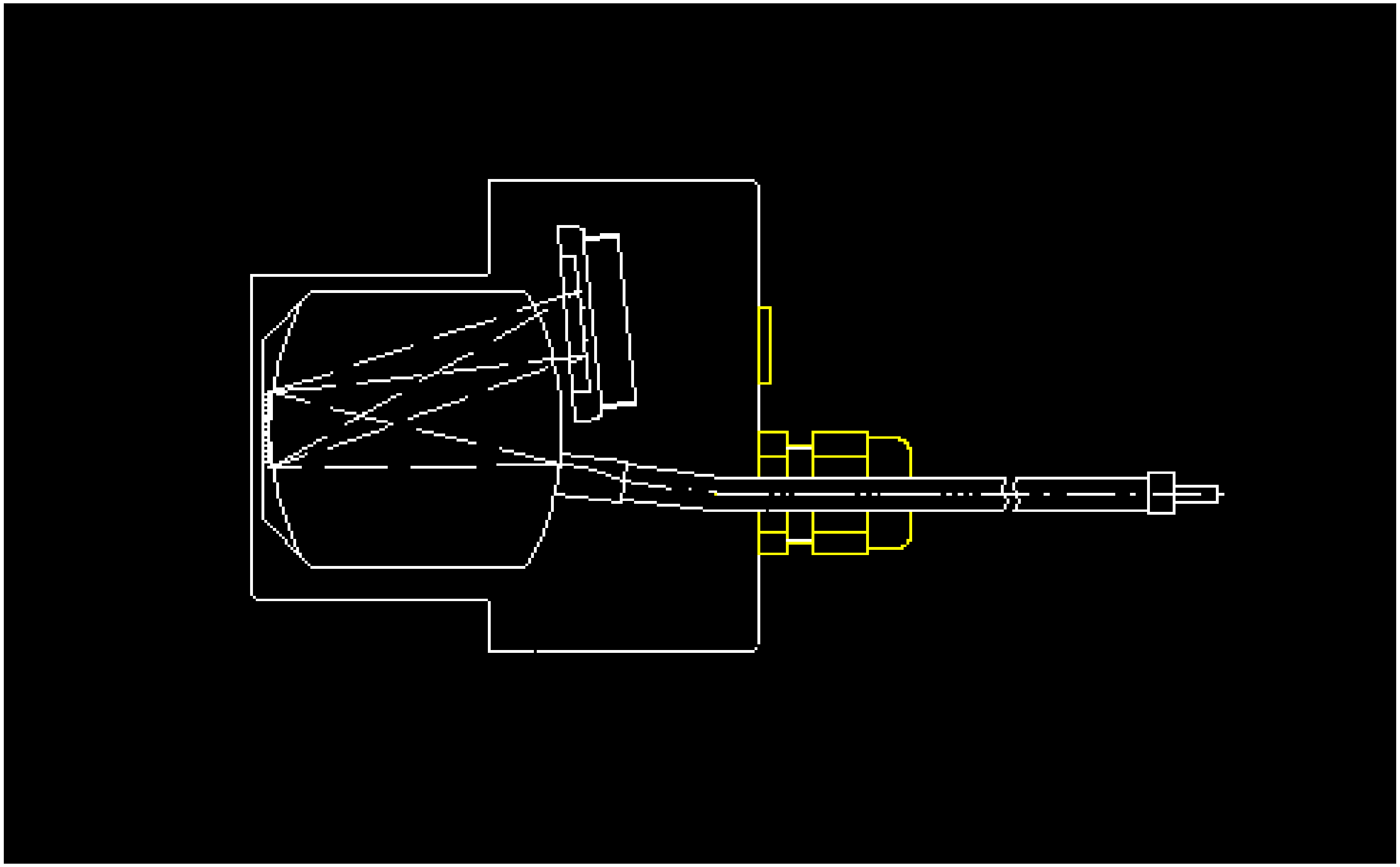
Spectral Sensors

- Spectral Range: 0.9 to 1.7µm
- up to 2.4µm under development
- Spectral Resolution: < 20nm
- Accuracy: < 0.5nm

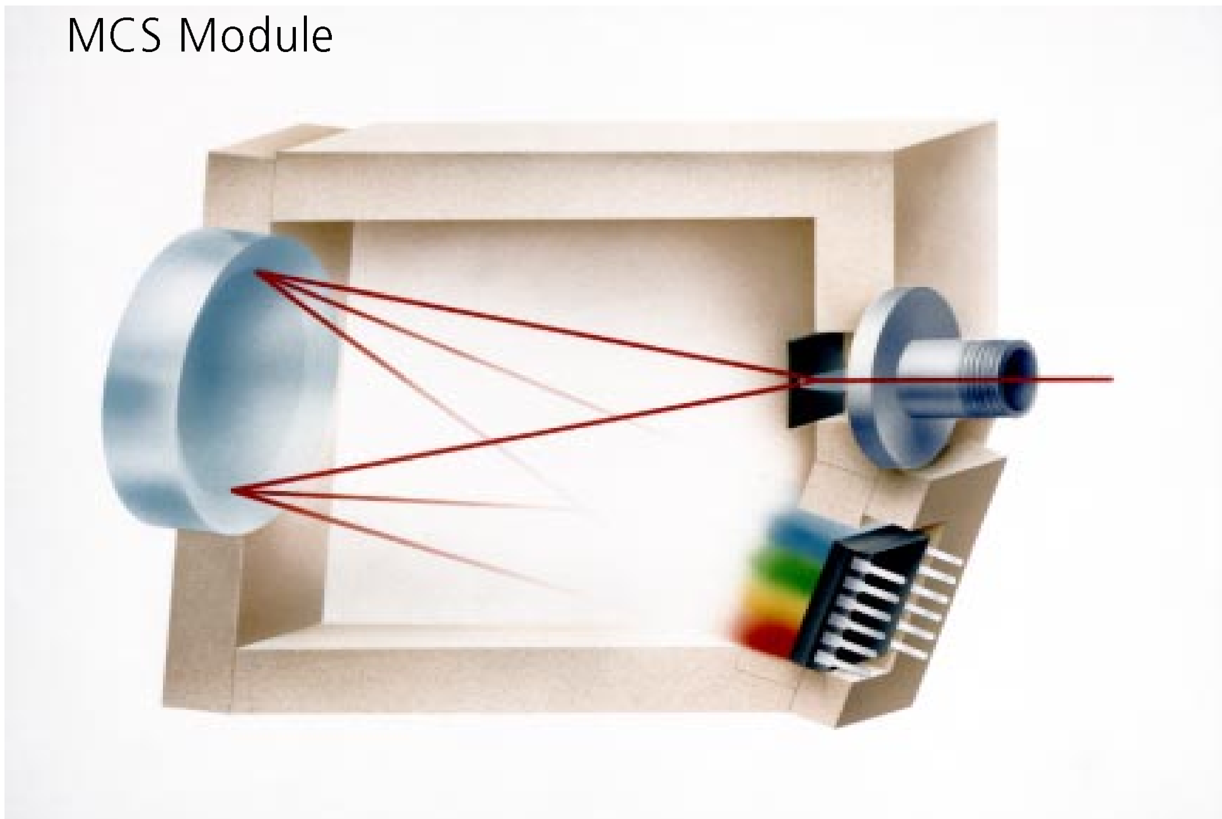
Spectral Sensors

- Monolithic design
- Compact
- Sensitive
- Reliable
- Sealed
- Simultaneous Read-Out

Spectral Sensors



Spectral Sensors



Spectral Sensors

- Accuracy: < 0.3 nm
- Straylight: < 0.1%
- Diode Array
  - Hamamatsu
  - 512 or 1024 Pixel
  - Maximum Clock Rate 2 MHz

MCS UV NIR	**190 – 1015 nm**
MCS UV VIS	**200 – 620 nm**
MCS VIS	**360 – 780 nm**
MCS NIR	**700 – 1100 nm**

Spectral Sensors

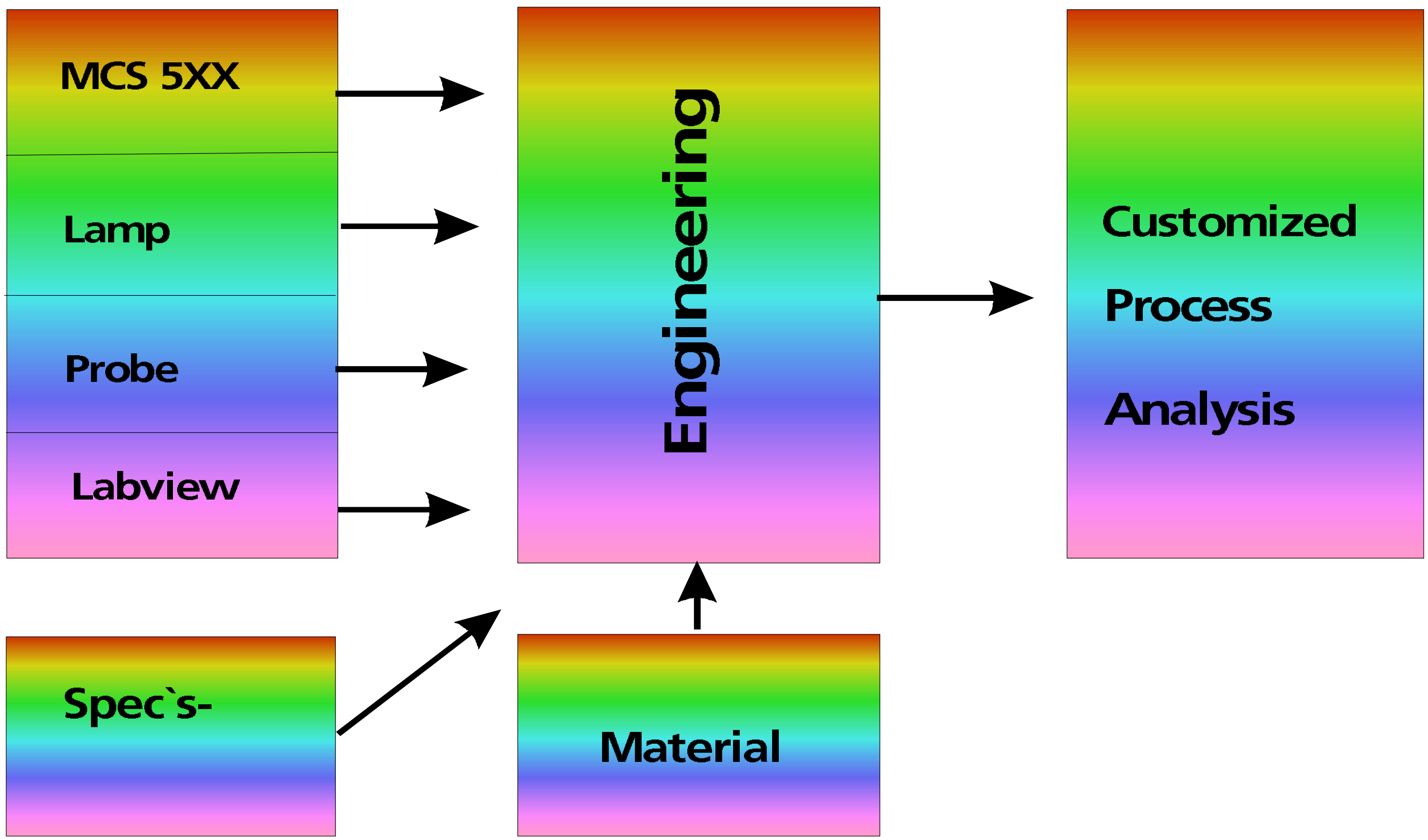
Measuring method	Transmission	Interference spectrum evaluation
Background	Spectral dependence of absorption constant	Evaluation of phase differences in the light reflected by optically transparent layers
Demands on sensor	High speed High wavelength reproducibility	High wavelength accuracy High wavelength reproducibility
Suitable CZ sensors	All MMS/MCS	MMS VIS for optical layer thickness measurement <40 µm MCS VIS/NIR <150 µm
Fields of application	Concentration analyses of fluids Filter measurement Measurement of architectural glass	Layer thickness measurement on transparent materials such as coating films, plastics, films

Spectral Sensors

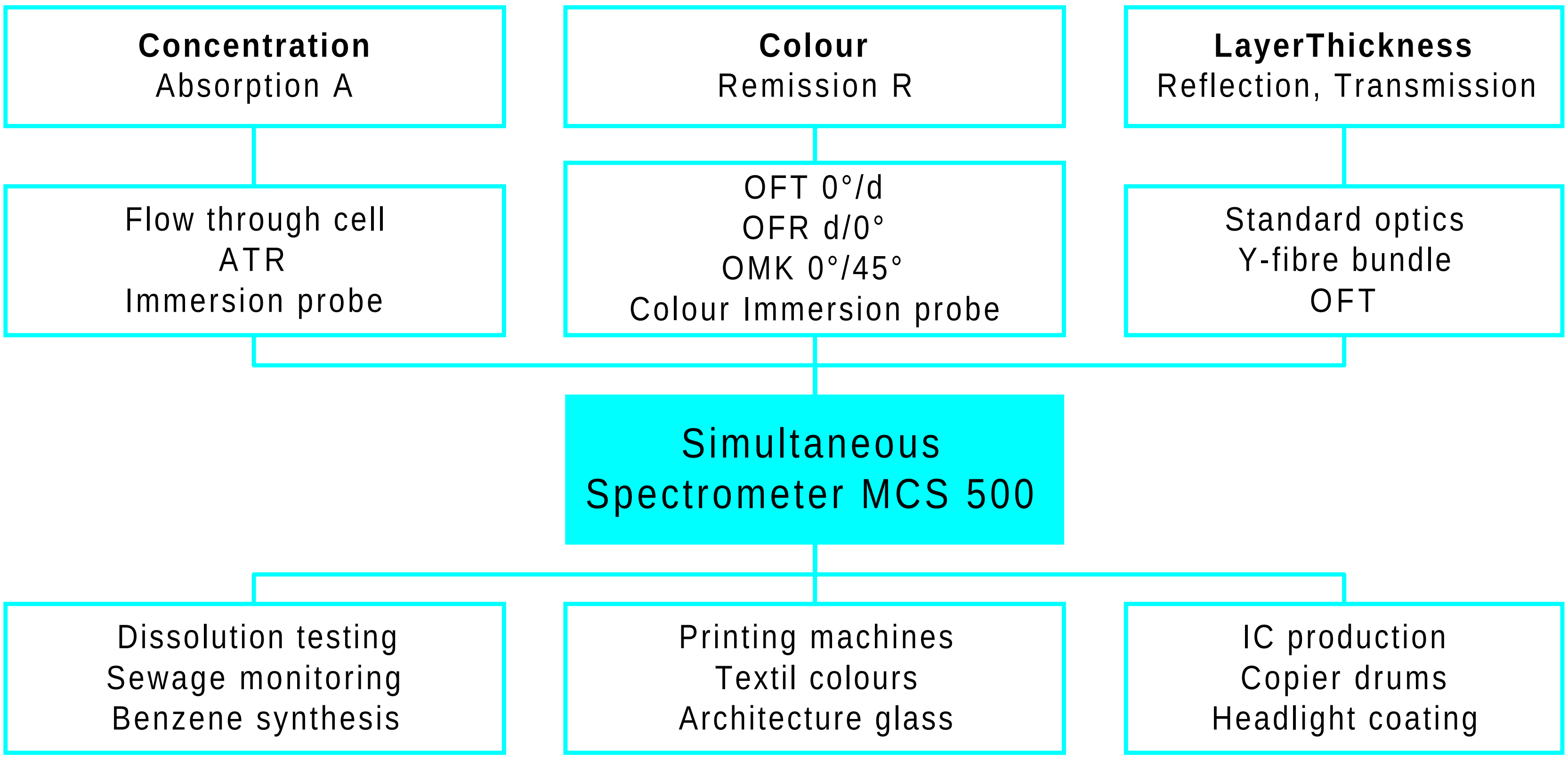
Measuring method	Emission	Remission	Reflection
Background	Spectral emission of light sources	Diffuse reflection	Directly reflected light
Demands on sensor	High wavelength accuracy High wavelength reproducibility Good spectral resolving power High light sensitivity	High light sensitivity High reproducibility	High wavelength accuracy
Suitable CZ sensors	All MMS/MCS Limited spectral resolution in case of very closely spaced lines	MMS VIS MCS UV-VIS MCS VIS	All MMS/MCS
Fields of application	Monitoring of plasms Measuring the solar spectrum Fluorescence Production screening of lamps Wavelength determination of LEDs	Colour measurement on different surfaces	Measurement of metal surfaces

Spectral Sensors

Process Analysis

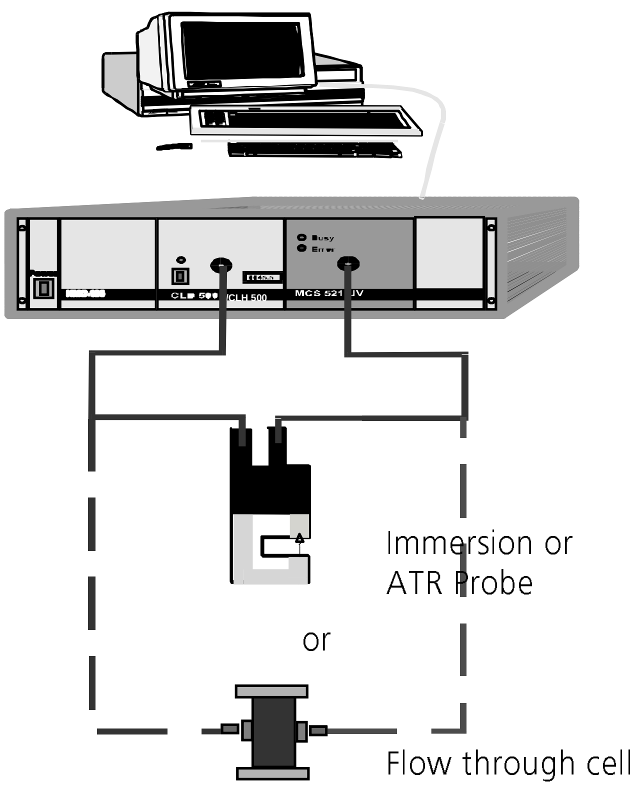


Spectral Sensors

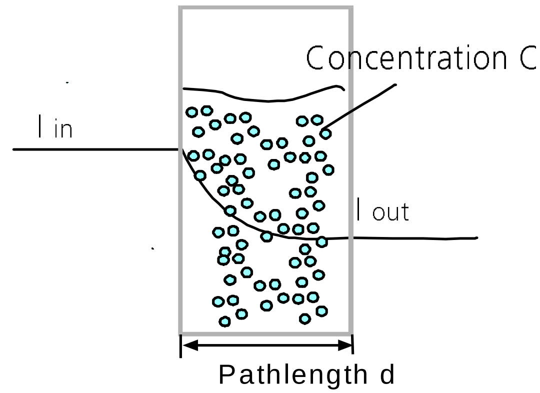


Spectral Sensors

System Setup Concentration



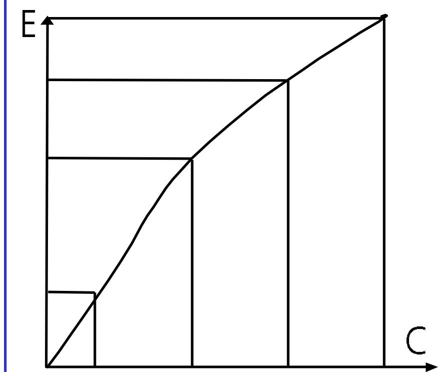
Measuring Principle



$$e\,(I)\,dc = \log \frac{I_{in}}{I_{out}} = E$$

I_{in}: incident intensity
I_{out}: emitted intensity
$e\,(\lambda)$: spectral extinction module
E: extinction (absorbance)

Evaluation



calibration curve: c = f(E)

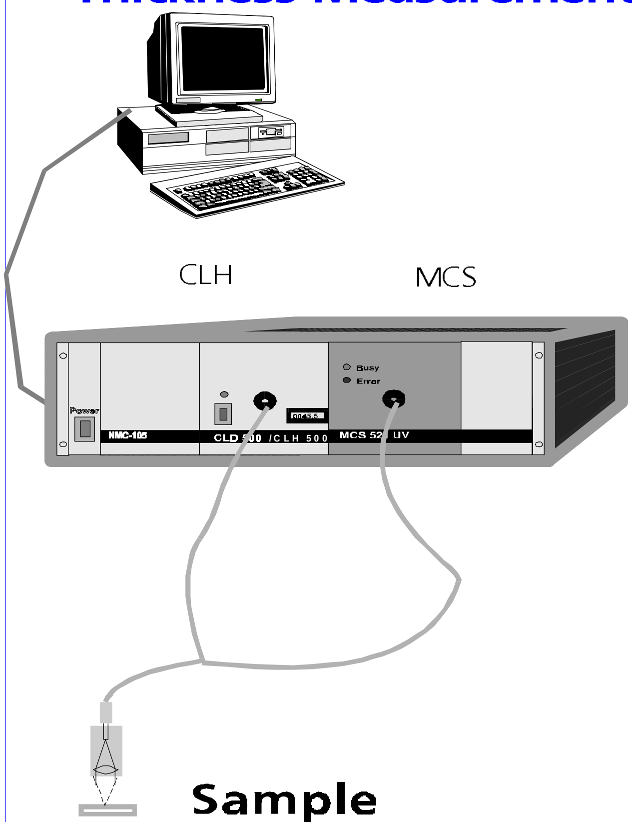
for single component analysis at a single wavelength

or

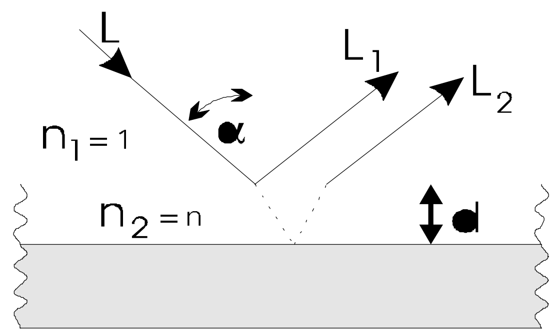
for multicomponent analysis using Partial Least Squares

Spectral Sensors

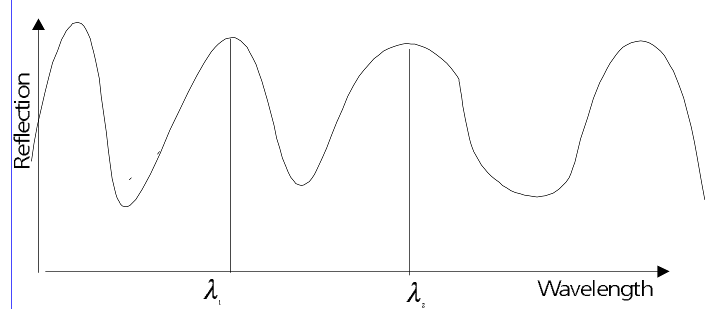
System Setup Thickness Measurement



Measuring Principle



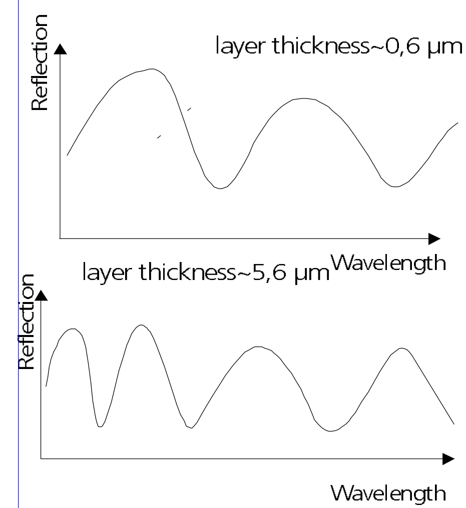
Interferences
Reflection of the incident light L of the upper and lover face of the optically transparent layer produce a shift between emitted beams L1 and L2.



$$d = \frac{1*}{2*n} \cdot \frac{\lambda_1 * \lambda_2}{\lambda_1 - \lambda_2}$$

Evaluation

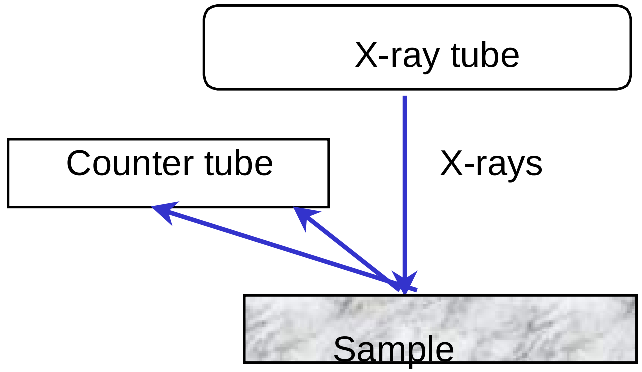
The interference pattern changes in dependance on the layer.



Phase evaluation of thin layers 0,5µm -1µm

Fast-Fourier Transformation of thick layer 2µm - 150 µm

Method for Layer Thickness Measurement X-ray Fluorescence Method



Non-contact layer thickness measurement

Principle

The primary X-rays fall on the sample at a right angle. A counter tube is located at a take-off angle. The spectrum is then evaluated.

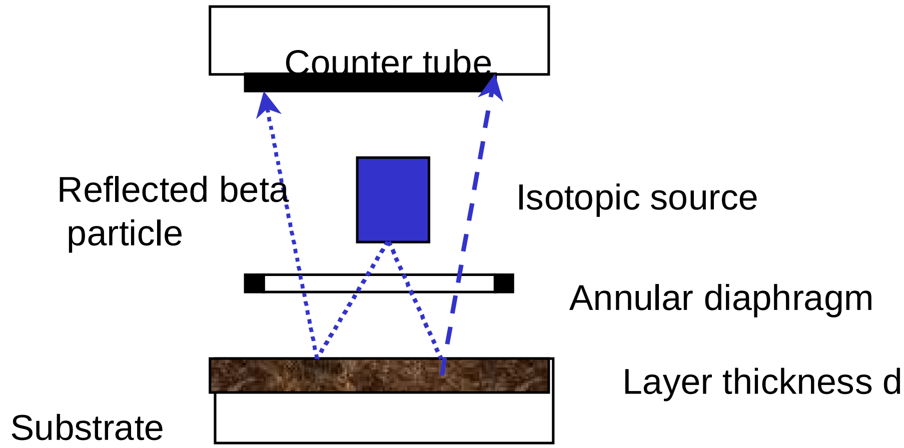
Measuring range

The measuring range depends on the material and the software.
Single layers approx. 0.1 - 100 µm
Double layers <25 µm per layer

Remarks

- Multi-layer systems can be analyzed
- State-of-the-art measuring method, but still relatively expensive
- At present, few on-line applications possible

Methods for Layer Thickness Measurement - Beta Reflection Method



Non-contact thickness measurement of layers whose atomic number differs substantially from the substrate material.

Principle

An isotopic source emits beta rays . These fall upon the surface and interact with the materials of the layer and the substrate. The number of reflected electrons is counted.

Measuring range

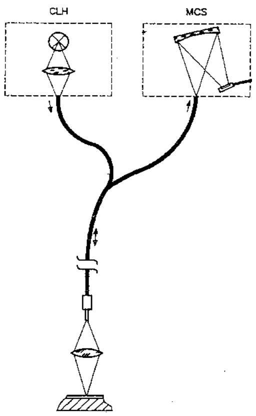
The measuring range strongly depends on the material to be examined.
For varnish, for example, it is 0.5 ...... 200 µm

Remarks

- Contact-free, non-destructive measurement
- High measuring accuracy

Spectral Sensors

Method for Layer Thickness Measurement
Interference Spectrum Evaluation



Non-contact layer thickness measurement of transparent materials

Principle

Evaluation of the reference pattern caused by the phase differences in the light reflected by the upper and lower boundary surfaces.

Measuring range

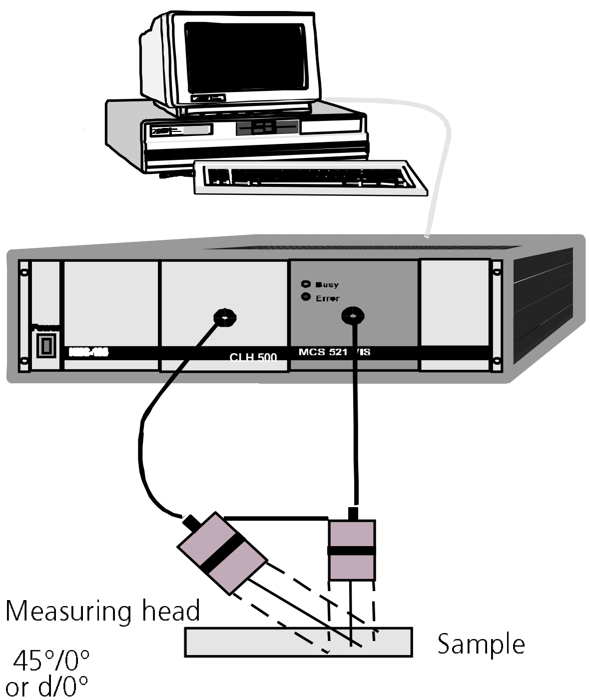
- Upper limit depends on the spectrometer resolution
- MMS: 10 nm - 40 µm optical layer thickness
- MCS: 10 nm - 150 µm optical layer thickness

Remarks

- Contact-free, non-destructive measurement
- Reflection and transmission measurement possible
- Relatively insensitive to vibrations
- No hazardous or harmful radiation
- Simple installation for on-line use

Spectral Sensors

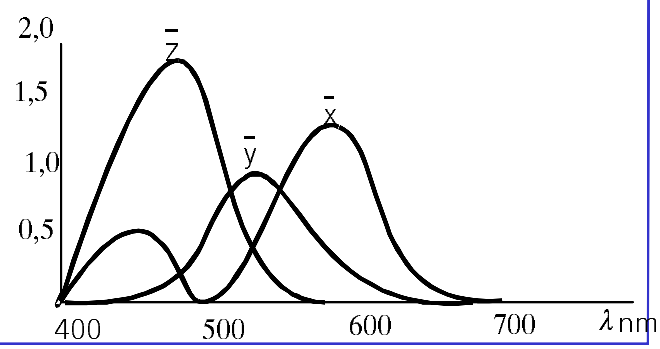
System Setup Colour Measurement



Measuring Principle

The colour impression received from an illuminated body can be described by means of 3 colours. To determine the values the following data must be provided:

1. Spectral diffuse remission R (l) or transmission T (l) curve, obtained by spectral-photometric measurement of the sample using a corresponding measuring geometry.
2. Defined norm light types described as a function of relative intensity against wavelength.I rel (l)
3. Normalized spectralfunction x (l),y (l), z (l) that define the standard colour sensitive human eye



Evaluation

The tristimulis values can be derived from:

$$X = 100 \cdot \frac{\int R(\lambda) \cdot I(\lambda) \cdot \bar{x}(\lambda)\, d\lambda}{\int I(\lambda) \cdot \bar{y}(\lambda)\, d\lambda}$$

$$Y = 100 \cdot \frac{\int R(\lambda) \cdot I(\lambda) \cdot \bar{y}(\lambda)\, d\lambda}{\int I(\lambda) \cdot \bar{y}(\lambda)\, d\lambda}$$

$$Z = 100 \cdot \frac{\int R(\lambda) \cdot I(\lambda) \cdot \bar{z}(\lambda)\, d\lambda}{\int I(\lambda) \cdot \bar{y}(\lambda)\, d\lambda}$$

In order to achieve a better correspondenc

with subjective colorimetric distances
the tristimulis values can be transformed

into colour coordinates of difficult

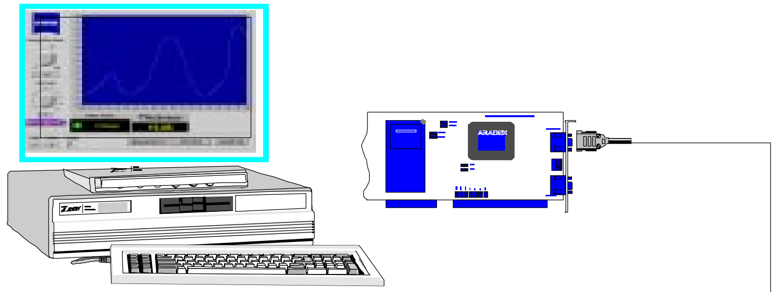
colourspaces eye.

L*, a*, b* (CIELAB) or L*, u*, v*

Spectral Sensors

Software

ASPECT PLUS
COLOUR
THICKNESS
METHOD
MCA
Labview Library
C- Library

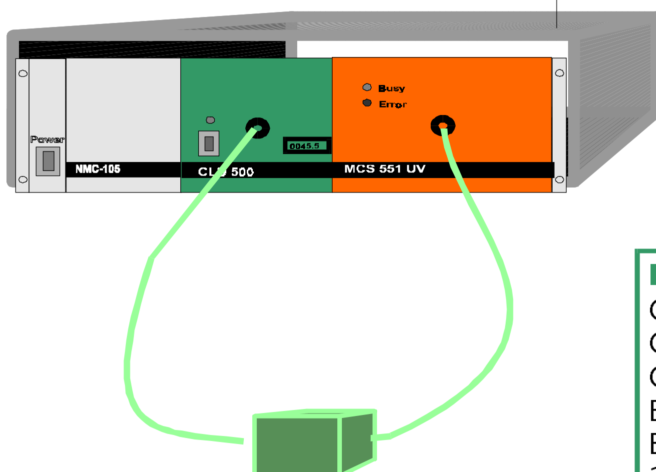


Interfaces

RS 422 PC
RS 422 PC/T8
PCMCIA

Spectrometer units

MCS 501
MCS 551 UV
MCS 551 VIS
MCS 551 NIR
MCS 521 UV
MCS 521 UV-VIS
MCS 521 VIS
MCS 522 VIS
MCS 522 UV VIS
MCS 511 NIR



Probes

Monofibres
Fibre bundles
Y-Fibre bundles
Immersion probes
Immersion probes for reflection
OMK 500
ATR-probes
Collimator optics
Measuring heads
transmission, reflection
Microscope adaptors

Light sources

CLD 500
CLH 500
CLX 500
BLX 500/4
BLX 500/6
2 channel multiplexer
4 channel multiplexer

Laser In-Situ Ammonia Monitor for Power Plants

Principle: differential absorption spectroscopy
Laser: 1W CO_2 -Laser;10,80 µm/ 10,78 µm
Lower Detectable Limit: <1 ppm
Switching Frequency: 1 KHz
Measuring Length: 1 - 20 m

Application: Waste incineration plants
Power plants