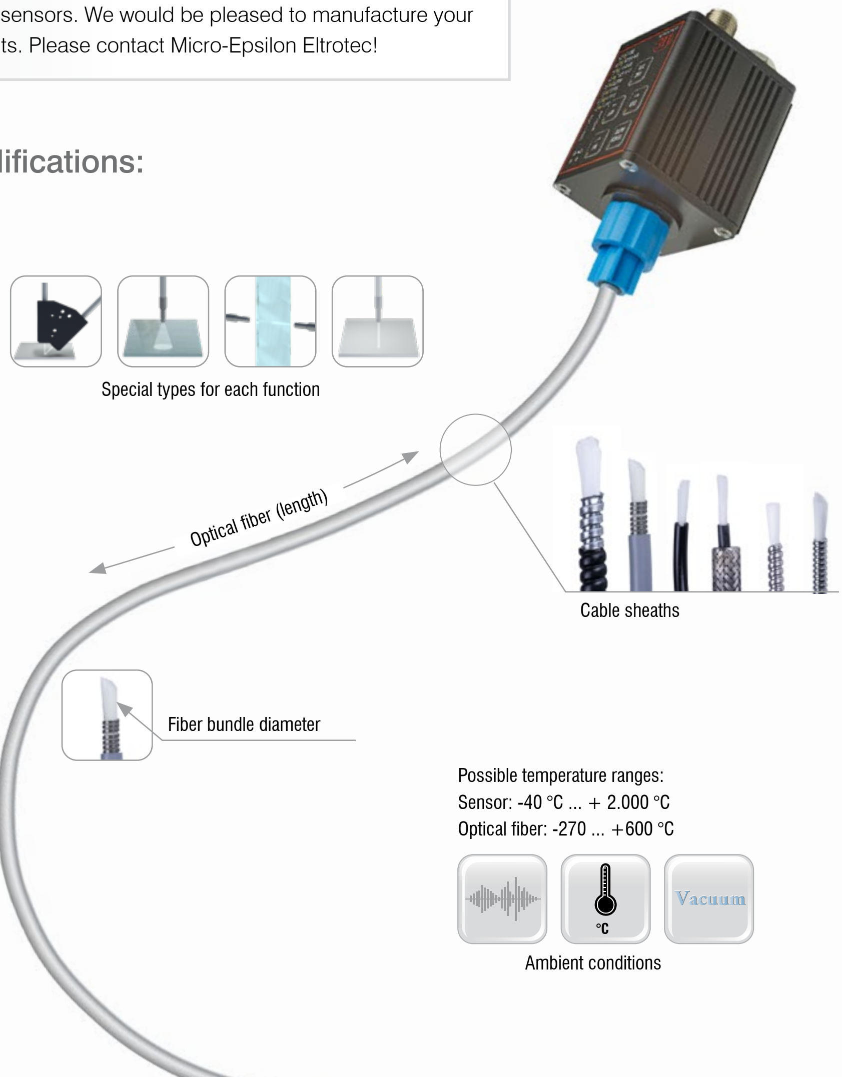
More Precision

colorSENSOR // True Color Measuring Systems

Customer-specific adaptations are possible for all sensors. We would be pleased to manufacture your sensor according to your specification/requirements. Please contact Micro-Epsilon Eltrotec!

Examples of customer-specific modifications:



Function
- Special types for CFS4 reflex sensor
- Special types for CFS3 transmission sensor or CFS1 angle sensor
- Special types for CFS5 receiving sensor

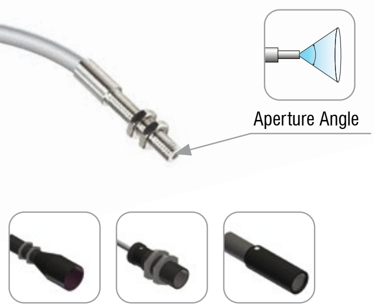
Optical fiber sheath
- Silicone-metal sheath
- VA stainless-steel sheath
- Metal sheath
- PVC metal sheath
- PVC special sheath
- BOA special sheath
- MA-radius-limiting special sheath

Fiber bundle diameter
- 0.6 / 1 / 1.5 / 2.5 / 3 mm

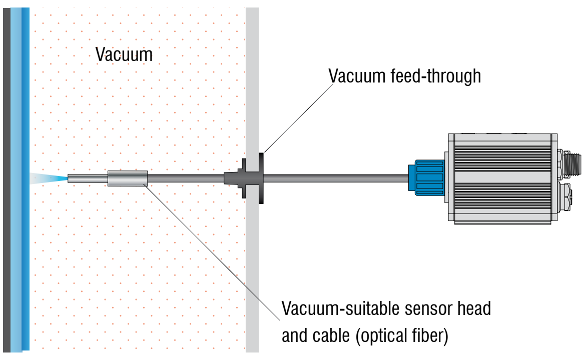
Optical fiber (length)
- Available from 300 mm
- Standard length 1,200 mm
- 600, 1,800 and 2,400 mm optionally available
- Individual length of 0.3 ... 2.4 m possible

Aperture angle
- Standard 67°
- Optional 22° / 35°

Ambient conditions
- Special versions with increased vibration resistance (VS)
- Special variants with special bonding for high temperatures (T250 / T400)
- Pressure-tight special variants with vacuum feed-through (up to 10^{-5} mbar)



Mountable lenses
- Focusing for small light spots (> 0.8 mm)
- Large object distances (= distance between sensor and measuring object) up to 200 mm
- Distances > 300 mm with C-mount lens



Vacuum suitability

The color sensors and optical fibers consist of passive components and do not give off heat. In vacuum, sensors (temperature bonding T250), optical fibers (stainless steel sheath), and the vacuum feed-through up to 10-5 mbar can be used.

In order to create a basis for worldwide color communication and standardized color measurement systems, the CIE (Commission internationale de l'éclairage, International Commission on Illumination) was founded in 1931 and is responsible for monitoring and inspection of internationally recognized color values. The observer was defined (see "Standard observer") in a study based on individual color impression.

Furthermore, light sources such as fluorescent lamps, candles, the sun etc. were defined as illuminants. If a sample is measured using a color measurement device, the factors illuminant and observer are standardized, adjustable parameters with international validity. The color perception of the test persons was defined in the standard spectral sensitivity functions $\bar{x}$ (long-), $\bar{y}$ (medium-) and $\bar{z}$ (short-wave).

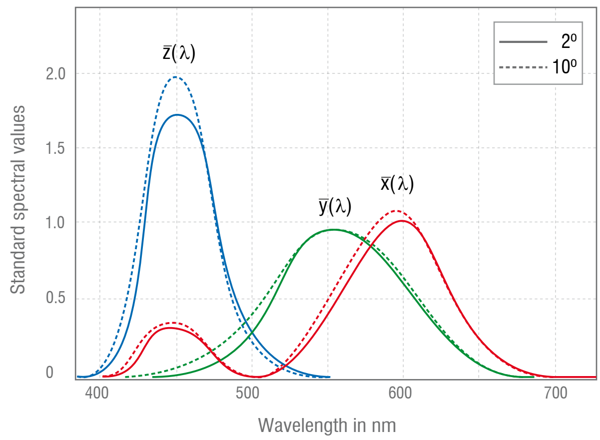
Color assessment based on:

Hue: Color differentiation, e.g., red, green, blue, yellow, etc.

Brightness: Intensity of light perception, color appears darker or brighter

Colorfulness: Intensity of the color compared with a gray color (not colored) with the same brightness

Saturation: Describes the relation between colorfulness and brightness



People perceive colors differently. In order to achieve perceptual uniformity, the International Commission on Illumination (CIE) stipulates spectral weighting functions. These functions describe how people perceive colors. They are based on experimentally determined sensitivity curves of the long-wave L-cone (X), medium-wave M-cone (Y) and short-wave S-cone (Z).

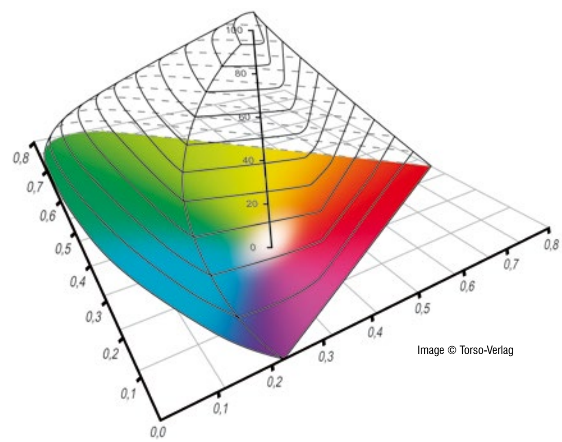
This is how each perceivable color can, due to its characteristics, be assigned an exact location in a color space and be communicated worldwide.

Color spaces

The human eye has three color receptors (L = long, M = middle, S = short). This is why 3D color models are used in order to clearly identify colors and to compare these with other colors (see color distance). In the industry, particularly the L*a*b* color space has become established.

Standard color space CIE 1931 (xyY color space)
This color space is based on perceived color in human color vision. (very large green and small blue/red range).
x and y = color vectors describing hue and saturation
Y = value (brightness) scaled from 0 to 100
W = white point (x=y=z=1/3)
Spectral lines = "pure" colors
Black body curve = color as temperature of an ideal, black radiator

! *Suitable for testing green and white LEDs.*



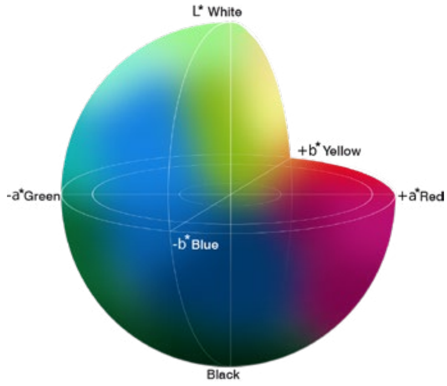
xyY Color space

Standard color space CIELAB76

The L*a*b color space comprises all colors perceptible to the human eye. In this 3D color model, each hue is described with approximately the same volume of space. The L*a*b* color space has established itself in the industry and is used by device manufactures for color inspection.

Each color is described by the color location (L*; a*; b*).
L* = lightness (black = 0; white = 100)
a* = green/red colors (green = -100; red = +100)
b* = blue/yellow colors (blue = -100; yellow = +100)

! *Ideal color space for color test, as each color range is the same size.*



L*a*b* Color space

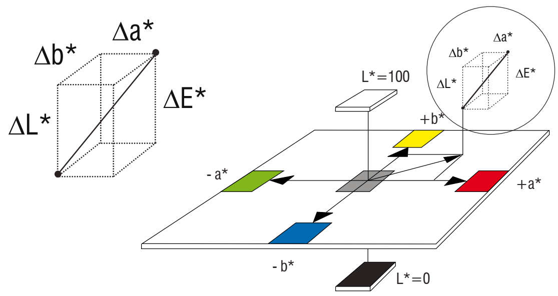
Color distance ΔE

The larger the difference between the colors within the color space, the more clearly the difference can be perceived with the human eye. This is defined as ΔE color distance.
Delta E; ΔE; dE = is a metric for the perceived color distance between colors (DIN 5033)

$$\Delta E = \sqrt{(L^*_p - L^*_v)^2 + (a^*_p - a^*_v)^2 + (b^*_p - b^*_v)^2}$$

ΔE of 11.61 corresponds to the difference between sample (p) and comparison (v)

$$\Delta E = \sqrt{(60^*_p - 55^*_v)^2 + (-38{,}6^*_p - (-30)^*_v)^2 + (-46^*_p - (-52)^*_v)^2} = 11{,}62$$



Sample (p)

Comparison (v)

Interpretation:

ΔE > 5	Large color difference
ΔE 0.5 … 1	Limits of human perception
ΔE < 0.3	Required by the paper industry
ΔE < 0.1	Required by the automotive industry

RGB Color space

It combines the colors red (R), green (G) and blue (B) into one. It is an additive color space, i.e. all three colors as one result in the color white. Black color is produced when R/G/B = 0/0/0.

The RGB color space has established itself in the display industry but is of no interest for industrial measurement technology since not every color can be displayed and measured.

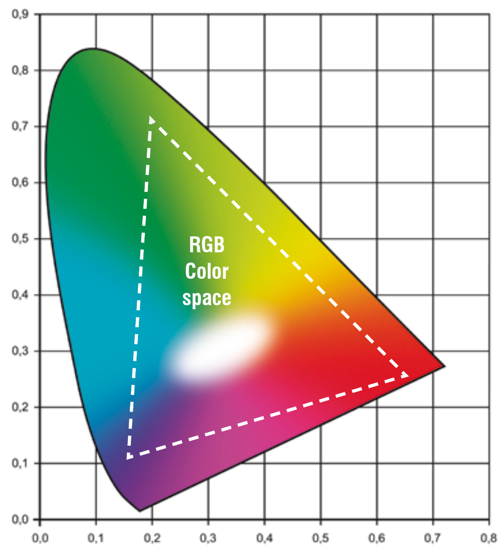
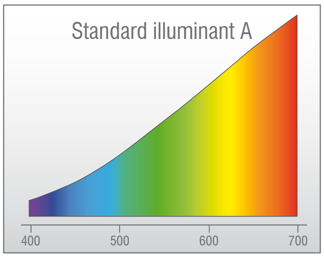


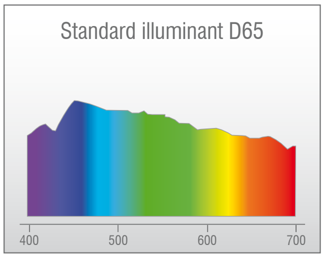
Image © Torso-Verlag

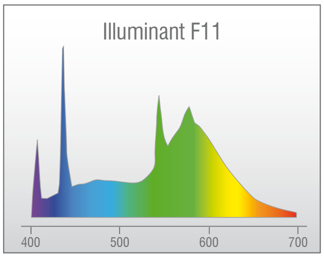
Standard illuminants and light sources

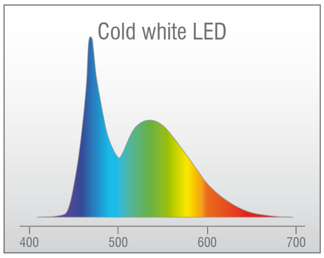
Standard illuminants are defined from 380 to 780 nm.

- **Illuminant A** = light bulb with 2865 k
- **Illuminant D65** = medium daylight with approx. 6500 k
- **Illuminant F11** = fluorescent lamp
- **Cold white LED**



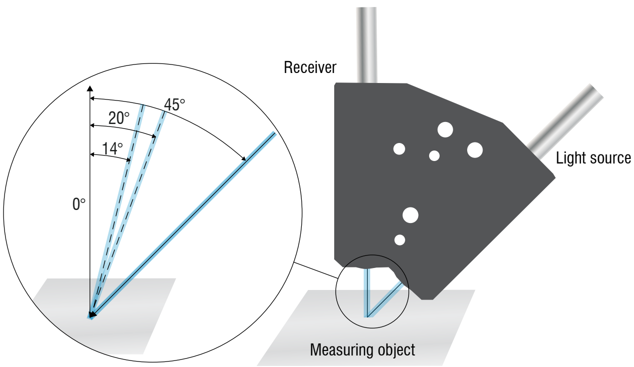




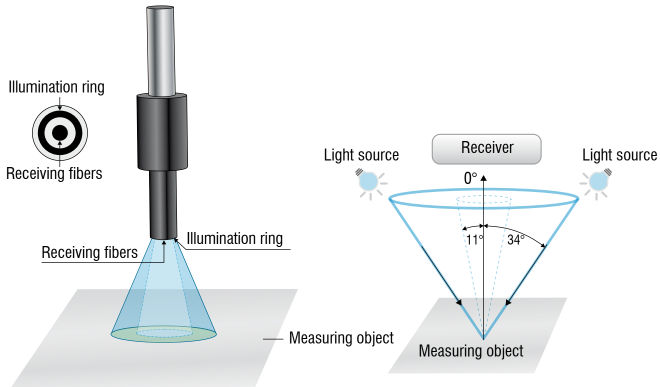


Measurement geometries

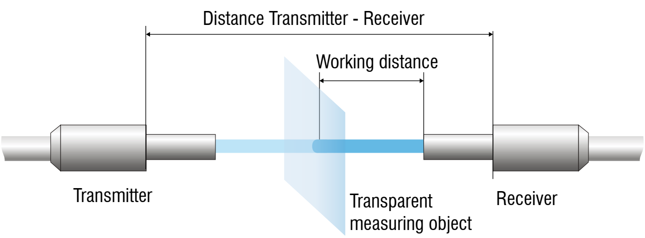
Standard sensor 45°x:0°, 20°x:0°, 14°x:0°



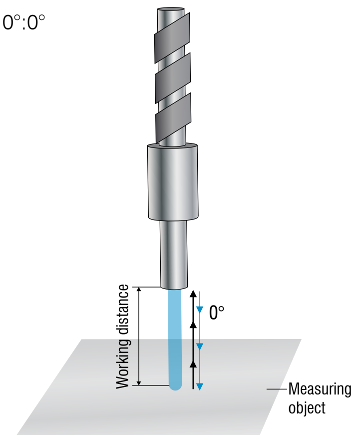
Circular sensor R34°c:0°, R11°c:0°



Transmission sensor 0°:180°



Reflex sensor 0°:0°



With structured surfaces, it is recommended to perform the inspection from all four directions (north, east, south, west on one side) and to calculate the average on different positions or to illuminate the specimen from all directions (ring illumination (R45°c:0°) and to measure only one position. With translucent samples, a defined background or folding the sample should provide sufficient layer thickness for the inspection. You can alternatively use some illumination as background in order to inspect in transmission (0°:180°) mode.

Sensors and Systems from Micro-Epsilon

Sensors and systems for displacement, distance and position

Sensors and measurement devices for non-contact temperature measurement

Measuring and inspection systems for metal strips, plastics and rubber

Optical micrometers and fiber optics, measuring and test amplifiers

Color recognition sensors, LED analyzers and inline color spectrometers

3D measurement technology for dimensional testing and surface inspection

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