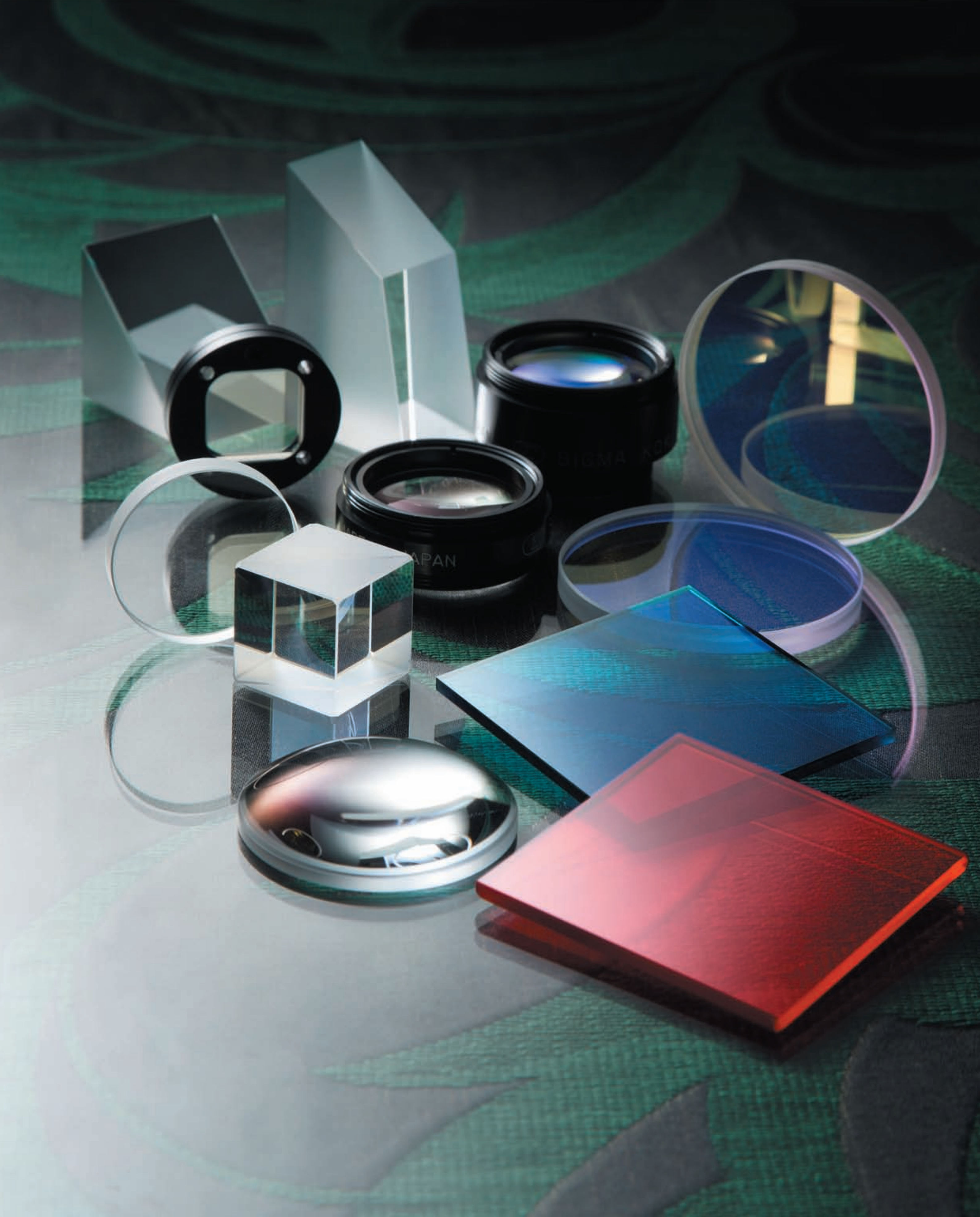
Optics & Optical Coatings



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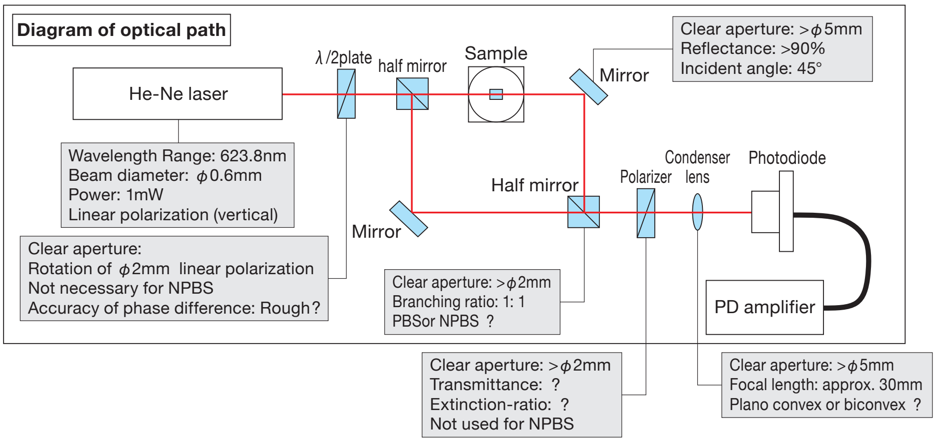
Optics & Optical Coatings Guide

Selection of Optics

Prepare a diagram featuring your desired optical path based on your experimental principles for the optical system. Check the required specifications of each optical component stated on the optical path and select the correct components. As the options available are extensive, we can assist you by introducing the following two important factors when selecting your optics. (Laser Specifications & Classification of Optical Systems)



Laser Specifications

When selecting optics, determine the type of "light" to be used. As there are various types of light sources in the market, our Sigma Koki catalog offers Laser, LED, Halogen and Metal Halide solutions. Laser typically offers various wavelengths and the accompanied optics to be used can differ depending on the wavelengths. In addition to the wavelength of laser, there are some elements to consider when deciding the specification of optics.

Check Items for Laser	Example 1	Example 2	Related Spec
Laser Type	He-Ne	YAG	Compatible Wavelength
Wavelength [nm]	632.8nm	532nm	
Calculation of Energy Density [J/cm^2] (User should calculate)	Any	78J/cm^2	Not applicable for CW of laser damage threshold of 0.5W or lower Not applicable for pulse of 100mJ/cm^2 or lower
Output beam diameter (1/e^2, diameter) [mm]	0.59mm	0.7mm	
For continuous wave (CW) laser Output [W]	1mW	–	
For pulse laser Energy [J], Pulse width [s], Repetition frequency [Hz]	–	300mJ 10ns, 20Hz	
Beam Spread Angle (Full) [rad]	1.35mrad	1.3mrad	Clear aperture
Transverse Mode	TEM00	Single	Focus spot diameter
Polarization Orientation (Vertical, horizontal, or random)	Vertical	Horizontal	Reflectance, transmittance

If the information provided above is still uncertain, please check with the manufacturer of the Laser and they will provide you with the necessary information and specifications.
Compare the specifications of the optics listed in our catalog against the laser and select the optics that is compatible especially in the area of laser damage threshold and polarization orientation.

Classification of Optical System

Confirm the type and degree of precision required for your optical system. If uncertain, you may classify by its intended usage. Illumination by itself does not require precision but more towards functionality and purpose. Please see chart below to have a better understanding.

Class	Surface Accuracy	Surface Quality	Product Example	Usage
Illumination System Class	About λ	About 60–40	Biconvex lens Reference B123 Aspheric lens Reference B159	Lamp illumination of microscope Condensing beam to a detector, etc.
Simplified Optical System Class	λ/4 or lower	40–20 or lower	Plano convex lens Reference B108 Achromatic lens Reference B172 Aluminum* / Dielectric multi-layer mirror coating Reference B030, B027	Various imaging systems Interferometers for small diameter beam
Interferometer Class	λ/10 or lower	20–10 or lower	Surface accuracy guaranteed mirror Reference B016, B030 Femto high power mirror Reference B011, B020 Focusing lens Reference B180	Interferometers for wavefront observation, laser processing devices Optical experiments with higher resolution

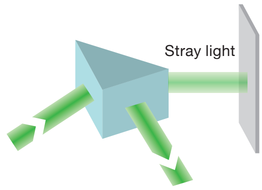
The above classification is a rough guide. The classification may not apply depending on products or materials.
For selection of each product, refer to the selection guide. Also refer to the explanations in the selection guides or application notes such as "Beam Expanding Method" or "How to Use Polarizers".
If you have any question, contact our International Sales Division.
When making an inquiry, do let us know your laser specifications or intended usage, we can provide you with a quicker and more comprehensive answer or solution.

Laser Safety

Laser light irradiating into the eyes could cause serious disability that leads to blindness. For this reason, the Ministry of Health, Labor and Welfare issued a directive "Preventive Measures against Disabilities Caused by Laser Light" for laser users and manufacturers. Laser users must confirm with the safety managers of their businesses or organizations. Safety standards or safety measures vary depending on the businesses or organizations.
JIS C 6802 specifies the classes of laser products. According to the specification, laser products have a label of the corresponding laser class. JIS defines staged preventive measures for users according to the classification. Reference H005
When purchasing or using a laser, make sure to check the class of the laser, and use upon understanding the risk.

Laser Safety Glasses

Laser safety glasses to be used are predetermined for each laser.
If you use glasses not compatible with the wavelength of the laser to be used, you cannot get protection and it is very dangerous.
Select the laser safety glasses appropriate for the wavelength of the laser to be used.



Handling of Optics

Some optics split light into multiple beams. (Glan-Thompson prism, PBS, beamspliter, etc.)
When using these optics, terminate all divided beams safely.
Also, optics having a shape like a prism may split a beam in an unexpected direction.
Make sure to check the all circumferences of a prism, and safely handle stray light.

Installation of Optical Systems

When installing an optical system, the desired height of laser beam is said to be higher than the eye level of standing workers or lower than the eye level of seated workers.
Installing a fire-retardant beam enclosure around optical paths is also effective to prevent unnecessary laser exposure.

Laser Installation Environment

To prevent laser beams from reaching outside of an experiment space, covering the experiment space with a darkroom is very effective as a safety measure. A darkroom can also be a partition of a laser controlled area to limit entrance to only authorized people.
In addition, it can eliminate the influence of disturbance light from an optical experiment, which is effective when performing optical adjustment with weak light.

Handling of Optics

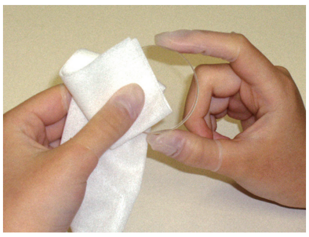
Optics has a limited life span and degradation starts from the moment the package is opened. Scratches, dirt or dust will accumulate on its surface after lengthy usage and will cause light to scatter or diffract and with the high possibility of poor optical performance.
The durability of optics will change depending on the purpose of experiment and usage environment, but generally they can be used for two to three years.

Handling

Handling of optics requires good care and understanding to prevent surface scratches or dirt. Importantly, do not touch the polished surface.
Lightly hold the ground surface or its edge.
When handling optics, it is good practice to use finger sacks.
When fixing an optic in a holder, do not tighten the optic retaining screw too hard unless for special occasions such as transportation. Tightening the screw too hard may break the optic or significantly deteriorate the performance of the optic.
Lightly tighten the screw so that the optic does not move. If the optic retaining screw might get loose due to vibration or the like, we recommend adhering the optic to the holder, or fastening the screw with screw locking glue.

Cleaning

Should an optical component get dusty or dirty, first check if the condition permits cleaning.
Cleaning optics with paper on Gold and Aluminium coating without protective coating is not recommended as it will cause scratches. As for Dielectric multi-layer coating with protective coating, it is possible but we recommend cleaning to its minimum to avoid risk of scratches.
When wiping optics, always remove them from the holder for effective cleaning.
Wiping an optic in a holder is very difficult and requires experience.



How to Wipe Optics

(1) Prepare several lens papers*1, alcohol (ethanol, methanol, etc.), finger sacks (powder-free type if available), and air blower*2.
(2) Put finger sacks on the fingers of both hands, and wipe off dirt from the finger sacks using paper moistened with alcohol. Then, fold a lens paper into a strip of 3 to 4cm width.
(3) With the non-dominant hand, hold the edge of the optic as shown in the picture.
(4) Moisten the folded lens paper lightly with alcohol, and fold it so that it tucks into the faces of the optic.
(5) Hold the center of the optic with the lens paper, and rotate the optic using the fingers of the non-dominant hand.
(6) Gradually move the lens paper from the center of the optic toward the edge, and when it reaches the edge, slowly relax the fingers holding the paper, and remove the paper from the optic.
(7) Hold the surface of the optic against the light to check cleanliness. Use the air blower to blow off fine dust on the surface of the optic.
(8) If there is still dirt or traces of wiping, change the lens paper, and wipe the optic again with the same procedure. After finished wiping (change to) Upon finishing the wiping process, keep in a powder paper or special plastic case.

The art of wiping optics is to do it lightly with constant pressure.

*1 Lens Paper (SLP-2) Reference B346 *2 Air Blower (DOP) Reference B346

Optics & Optical Coatings Guide

Storing Method

Optics are very stable in our general environment, but if kept in a location with high temperature and humidity for long periods, its surface may get cloudy and mold may also develop on the optics if left unattended. When optics is not being used, keep them in a dry container.
For storage of large optics and optical devices, use a Dry-Cabi®[*3]. Ensure the power is on for optimum performance.
In addition, when storing an optic just purchased, we recommend storing it after taking it out from the package.
*3 Dry-Cabi® (H-D2) Reference B348

Handling of Silica Gel

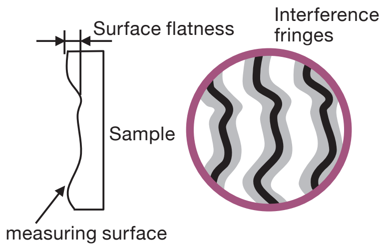
Check the color of silica gel periodically, and when the color becomes reddish, replace with new silica gel.
Use of a transparent lunch box is convenient because you can check the color of silica gel without opening the cover.
You can reuse the reddish silica gel if you dry it in an oven.

If dust is on the surface of an optic and you irradiate the surface with a strong laser, the dust will burn and the stain caused might not be removed from the optic surface. For this reason, we recommend the use of a cover to prevent dust from adhering on optical systems when they are not used.
Just before using an optical system, we also recommend that you remove dust from optics using an air blower or by cleaning.

Explanation of Basic Terms

Surface Accuracy

A value indicating the deviation between the polished surface and the ideal flat surface. It is also called reflected wavefront distortion because it is measured using an interferometer which measures wavefronts. Surface accuracy is expressed in units of [λ], which uses the number of interference fringes. λ indicates the wavelength 632.8nm of a He-Ne laser used in interferometers.
In addition, there are two notations used for surface accuracy, PV and RMS.
PV stands for Peak to Valley (difference between the maximum value and the minimum value), and RMS stands for Root Mean Square (least mean square). Empirically, the RMS value is about 1/3 of the PV value. The PV is often used for simple shapes such as a flat surface, and the surface accuracy shown in this catalog uses the PV value. For example, the surface accuracy of PV λ/2 indicates that the deviation is maximum 316.5nm from the ideal flat surface.



Surface Quality (Scratch-Dig)

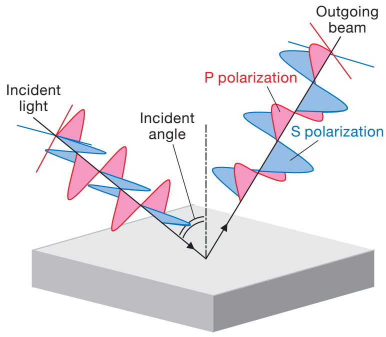
The standard of scratch on processed optics or coated optics is appeared as; long mark for scratch and deep mark for dig.
If the scratch–dig is 20–10, there are no scratches wider than 2μm, and no digs larger than 100μm.
SigmaKoki adopts the MIL-PRF-13830B standard, which consist of visual comparaison inspection of criteria sample.

Laser Damage Threshold

When you irradiate an optic with a high energy pulse laser, it may cause damage to the coating or glass material of the optic. Laser damage threshold is the energy density [J/cm^2] of laser light that will start causing damage to the optic.
Sigma Koki employs the S-on-1 test specified by the international standard ISO21254 for the laser damage threshold. By comparing the laser damage threshold of optics with the energy density[*4] of the laser to be used, you can select the optics that can withstand the laser. Note that laser damage threshold is not an issue for pulse laser (10ns pulse width) of 100mJ/cm^2 or lower, or CW laser of 0.5W or lower.
*4 Energy density [J/cm^2] = Laser energy [J] / (π × Beam radius [cm]^2)

P and S Polarization

When light enters a glass surface at an angle, the reflectance changes according to the polarization orientation of the incident light. P polarization is light waves oscillating in-plane including those of the normal vector to glass surface and incident beam, while S polarization is light waves oscillating orthogonal to the P polarization. Polarization states other than these can be considered combinations of P and S polarization in varied distribution ratio.
The reflectance of P and S polarization is determined by incident angle and the refractive index of glass, but since each of them follows a different law, the reflectance of P polarization is different from that of S polarization. Reference B342

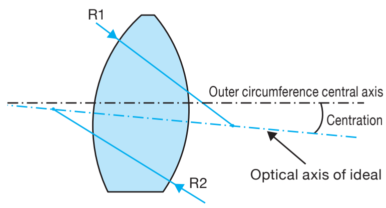


Angular Deviation of Beam

When an optic is inserted in an optical path of a laser beam, the beam sometimes tilts.
The angle of the tilt from the original beam is called angular deviation of beam. Angular deviation of beam is determined by the parallelism and refractive index, and in BK7, the parallelism of 1 minute is equivalent to the angular deviation of beam of about 0.5 minutes. Reference B342

Centration

When a lens rotates with reference to the outer diameter of the lens, if the lens is ideal, the transmitted beam or focused beam will not move when the lens rotates, but if there is deviation between the central axis of the outer diameter of the lens deviates and the optical axis of the ideal lens, the beam moves as if drawing a circle. The angular deviation between the transmitted beam and the rotation axis is called centration.



Reflectance and Transmittance Wavelength Characteristics Data

The catalog shows a graph of reflectance or transmittance wavelength characteristics for most of the optics listed.
This graph of reflectance or transmittance wavelength characteristics is measured using a spectrophotometer. [*5]
The catalog shows a wide wavelength range in addition to the range guaranteed by design, but because the values out of the guaranteed range have poor reproducibility and significantly vary among each optic, it is dangerous to trust them.
For a beamsplitter or the like, only the graph of transmittance is listed without the graph of reflectance. The reflectance is however easily deduced by inverting the vertical axis of the graph because no absorption occurs in the case of dielectric multi-layer coating. [*6]
In addition, incident angle and polarization orientation are specified for measured data. For measurement of reflectance, the incident angle is 5 degrees or 45 degrees, and for transmittance, it is 0 degree or 45 degrees.
Reflection type optics of 45 degrees incidence are listed with a graph of P and S polarization. This is because, in dielectric multi-layer coating, the reflectance characteristics significantly changes depending on the polarization orientation. If the catalog cannot show a graph of P and S polarization due to a space constraint, then it shows the mean value of S and P polarization.
*5 Simulation data of thin film design is used for some optics.
*6 In case of chromium coatings, 1 - Transmittance = Reflectance is not true due to absorption.