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Optics and photonics — Holography —

Part 1:
Methods of measuring diffraction efficiency and associated optical characteristics of holograms

Optique et photonique — Holographie —

Partie 1: Méthodes de mesurage de l'efficacité de diffraction et caractéristiques optiques associées aux hologrammes

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Foreword

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The committee responsible for this document is ISO/TC 172, *Optics and Photonics*, Subcommittee SC 9, *Electro-optical systems*.

ISO 17901 consists of the following parts, under the general title *Optics and photonics — Holography*:

— *Part 1: Methods of measuring diffraction efficiency and associated optical characteristics of holograms*

— *Part 2: Methods for measurement of hologram recording characteristics*

Introduction

The aim of this part of ISO 17901 is to specify the terms related to holograms and basic measurement methods to characterize them.

A hologram is an optical device utilizing interference and diffraction phenomena and is characterized differently from optical devices based on reflection, refraction, and scattering. By exploiting the characteristics of holograms, they have been successfully applied in numerous applications such as displays, metrology, and anti-counterfeit security.

The expanded market in holography has generated a need to agree on basic terms and definitions for holograms and measurement methods and this part of ISO 17901 aims to satisfy that need.

Optics and photonics — Holography —

Part 1:
Methods of measuring diffraction efficiency and associated optical characteristics of holograms

1 Scope

This part of ISO 17901 specifies the terms related to optical characteristics of holograms, the method to measure their diffraction efficiency, and the angular and wavelength selectivity measurement methods. These measurement methods are applicable to any type of hologram if the hologram yields a simple diffraction pattern, which means the reconstructed wave can be clearly separated from other diffracted and non-diffracted waves. In other words, holograms that yield complex diffraction patterns are excluded. There are no restrictions on the materials used to form the holograms.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15902, *Optics and photonics — Diffractive optics — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15902 and the following apply.

3.1
hologram
interference pattern formed between the wave emitted from the object and its coherent reference wave, which is recorded in the recording material

Note 1 to entry: The holograms also include those formed through embossed copying of surface relief or those recording the periodic structure spatially by etching or engraving.

3.2
object wave
object beam
wave emitted from an object and entering the recording material in the course of recording the hologram

3.3
reference wave
reference beam
wave entering the recording material while forming a certain angle with the object wave in the course of recording the hologram

3.4
illuminating wave
illuminating beam
wave allowed to enter the hologram when reconstructing the image from the hologram

3.5
reconstructed wave
reconstructed beam
wave diffracted by the hologram

Note 1 to entry: Generally, this term indicates either the +first-order diffracted wave or –first-order diffracted wave but can indicate second or higher order diffracted waves.

3.6
specular wave
perfectly reflected light waves, to be distinguished from diffuse reflection

3.7
transmission hologram
hologram using transmission reconstructed waves

Note 1 to entry: A hologram recording the interference pattern between objects and reference waves from the same side of the recording material is a transmission hologram.

3.8
reflection hologram
hologram using reflection reconstructed waves

Note 1 to entry: A reflection hologram recording the interference pattern between an object wave and the reference wave from the mutually opposite sides of the recording material is generally a volume reflection hologram and is also called a Lippmann or Lippmann Denisyuk hologram. Of the *surface relief hologram* (3.13), the hologram using the wave reflected from the relief surface is a surface relief reflection hologram.

3.9
phase hologram
hologram having a spatially-periodic phase modulation structure

3.10
amplitude hologram
hologram having a spatially-periodic amplitude modulation structure

3.11
volume hologram
hologram causing Bragg diffraction

Note 1 to entry: A hologram having a sinusoidal refractive–index distribution is one whose hologram recording layer is sufficiently thicker than the interval of interference fringes. Holograms characterized by a Q-value $Q \gg 1$ are considered to be volume holograms.

3.12
plane hologram
hologram causing Raman-Nath diffraction

Note 1 to entry: This type of hologram is the one whose hologram recording thickness is sufficiently smaller than the interval of interference fringes. Holograms characterized by a Q-value $Q < 1$ are considered to be plane holograms.

3.13
surface relief hologram
hologram recording the interference pattern as relief structure in the surface of the hologram recording material

3.14
Q-value
in the periodic structure based on the sinusoidal refractive-index distribution, the value of Q defines the thickness of the diffraction grating and is determined by the following formula:

$$Q = \frac{2\pi\lambda T}{\bar{n}d^2}$$

where

- T is the thickness of hologram (μm);
- λ is the wavelength in air (μm);
- d is the interval of interference fringe (μm);
- $\bar{n}$ is the mean refractive-index of hologram

Note 1 to entry: This value is used to classify the hologram into the volume hologram and the plain hologram. Note that this value is applicable only to the cyclic structure based on the sinusoidal refractive-index distribution.

3.15
diffraction efficiency
<of the hologram> ratio of the radiant flux of the reconstructed wave relative to the radiant flux of the illuminating wave

Note 1 to entry: The diffraction efficiency of holograms is generally expressed as a percentage (%).

3.16
angular selectivity
<of the hologram> dependence of the radiant flux of the reconstructed wave on the angle of incidence of the illuminating wave if the hologram is reproduced while using a monochromatic illuminating wave

3.17
wavelength selectivity
<of the hologram> dependence of the radiant flux of the reconstructed wave on the wavelength of the illuminating wave if the hologram is reproduced while keeping the angle of incidence of illuminating wave constant

4 Symbols and abbreviated terms

η Diffraction efficiency (%)

5 Principles

The diffraction efficiency is determined by measuring the radiant flux of the reconstructed wave or the zero-order diffracted wave while the illuminating wave enters the hologram. The absolute diffraction efficiency, which is the ratio of the radiant flux of reconstructed wave relative to that of the illuminating wave, is the basis of the measurement. The relative diffraction efficiency, which is the ratio of the radiant flux of the reconstructed wave relative to that of the sum of the radiant fluxes of all diffraction orders, might be important for certain applications. There is also a simplified method to determine the diffraction efficiency from the spectral distribution of either the transmittance or reflectance of the hologram. Finally, the angle selectivity of the hologram is determined from diffraction efficiency as a function of the angle of incidence and the wavelength selectivity is determined from the diffraction efficiency as a function of the wavelength.

6 Measurement methods

6.1 General

This part of ISO 17901 covers the measurement of the diffraction efficiency as well as the angle selectivity and wavelength selectivity as described below. Since for multiple purposes there is more than one definition of diffraction efficiency, its measurement shall be made according to the method appropriate to the purpose.

When the hologram to be measured is formed through the two-flux interference of reference waves, they are assumed to be plane waves. If the reference waves are not plane waves, the method can be applied by using either the absolute diffraction efficiency or relative diffraction efficiency. If this applies, the fact shall be cited clearly in the report.

This part of ISO 17901 is applicable to holograms formed by the method other than two-flux interference of laser beams, such as the embossed hologram formed by transferring and reproducing the interference pattern, the hologram formed by the electron beam lithography system, and all other etching or engraving methods. If any alternative method is used, that fact shall be cited clearly in the report.

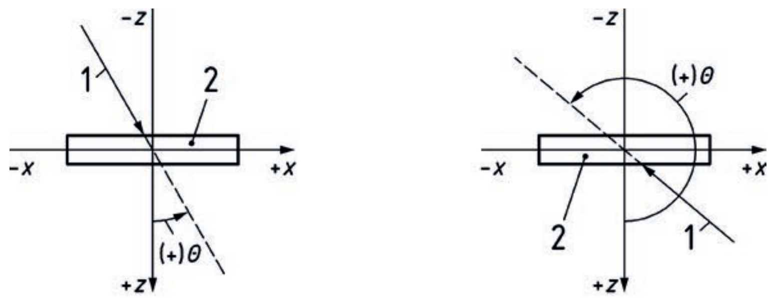
6.2 Definition of the coordinate system

The axis of coordinates and the angle of waves are defined as follows.

a) The recording material (or hologram) plane shall be the *xy*-plane while the axis vertical to the plane shall be the *z*-axis.

b) For the *z*-axis, the advance direction of the object or reconstructed wave shall be positive.

c) As shown in Figure 1, the angle of incidence θ [degree (°) or rad] is formed between the *z*-axis in the positive direction and the extension of the incident wave. The positive θ–symbol indicates a counter-clockwise direction.



a) Wave advancing in the +*z* direction **b) Wave advancing in the –*z* direction**

Key

1 incident light wave

2 recording material or hologram

Figure 1 — How to establish the coordinate system and wave angle in measurement of optical characteristics of holograms

6.3 Hologram measurement environment

Measurement of the diffraction efficiency shall be made inside a dark room at room temperature and in atmosphere with stable relative humidity (or under conditions designed to prevent entry of stray light into the detector).

6.4 Measurement device and measures

The measurement shall use the following equipment and measures, as required, according to the measurement method.

a) Light source

The light source for laser should ensure high temporal stability of the output (for example, ±5 % or less in output fluctuation over 30 min). The white-light illuminating source, if used, should provide a continuous spectrum over the measuring wavelength range concerned.

b) Mirror

The surface accuracy of mirrors should be sufficiently high (for example, better than 1/10 of the appropriate wavelength).

c) Holder

The holder should be able to move within a movable range equivalent approximately to the test piece size while holding the hologram.

d) Detector

The detector should have sufficient dynamic range and response relative to the intensity to be measured and should have been calibrated.

e) Monochromator

The monochromator should have a spectral resolution of 1 nm or less within the wavelength range to be measured.

f) Integrating sphere

Spherical optical component with the inner wall covered by a light diffusing material of high reflectance which can collect beams and homogenize them through spatial integration.

NOTE A typical coating material used for integrating spheres is barium sulfate.

6.5 Diffraction efficiency measurement method

6.5.1 General

In the strict sense of the word, diffraction efficiency is the absolute diffraction efficiency as measured according to the method described in 6.5.2.

However, the absolute diffraction efficiency might not be appropriate to represent the characteristics of certain recording materials that cause loss of light due to the hologram's reflection, scattering, absorption, and contraction properties. In such a case, it is recommended to apply the method described in 6.5.3.

In the case of volume holograms with expansion or contraction in the recording material, measurement of the diffraction efficiency might result in the lower R-value because of failure to meet the Bragg condition when the angle of incident [degree (°) or rad] or the wavelength of the illuminating wave is equal to that of the reference wave. In such an event, the transmission hologram requires adjustment of the angle of incidence of the illuminating wave, as required, for measurement of the diffraction efficiency. For the volume reflection hologram, either the spectral diffraction efficiency by transmittance measurement as described in 6.5.4 or the spectral diffraction efficiency by reflectance measurement as described in 6.5.5 can be used.

Generally, these four types of diffraction efficiency have different values for the same hologram so that the diffraction efficiency shall be used separately by identifying which measurement method has been applied to the efficiency concerned.

Oblique incidence of the illuminating or reconstructed wave to the detector might result in failure of correct measurement of the radiant flux because of reflection on the detector surface. In the case of measurement radiant flux, the detector should be set in such a manner that the illuminating or reconstructed wave can enter in the approximate vertical direction.

6.5.2 Absolute diffraction efficiency measurement method

The absolute diffraction efficiency (η) is defined as the ratio (%) of the radiant flux of the reconstructed wave (L_1) relative to that of the illuminating wave (L_0).

The measurement method includes the following procedure:

a) As shown in Figure 2, the illuminating wave from the light source is entered into the hologram held by the test piece holder. Adjustment shall be made so that the hologram's illuminated area by the illuminating wave becomes equal to or smaller than the hologram area. To adjust the illuminated area, an aperture may be inserted into the optical path of illuminating wave to restrict the illuminated area, if necessary.

   NOTE It is generally recommended to use, as the illuminating wave, one of two radiant fluxes in the optical system to record the hologram. The light source commonly used is a laser. When an aperture has been provided, it is possible to evaluate the diffraction efficiency distribution within the hologram plane by moving the hologram up/down and left/right.

b) The radiant flux of the illuminating wave is measured using the calibrated detector A. The radiant flux of the reconstructed wave is measured using the calibrated detector B in the state without the hologram as shown in Figure 2. These measurements are used to determine the diffraction efficiency from Formula (1):

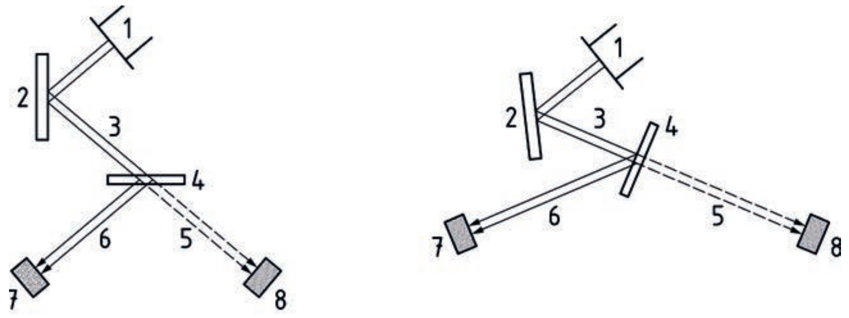
   NOTE For measurement of the radiant flux with the detector, due care is to be taken to ensure that all of the waves to be measured enter the detector.

$$\eta = \frac{L_1}{L_0} \times 100 \quad (1)$$

where

L_0 is the radiant flux of the illuminating wave (mW);

L_1 is the radiant flux of the reconstructed wave (mW).



a) Transmission hologram **b) Reflection hologram**

Key

1	aperture	5	illuminating wave when the hologram has been removed
2	mirror	6	reconstructed wave
3	illuminating wave	7	detector B
4	hologram placed on a holder	8	detector A

Figure 2 — Example of diffraction efficiency measurement method using a recording optical system

6.5.3 Relative diffraction efficiency measurement method

The relative diffraction efficiency (η) is the diffraction efficiency that takes into account the loss of light caused by the material characteristics and is defined as the ratio (%) of the radiant flux of reconstructed wave (L_1) relative to the sum of radiant fluxes of the diffracted waves of all orders (L_{all}).

The measurement method includes the following procedure.

a) The optical system shown in Figure 2 shall be used similarly to the case as described in 6.5.2 a).

b) L_{all} is determined by calculating the sum of measurements of the radiant fluxes of the reconstructed wave and those of diffracted waves of all orders using the calibrated detector B. By dividing the radiant flux of reconstructed wave (L_1) by the value thus obtained, the relative diffraction efficiency is determined from Formula (2):

NOTE For measurement of the radiant flux with the detector, due care is to be taken to ensure that all of the waves to be measured enter the detector.

$$\eta = \frac{L_1}{L_{all}} \times 100 \qquad (2)$$

where

L_{all} is the sum of radiant fluxes of diffracted wave of all orders (mW);

L_1 is the radiant flux of the reconstructed wave (mW).

c) If it is difficult to measure the radiant flux of the diffracted wave of all the orders, the following alternative method may be employed. Namely, the measurement shall be made using the radiant flux of the transmitted wave (for transmission holograms) or using the radiant flux of the specular wave (for reflection surface relief hologram). In both cases, the measurement shall be made for the portion where hologram recording has not been made. The measured value shall be treated as L_{all}. In this case, the fact that the alternative method has been used shall be clearly cited.

6.5.4 Spectral diffraction efficiency by transmittance measurement for volume holograms

The spectral diffraction efficiency by transmittance is defined as a ratio of the decrement (%) of the transmitted zero-order wave due to the recording material transmittance properties, relative to the transmittance (%) of the recording material assumed when the hologram has not been recorded and while taking the decrement of the transmitted zero-order wave as the diffracted wave.

The measurement method includes the following procedure.

a) Attach the volume hologram to the optical system containing a monochromator.

NOTE Figure 3 a) shows the optical system layout plan for measurement of the transmission hologram. The optical layout plan for measurement of the reflection hologram is as shown in Figure 3 b). The monochromator is placed at position A or B in the layout plan.

b) The beam from the light source is transformed into parallel beams by means of a collimating lens, and these parallel beams are allowed to enter the hologram as illuminating waves.

NOTE Generally, the light source to be used is the white-light illuminating source.

c) The measurement wavelength is sequentially changed and the intensity of transmitted wave at each wavelength is measured with the detector which results in the distribution of spectral diffraction efficiency by transmittance as shown in Figure 4.

d) The value for "T_a" and "T_b" is read from the graph of the spectral diffraction sensitivity, as represented in Figure 4, and the spectral diffraction efficiency by transmittance (%) is determined from Formula (3):

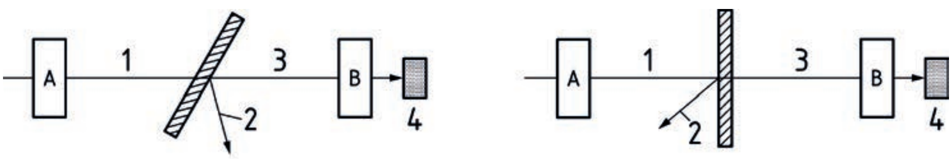
NOTE The volume reflection hologram is highly selective in terms of the wavelength. The spectral diffraction efficiency by transmittance that can determine the diffraction efficiency from this measurement has been determined by taking into account reflection and absorption of the hologram and will have the value close to the relative diffraction efficiency.

$$\eta = \frac{(T_a - T_b)}{T_a} \times 100 \quad (3)$$

where

T_a is the transmittance (%) of recording material at the wavelength where the transmittance shown in Figure 4 becomes minimum, which is assumed when the hologram has not been recorded;

T_b is the transmittance (%) of the hologram at the wavelength where the transmittance becomes minimum.

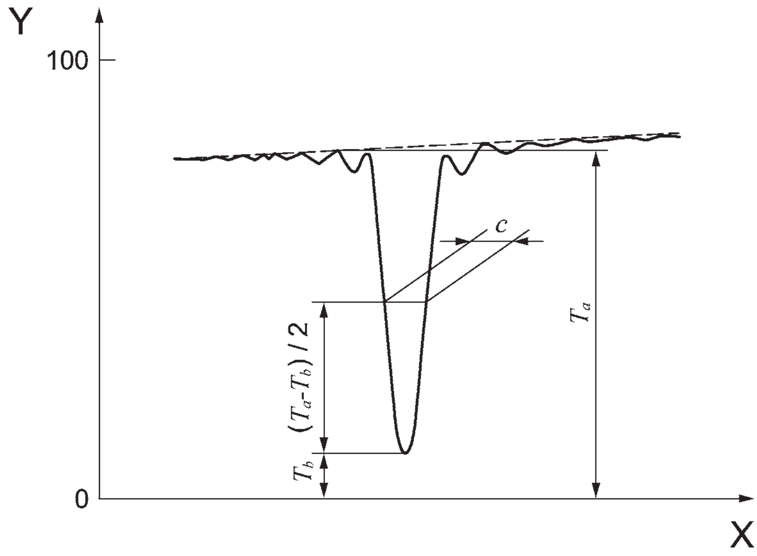


a) For volume transmission hologram **b) For volume reflection hologram**

Key

1 incident wave (illuminating wave)
2 diffracted wave (reconstructed wave)
3 transmitted wave
4 detector

Figure 3 — Diffraction efficiency measurement method using a monochromator



Key

X wavelength (μm)

Y transmittance (%)

T_a transmittance (%) of recording material at the wavelength where the transmittance becomes minimum, which is assumed when the hologram has not been recorded

T_b transmittance (%) of the hologram at the wavelength where the transmittance becomes minimum

c full width at half maximum

Figure 4 — Distribution of the spectral diffraction efficiency by transmittance of zero-order transmitted wave

6.5.5 Spectral diffraction efficiency by reflectance measurement for volume holograms

The spectral diffraction efficiency by reflectance is defined as the difference between the maximum value (%) of spectral reflectance of the incident light and the reflectance (%) of recording material assumed when the hologram has not been recorded.

The spectral diffraction efficiency by reflectance measurement method is applicable only to the volume reflection hologram and includes the following procedure.

a) As shown in Figure 5, the volume reflection hologram is attached to the measurement system in which the monochromator is combined with the integrating sphere.

b) The beam dispersed by the monochromator is transformed into parallel beams by means of a collimating lens and these parallel beams are allowed to enter the reflection hologram as illuminating waves.

c) The measurement wavelength of the illuminating wave is sequentially changed and the intensity of the reflected wave at each wavelength is detected with the integrating sphere, which results in the distribution of spectral diffraction efficiency by reflectance as shown in Figure 6.

   NOTE Generally, the light source to be used is the white-light illuminating source.

d) The values for "R_a" and "R_b" are read from the graph of the distribution of spectral diffraction efficiency by reflectance, as represented in Figure 6 and the spectral diffraction efficiency by reflectance (%) is determined from Formula (4):

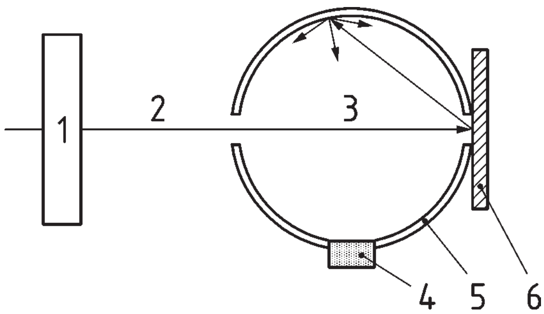
   NOTE The volume reflection hologram is highly selective in terms of wavelength, so that the diffraction efficiency can be determined from this measurement. The value of reflectance at 100 % is to be calibrated using a standard white board. The diffraction efficiency of Formula (4) will have the value close to the absolute diffraction efficiency.

$$\eta = R_b - R_a \tag{4}$$

where

R_a is the reflectance (%) of recording material at the wavelength where the reflectance becomes minimum, which is assumed when the hologram has not been recorded (see Figure 6);

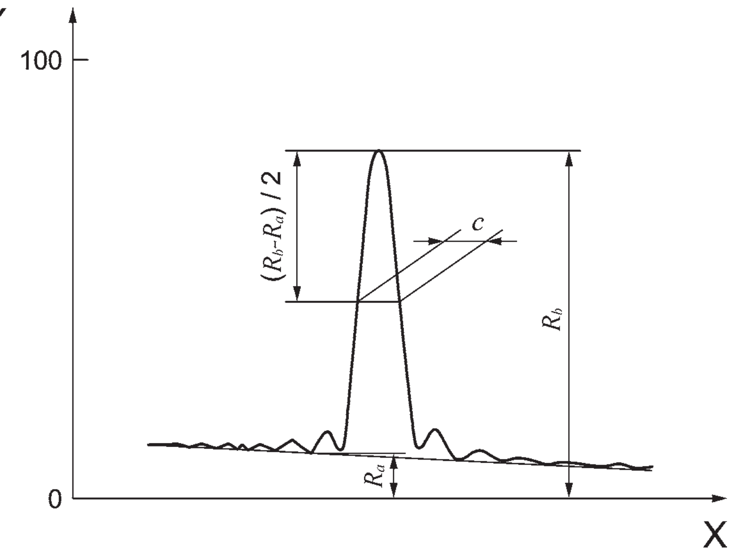
R_b is the reflectance (%) of hologram at the wavelength where the reflectance becomes the maximum (see Figure 6).



Key

1	monochromator	4	detector
2	incident wave (illuminating wave)	5	integrating sphere
3	diffracted wave (reconstructed wave)	6	volume reflection hologram

Figure 5 — Spectral diffraction efficiency by reflectance measurement method using the monochromator and integrating sphere



Key

X wavelength (μm)

Y reflectance (%)

R_a reflectance (%) of recording material at the wavelength where the reflectance becomes minimum, which is assumed when the hologram has not been recorded

R_b reflectance (%) of hologram at the wavelength where the reflectance becomes the maximum

c full width at half maximum

Figure 6 — Distribution of spectral diffraction efficiency by reflectance

6.6 Angular selectivity measurement method

The angular selectivity measurement of holograms includes the following procedure.

a) By establishing the wavelength of illuminating wave adequately and while changing the incident angle [degree (°) or rad] relative to the hologram at a small angular step (for example, π/180 (rad) step), the diffraction efficiency is measured according to the either 6.5.2 or 6.5.3.

b) The diffraction efficiency values relative to the illuminating wave incident angle [degree (°) or rad] are plotted to draw a graph and the incident angle at which the diffraction efficiency becomes the maximum and the full width at half maximum (angular space of two incident angles at which the diffraction efficiency becomes 1/2 of the maximum value) are read from this graph.

NOTE This graph enables evaluation of the angular selectivity. The hologram's angular selectivity represents the width (wide or narrow) of the incident angle range of illuminating wave to reproduce the image by hologram. When the angle range for image reproduction is relatively narrow, the "angular selectivity" is said to be "high". When this angle range is relatively wide, the "angular selectivity" is said to be "low."

6.7 Wavelength selectivity measurement method

The hologram's wavelength selectivity measurement method includes the following procedure.

a) The incident angle of the illuminating wave is determined for the sake of convenience. Either the distribution of the spectral transmittance of Figure 4 is obtained according to 6.5.4 or the distribution of spectral reflectance of Figure 6 is obtained according to 6.5.5. Alternatively, the graph representing the dependence of diffraction ratio on the wavelength may be plotted by measuring the diffraction efficiency for multiple wavelengths according to 6.5.2 or 6.5.3.

b) From the graph representing the dependence of the diffraction ratio on the wavelength, the wavelength at which the diffraction efficiency becomes the maximum and the half-value width are determined. For the distribution of the spectral transmittance, the full width at half maximum is given by the interval of two wavelengths, which is equivalent to 1/2 of the sum of transmittance at the wavelength at which the transmittance becomes the minimum and the transmittance of recording material assumed when the hologram has not been recorded. In the case of the spectral diffraction efficiency by reflectance measurement spectral reflectance efficiency, this is given by the interval of two wavelengths, which is equivalent to 1/2 of the sum of the reflectance at the wavelength at which the reflectance becomes the maximum and the reflectance of recording material assumed when the hologram has not been recorded. When the absolute or relative diffraction efficiency has been used, the full width at half maximum can be obtained from the interval of two wavelengths, which is equivalent to 1/2 of the maximum value of diffraction efficiency in the graph plotted in a) above to represent the dependence of diffraction ratio on the wavelength.

NOTE The wavelength selectivity of hologram represents the width (wide, narrow) of the wavelength range in which the image can be reproduced by the hologram. A relatively narrow wavelength range for reproduction of the image is referred to as "high in wavelength selectivity." A relatively wide wavelength range is referred to as "low in wavelength selectivity." The wavelength selectivity is a factor governing the sharpness of reproduced image and the colour reproducibility when the white light is used as illuminating wave.

7 Description of measurement results

7.1 General

The result of measurement on the hologram diffraction efficiency obtained according to 6.5 shall be described according to 7.3.

Description of the result of measurement obtained according to 6.6 and 6.7 is optional.

In addition to the measurement results on the basis of this part of ISO 17901, the forming procedure for the hologram concerned and the conditions as specified in 6.2 shall also be described.

7.2 Description of the diffraction efficiency measurement results

a) The diffraction efficiency shall be the numerical value expressed in percentage.

b) For description of the diffraction efficiency, the following information shall also be described additionally:

   1) measurement method (one or more) according to 6.5 (6.5.2 to 6.5.5);

   2) incident angle [degree (°) or rad] of illuminating wave during measurement of the diffraction efficiency;

   3) wavelength of the illuminating wave (in the case of 6.5.2 or 6.5.3).

7.3 Description of the angular selectivity measurement results

a) The angular selectivity shall be represented by both or either of the graph plotted on the basis of measurements according to 6.6 (the plot of diffraction efficiency relative to the incident angle of illuminating wave) and/or the numerical value of both peak incident angle [degree (°) or rad] and peak half-value width read from the graph.

b) For description of the angular selectivity, the following information shall also be described additionally:

   1) measurement method (one or more) according to 6.5 (6.5.2 to 6.5.3);

   2) wavelength (μm) of illuminating wave during measurement of the diffraction efficiency.

7.4 Description of the wavelength selectivity measurement method

a) The wavelength selectivity shall be represented by both or either of the graph plotted on the basis of measurements according to 6.7 (the plot of diffraction efficiency relative to the wavelength of illuminating wave) and/or the numerical value of both peak wavelength and peak half-value width read from the graph.

b) For description of the wavelength selectivity, the following information shall also be described additionally:

   1) measurement method (one or more) according to 6.5 (6.5.2 to 6.5.3);

   2) incident angle [degree (°) or rad] of illuminating wave during measurement of the diffraction efficiency.

Table 1 — List of reporting items

Item	Information to be described	Necessity of entry
(a) Diffraction efficiency (%)	a) Diffraction efficiency value (%) NOTE When the diffraction efficiency has been measured by adjusting the incident angle of illuminating wave as required, the maximum measurement of diffraction efficiency is normally described as the diffraction efficiency of the measured object. b) Diffraction efficiency measurement method (one or more of methods as described in 6.5.2 to 6.5.5) c) Incident angle [degree (°) or rad] of illuminating wave during measurement of diffracted wave d) Wavelength (µm) of illuminating wave (when the diffraction efficiency measurement method is as described in either 6.5.2 or 6.5.3.) e) Where the diffraction efficiency has polarization dependence, the state of the polarization of illuminating wave	Mandatory
(b) Angular selectivity	a) Both or either of the graph plotted on the basis of measurements (the plot of diffraction efficiency relative to the incident angle of illuminating wave) and/or the numerical value (rad) of both peak incident angle and full width at half maximum read from the graph b) Diffraction efficiency measurement method (one or more of methods as described in 6.5.2 to 6.5.5) c) Wavelength (µm) of the illuminating wave during measurement of the diffraction efficiency	Optional
(c) Wavelength selectivity	a) Both or either of the graph plotted on the basis of measurements (the plot of diffraction efficiency relative to the wavelength of illuminating wave) and/or the numerical value (µm) of both peak wavelength and full width at half maximum read from the graph b) Diffraction efficient measurement method (one or more of methods as described in 6.5.2 to 6.5.5) c) Incident angle [degree (°) or radian] of illuminating wave during measurement of diffraction efficiency	Optional

NOTE If the information is common to listed items, the description may not be made while identifying the reference relationship.

Bibliography

[1] ISO 17901-2, *Optics and photonics — Holography — Part 2: Methods for measurement of hologram recording characteristics*

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