TECHNICAL SPECIFICATION

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Imaging materials — Lenticular lens sheet — Measurements and specifications of dimensions

Matériaux pour l'image — Feuille lenticulaire — Mesurages et spécifications des dimensions

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 42, *Photography*.

Introduction

Lenticular lens are an array of magnifying lenses, which can generate a desired visual perception, including 3D effect, animation and flips, when the underlying interlaced printed image is viewed from different angles. The most widespread use of this technology is in lenticular printing, for use in packages, display posters, promotional buttons, magnets, coasters, collectibles, signs, menu boards, postcards and business cards.

It is reported that the market size of lenticular sheets is over 100 million m^2 and the market is growing. Moreover, the image qualities of lenticular printing have improved dramatically, and further improvement is expected in the future. While production of lenticular sheets with a lens frequency of 100 lines per inch (lpi) is routine, products with 200 lpi are also currently available. To produce the optimal perceptive experience, the right choice of lenticular sheet is crucial. Different use cases require different lens frequencies. For a 2D view application, a 200 lpi material can be optimal, and for multiview 3D effect viewed from one meter or further, a 12 lpi material can be optimal. On a separate note, lenticular sheets with higher lens frequency can be thinner; therefore, increasing its potential in high quality packaging and a variety of printings.

The multi-step process of lenticular printing involves creation of a lenticular image from at least two existing images and its combination with a lenticular sheet. The combining process can either be a 1) direct printing of the images on the lenticular sheets or 2) pasting the lenticular sheet and printed images. This process can be used to create various frames of animation (motion perception), offsetting the various layers at different increments (3D perception) or simply to show a set of alternate images which appear to transform into each other.

Major factors influencing the quality of a lenticular image is the precision in the dimensions of the lenticules in the lenticular sheet and the printed interlaced image and the precision in the positioning of the lens array and the interlaced images. Poor precision results in poor image quality and poor precision in the dimensions of lenticules in the lenticular lens sheet can result in low production yield, consequently resulting in higher costs.

Therefore, the demand for improving the precision in the dimensions of the lenticules in a lenticular lens sheet has been high. The standardization of the measurements of the dimension of the lenticules in a lenticular lens sheet has been requested from the market.

Imaging materials — Lenticular lens sheet — Measurements and specifications of dimensions

1 Scope

This Technical Specification specifies the measurements and specifications of the dimensions of a lenticular lens sheet. It describes measurement methods and specifies the nominal sizes and target dimensions with tolerance. It also describes methods to test the stability of dimensions of the lenticular lens sheet.

This Technical Specification is applicable to lenticular lens sheets used in lenticular prints, including those that give an image the illusion of depth or make images appear to change/move as the image is viewed from different angles. Both impact and non-impact printing can be used to generate the images. Examples of the former are off-set, gravure and flexography, while the examples of the latter are silver halide, inkjet, dye diffusion thermal transfer and electrophotography.

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 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

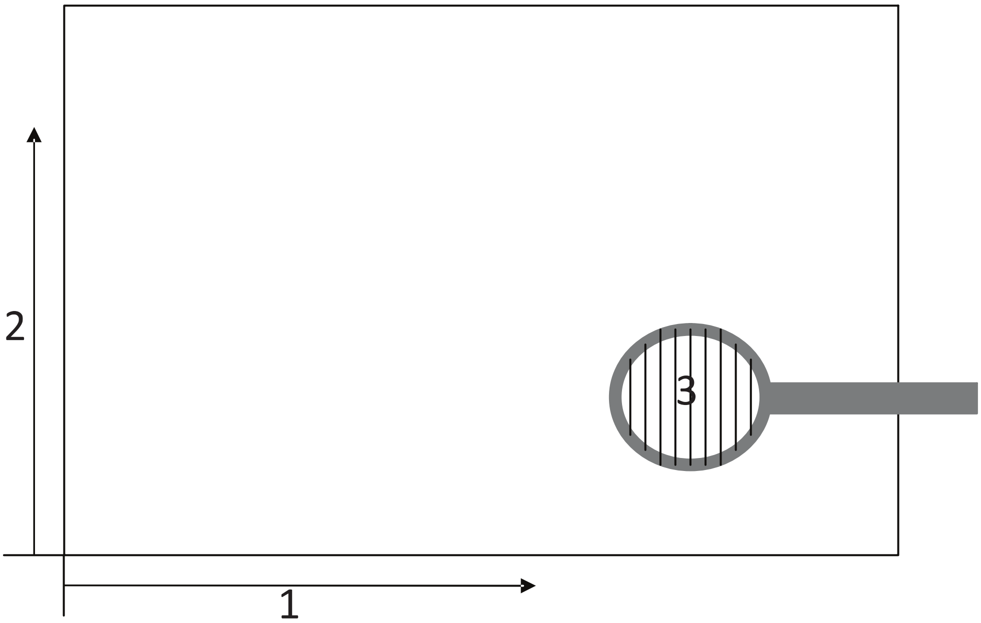
3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
lenticular lens
array of magnifying semi-cylindrical lenses, designed to produce a desired perception, such as 3D, motion or morphing, to the underlying interlaced image

EXAMPLE This technique is widely used in lenticular printing, wherein the lenticular lens is used to provide an illusion of depth, change or motion to an underlying interlaced image when viewed from different angles.

Note 1 to entry: Schematic diagrams of a lenticular sheet is shown in Figure 1 (top view) and Figure 2 (side view).



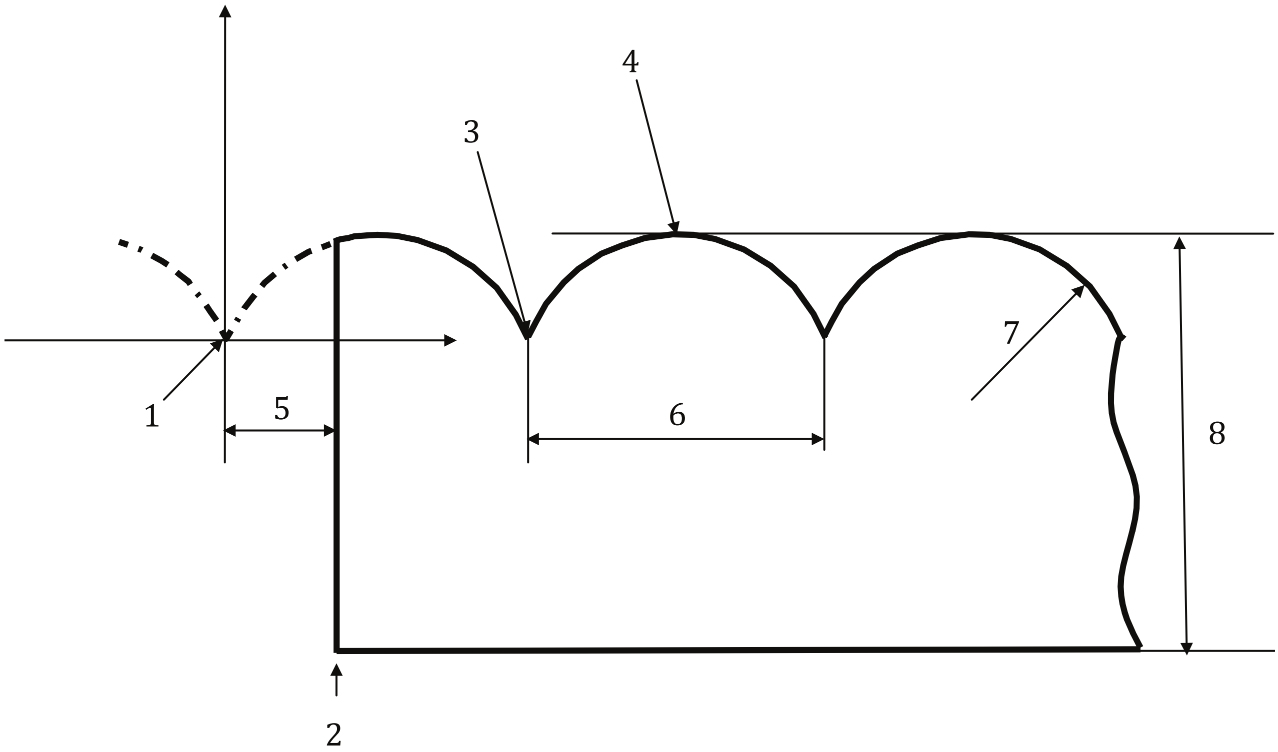
Key

1 length in X-direction

2 length in Y-direction

3 magnified lenticular pattern

Figure 1 — Top view of a lenticular lens sheet



Key

1 origin (zero point) of the coordinate

2 cutting end

3 valley of a lenticule

4 peak of a lenticule

5 Lc; distance to the origin from the cutting end (µm)

6 Wl; width of a lenticule (µm)

Figure 2 — Side view of a lenticular lens sheet

4 Measurement

4.1 General

4.1.1 Outline

Measurement procedures and specifications are described for the following parameters which determine the image quality of lenticular prints:

a) precision in width of a lenticule;

b) stability of the length of a lenticule under ambient conditions.

4.1.2 Standard ambient condition

Standard ambient conditions shall be a temperature of 25 °C ± 2 °C, a relative humidity of 50 % RH ± 5 % RH and a pressure of 96 kPa ± 10 kPa.

4.2 Width of a lenticule

4.2.1 Measurement equipment

Calibrated dimension measurement equipment shall be used. The spatial resolution capability of the equipment shall be finer than 20 µm.

For example, a stylus type surface measuring instrument, used typically for measuring surface roughness and contour, can be used. An example for the stylus is 5 µm diamond stylus tip with 40° angle.

4.2.2 Measurement procedures

The sample should be equilibrated to the standard ambient conditions for one hour before measurements. The measurements should be made at the standard ambient conditions.

An area that includes 20 or more lenticules shall be measured. As shown in Figure 2, a valley, represented by “3” is located between two lenticules. The width of a lenticule (Wl) is the distance between any two adjacent valleys. The measurement shall be performed both in the forward and backward directions.

The distance from the first valley to the 21st valley, i.e. the combined width of 20 lenticules, shall be measured.

The measured width of each lenticule shall be recorded and be expressed in µm.

4.2.3 Reporting of the precision

The following shall be reported:

a) the measured average width of the lenticule;

Average *Wl* is calculated by dividing the combined length by the number of lenticules, as shown in Formula (1). The width shall be expressed in µm;

$$\mathrm{Wl(average)} = {\sum\nolimits_{1}^{20} \mathrm{Wl}}\Big/{20} \qquad (1)$$

b) the nominal width of the lenticule, calculated as shown in Formula (2);

$$\left[\mathrm{Nominal\_width\_of\_lenticule}\right] = {25\,400}\Big/{\left[\mathrm{Nominal\ resolution\ (lpi)}\right]} \qquad (2)$$

c) the difference between measured average width and nominal width of the lenticules;

d) the standard deviation of the average width of the lenticules;

e) classification of the precision according to Table 1.

Table 1 — Classification of precision of lenticule width

(Difference between average width and nominal width/Nominal width) × 100	Precision classification
2 % or over	Poor
from 1 % to 2 %	Medium
from 0,5 % to 1 %	High
Less than 0,5 %	Super high

4.2.4 Lens frequency (lpi)

The lens frequency of lenticular lens sheet shall be calculated using Formula (3)

$$\text{Resolution(lpi)} = {}^{25400}\!\big/_{\text{Wl(average)}} \quad (3)$$

The lens frequency-based classification is shown in Table 2.

Table 2 — Classification of lenticular lens sheet lens frequency

Nominal lens frequency range	Classification of lens frequency
less than 75 lpi	Low
from 75 lpi to 150 lpi	Medium
150 lpi and over	High

4.2.5 Precision within lot and lot-to-lot

Sampling shall be as follows.

Within lot: The first three and the last three sheets in the course of the “production” shall be used for measurements. Here, “production” relates to the generation of the sheets for a single shipment. For example, if the first 3 sheets, i.e. 1st, 2nd and 3rd, are to be discarded, the next 3 sheets, i.e. 4th, 5th and 6th, shall be used for measurements.

Lot-to-lot: Every lot shall be evaluated following the above sampling rules.

The average width of the lenticules of the sheets measured shall be reported.

4.3 Thickness of lenticule lense sheet

4.3.1 Measurement equipment

Calibrated mechanical thickness measurement equipment shall be used. The gauge head shall be larger than 3 mm and smaller than 20 mm in diameter. The tolerance of precision and accuracy of the measurement equipment shall be smaller than 2 µm.

4.3.2 Measurement procedures

The thickness of the lenticular lens sheet is defined as the distance between the top of the lenses to the bottom of the base film, as illustrated in Figure 2.

The sample should be equilibrated to the standard ambient conditions for one hour before measurements. The measurements should be made at the standard ambient conditions.

4.3.3 Reporting and classification of thickness of lenticular lens sheet

The difference from the target value shall be reported. The classification of precision of lenticule lens sheet thickness is shown in Table 3.

Table 3 — Classification of precision of lenticule lens sheet thickness

Difference from the target value	Precision classification
10 % or over	Poor
less than 10 %	Good

4.4 Temperature and humidity dependence

4.4.1 General

When interlaced images are directly printed on lenticular lens sheets or the printed interlaced images are attached to the lenticular lens sheets, the ambient temperature and/or humidity of the work area may not be controlled. Nevertheless, stability of the dimensions of the lenticular lens sheet is a critical factor for ensuring coordination between the array of lenses and the printed interlaced images.

In this subclause, procedures for measuring the temperature and humidity dependence of the dimensions of lenticular lens sheet are described.

4.4.2 Measurement equipment and procedures

The length of a strip of the lenticular lens sheet shall be measured under different temperature and humidity conditions.

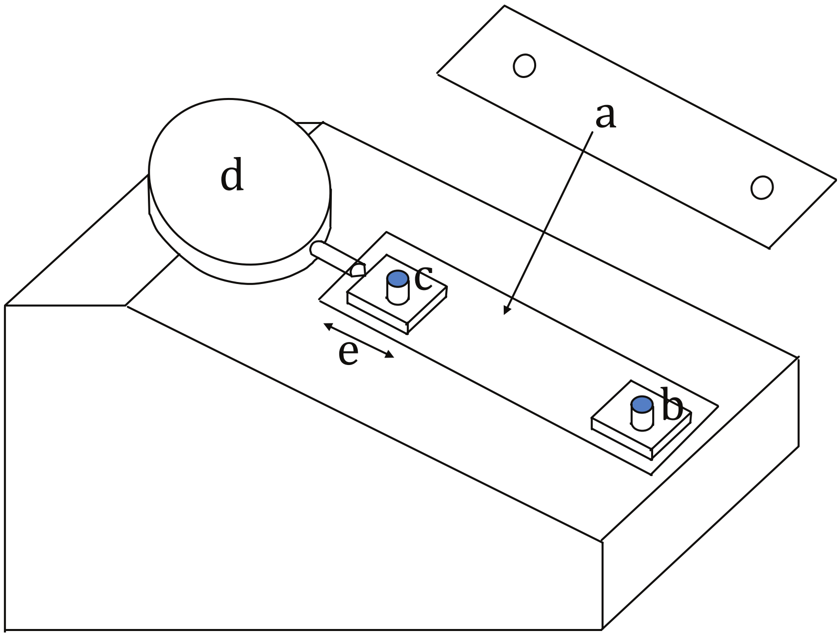
The precision of the measurements of the dimensions shall be smaller than 0,01 % in terms of the ratio of change (in dimension)-to-original length.

An example of the measurement procedure is as follows.

Size of the strips: Width = 4 mm and length = 20 mm; here the length, representing the distance along X-axis in Figure 1, is the distance between the two clipped edges of the lenticular lens sheet.

Equipment: An example of the equipment used to measure the dimensions of the sheets is shown in Figure 3.

The terminal c pull the sample strip with 10 mN tension.



Key

a sample strip

b clamped end

c terminal which give a tension of 10 mN to the sample strip

d micrometre callipers

e range of movement depending on temperature changes or humidity changes

Figure 3 — An example of measurement equipment used to measure the temperature- or humidity-dependent changes in length

4.4.3 Measurement and calculation of temperature dependence

The sample and the equipment shall be equilibrated to 25 °C 50 % RH at least for 1 h before measurements. The length of the sample shall be measured.

Subsequently, the temperature shall be raised to 55 °C at a rate that is equal to or lower than 5 °C/min. The changes in the length shall be measured and the changes in the length per change in temperature shall be calculated. The moisture content shall be kept constant when the temperature shall be used.

The details of the protocol are described in ISO 11359-2.

NOTE 1 The temperature is raised from 25 °C to 55 °C in order to attain the sufficient precision and accuracy to calculate the change in length per 1 °C, assuming that the length of the sample changes in direct proportion to temperature within this temperature range.

NOTE 2 The moisture content can be kept constant by not adding moisture when the temperature is raised.

4.4.4 Measurement and calculation of humidity dependence

The sample and the equipment shall be equilibrated to 25 °C 50 % RH at least for 1 h before measurements. The length of the sample shall be measured. Subsequently, the relative humidity shall be raised to 80 % RH at a rate that is equal to or lower than 1 % RH/min. The changes in the length shall be measured.

Next, the sample and the equipment shall be equilibrated to 25 °C 50 % RH at least for 1 h. The length of the sample shall be measured again. Subsequently, the relative humidity shall be lowered to 20 % RH at a rate that is equal to or lower than 1 % RH/min. The changes in the length shall be measured.

If the changes in the length is the same between the measurement in higher humidity and the lower humidity, the changes in length per change in humidity shall be calculated. If the changes in the length is not same, the narrower humidity range shall be applied to measure the length in humidity range that the length changes in direct proportion to the humidity.

The details of the protocol are described in ISO 11359-2.

NOTE The relative humidity is raised from 50 % to 80 % and lowered to 20 % in order to attain the sufficient precision and accuracy to calculate the change in length per 1 % RH, assuming that the length of the sample changes in direct proportion to relative humidity within the measurement range.

4.4.5 Classification of the temperature and humidity dependence

With regard to the temperature stability, the lenticular lens sheets shall be classified as described in Table 4.

Table 4 — Classification of lenticular lens sheet based on temperature

Ratio change in length/°C	Stability classification
Less than $4,5 \times 10^{-5}$	High
From $4,5 \times 10^{-5}$ to $6,5 \times 10^{-5}$	Medium
Over $6,5 \times 10^{-5}$	Low

Similar humidity-dependent classification of the lenticular lens stability shall be done as described in Table 5.

Table 5 — Classification of lenticular lens sheet based on humidity

Ratio change in length/1 % change in RH	Stability classification
Less than $2,3 \times 10^{-5}$	High
From $2,3 \times 10^{-5}$ to $3,3 \times 10^{-5}$	Medium
Over $3,3 \times 10^{-5}$	Low

Annex A
(informative)

Explanation of lenticular lens print

A.1 General

A lenticular lens comprises an array of magnifying lenses which are designed so that when the underlying interlaced images are viewed from slightly different angles, different images are magnified. When used in lenticular printing, this technology provides an illusion of depth, morph or motion as the underlying composite image is viewed from different angles.

A.2 Structure of lenticular lens print

A photograph of a typical lenticular lens sheet is shown in Figure A.1.

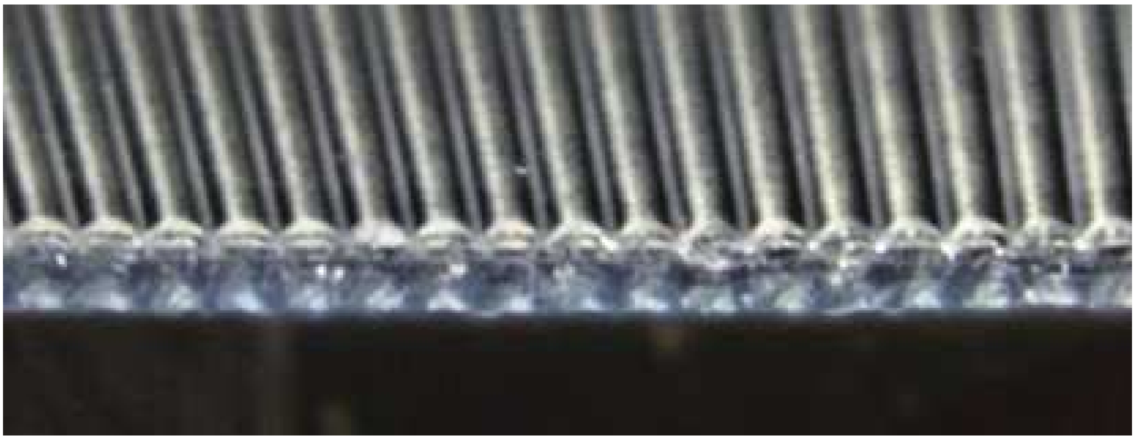
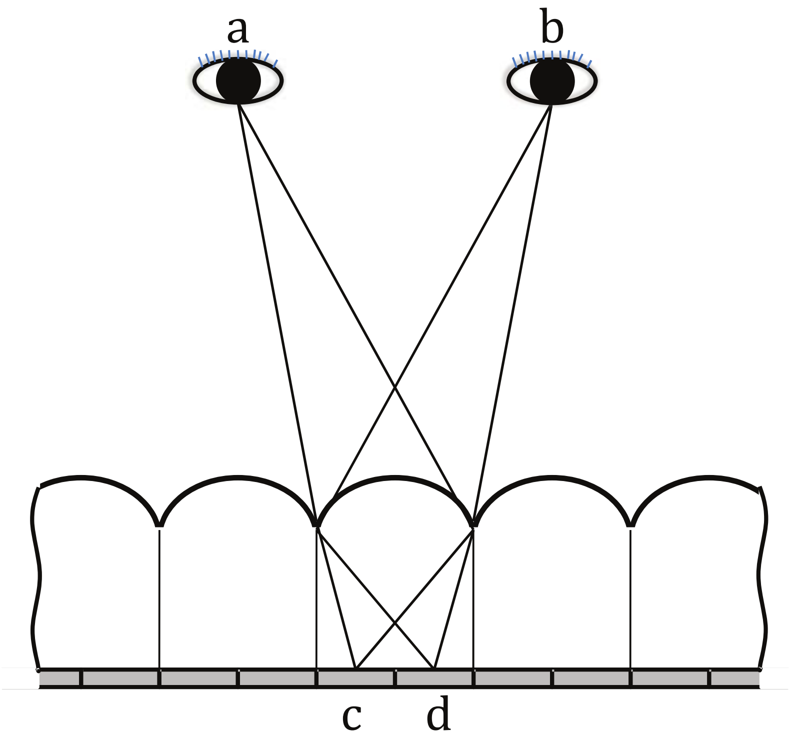


Figure A.1 — Image of a lenticular lens sheet

A.3 Mechanism of illusion of depth (3D)

The mechanism of illusion of depth (3D) is illustrated in Figure A.2.



Key

a right eye

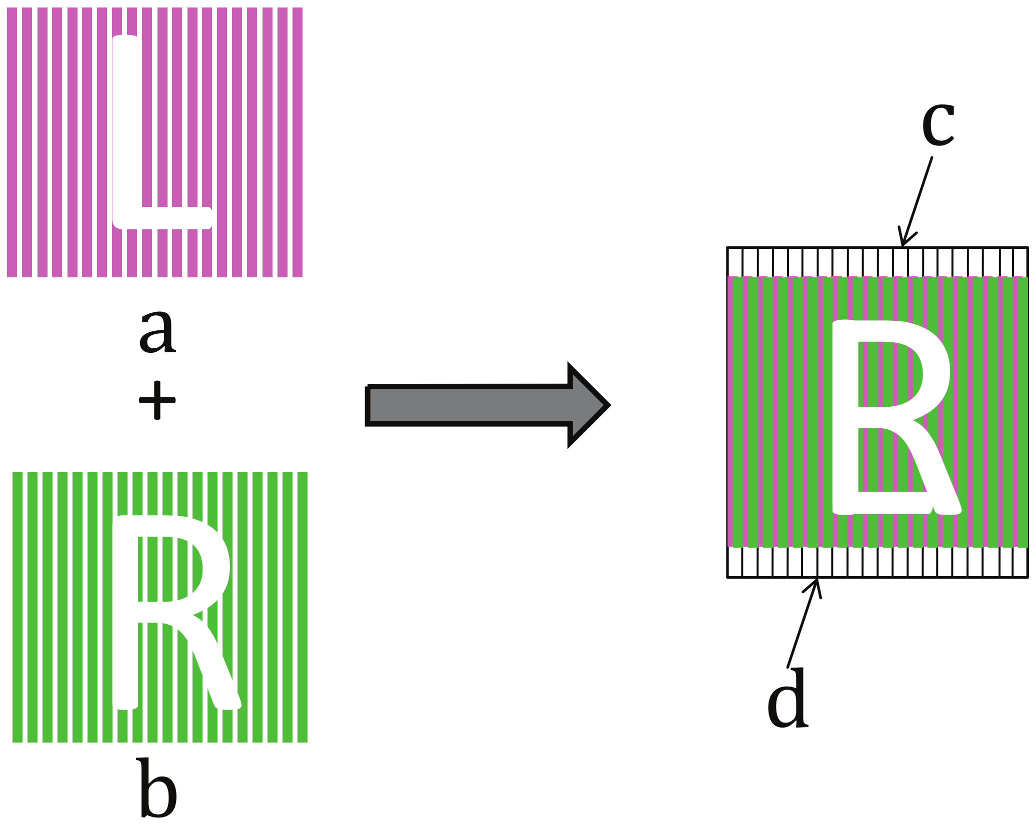
b left eye

c image element for left eye

d image element for right eye

Figure A.2 — Illustration for displaying the mechanism of illusion of depth

Figure A.3 displays both the initial independent interlaced images intended for the left and right eyes and the final interlaced image.



Key

a interlaced image for the left eye

b interlaced for the right eye

c lenticule sheet

d valley of lenticule

Figure A.3 — Incorporation of interlaced images for left eye and right eye to generate the interlaced image

Bibliography

[1] JIS K7197, *Testing method for linear thermal expansion coefficient of plastics by thermomechanical analysis*

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