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**Haseyama et al.**

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(54) **BEAM INTENSITY UNIFORMIZING ELEMENT**

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***G02B 3/00*** (2006.01)

(52) **U.S. Cl.**
CPC ....... ***G02B 27/0961*** (2013.01); ***G02B 3/0025*** (2013.01); ***G02B 27/0927*** (2013.01); *G02B 3/0043* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

A beam intensity uniformizing element includes an optical base, a first lens array disposed at a front surface of the optical base; and a second lens array disposed at a back surface of the optical base. The first lens array includes first mold lens cells arranged in different directions along the front surface of the optical base. The first mold lens cells have surfaces constituting the front surface of the optical base. The surfaces of the first mold lens cells have first linear marks thereon extending in a first direction. The second lens array includes second mold lens cells arranged in different directions along the back surface of the optical base. The second mold lens cells have surfaces constituting the back surface of the optical base. The surfaces of the second mold lens cells have second linear marks thereon extending in a second direction different from the first direction. This element suppresses generation of an interference pattern and reduces cost.

**2 Claims, 3 Drawing Sheets**

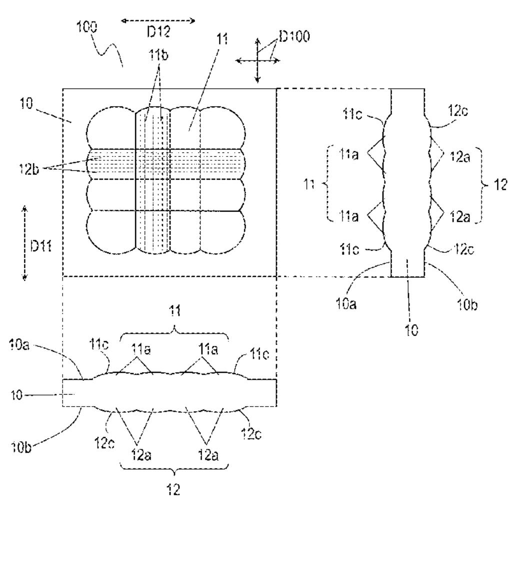

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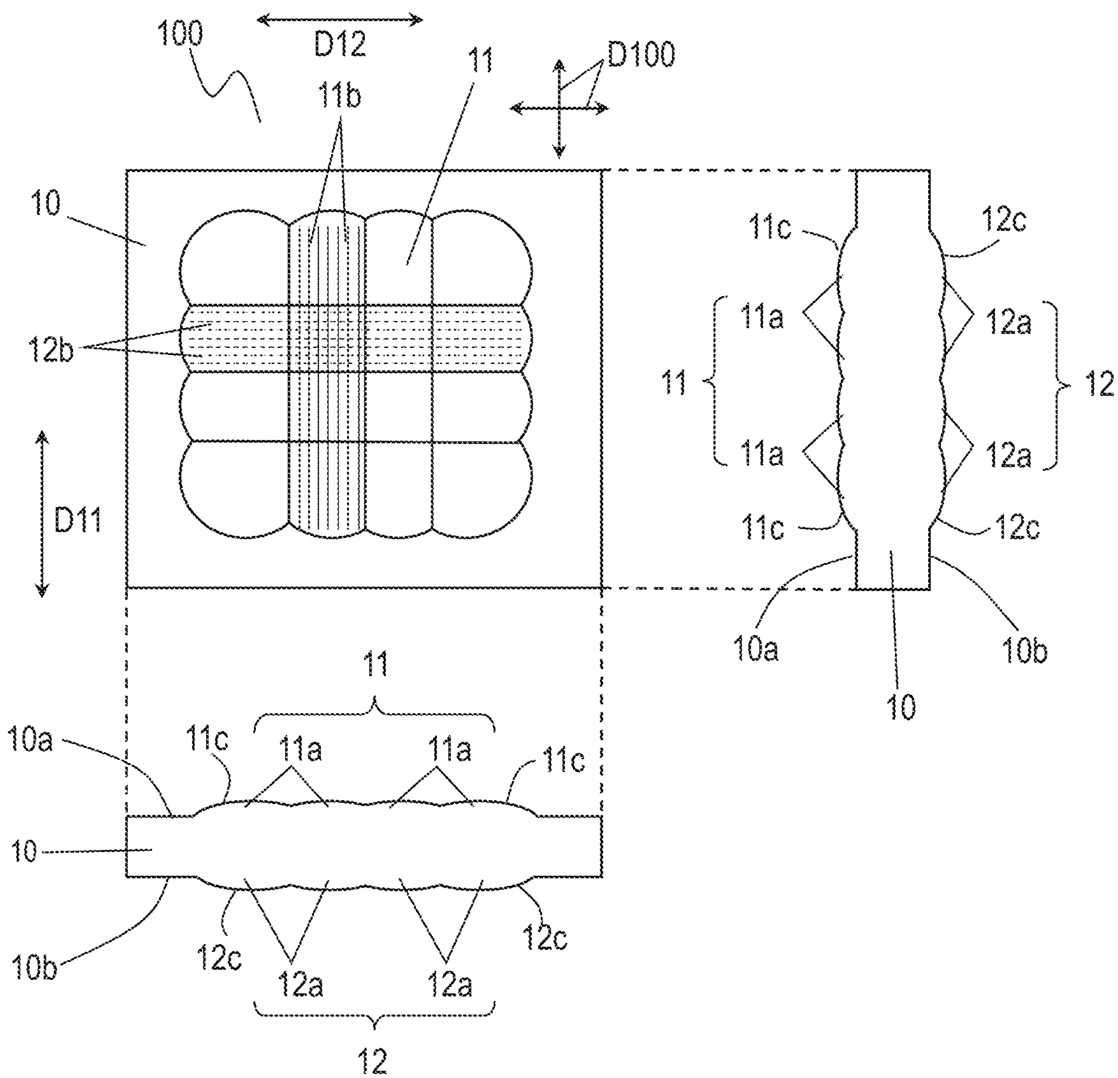
FIG. 1



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11b
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11c
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12c
10a
10b
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12c
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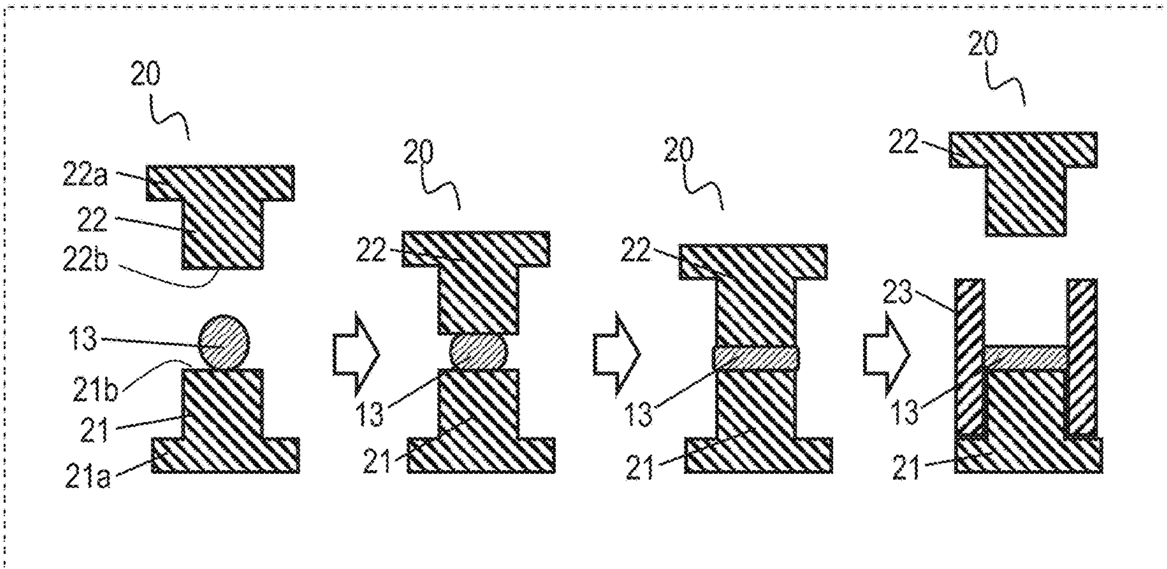
FIG. 2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22b
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21a
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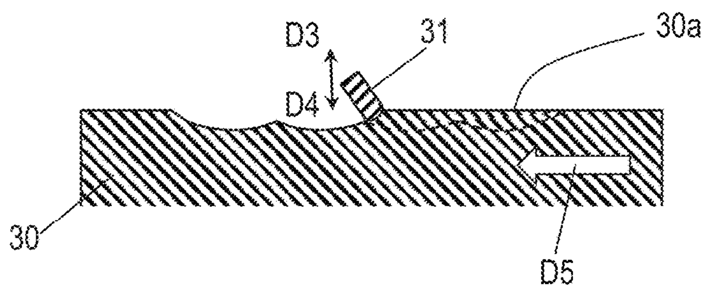
21

FIG. 3


D3
31
30a
D4
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D5

FIG. 4

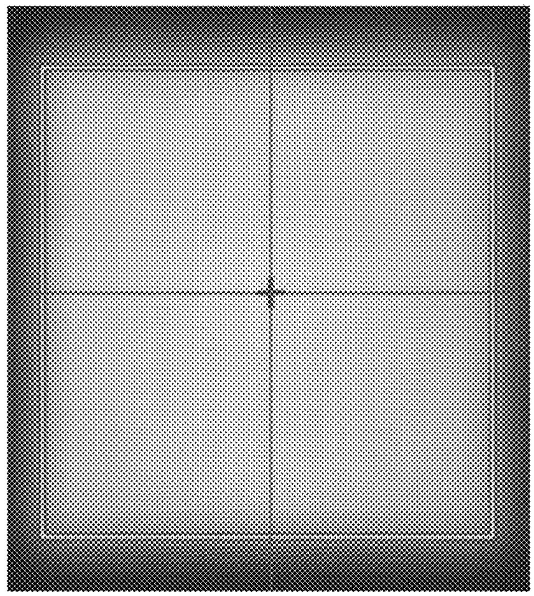
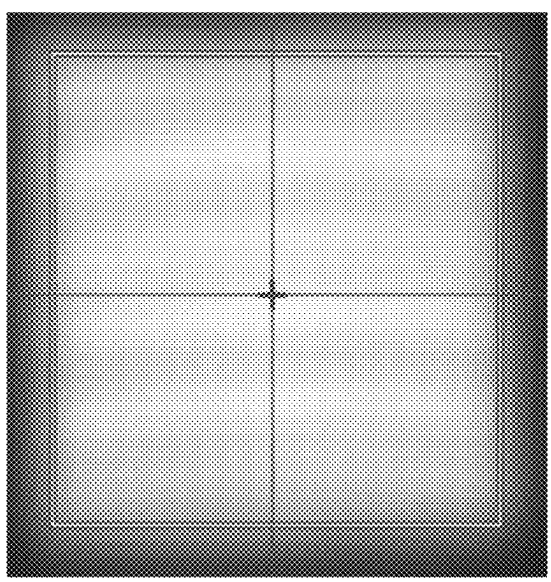


FIG. 5



# BEAM INTENSITY UNIFORMIZING ELEMENT

## TECHNICAL FIELD

The present disclosure relates to a beam intensity uniformizing element for uniformizing light intensity distribution of a light beam.

## BACKGROUND ART

A beam intensity uniformizing element includes a lens array. The lens array has a structure in which plural lens cells are arranged two-dimensionally. The lens array is produced by the so-called molding, in which a glass material is press-molded with a mold. A molding surface of the mold used for molding a lens for transferring the lens surface is produced by cutting machining. Therefore, the molding surface has linear machining marks formed thereon along the direction of the cutting. The machining marks are transferred to the surfaces of the mold lens cells as linear marks. Appearing regularly on the surfaces of the mold lens cells, the linear marks may cause the light beam transmitted through the mold lens cells to generate an interference pattern.

To suppress generation of the interference pattern, such a structure was proposed that the pitches of the linear marks formed on adjacent two of the mold lens cells in the lens array are different from each other.

A conventional beam intensity uniformizing element is disclosed, for example, in PTL1.

## CITATION LIST

### Patent Literature

PTL 1: Unexamined Japanese Patent Publication No. 2016-1225

## SUMMARY OF THE INVENTION

To produce the above-mentioned conventional beam intensity uniformizing element in which the pitches of the linear marks are changed on a lens cell by lens cell basis, it is necessary to change the machining conditions for forming the molding surface of the mold on a lens cell by lens cell basis. Machining of the mold for molding the lens array thus becomes extremely complicated. Accordingly, the cost of producing the mold increases, and, as a result, the cost of the lens array increases.

A beam intensity uniformizing element includes an optical base, a first lens array disposed at a front surface of the optical base, and a second lens array disposed at a back surface of the optical base. The first lens array includes first mold lens cells arranged in different directions along the front surface of the optical base. The first mold lens cells have surfaces constituting the front surface of the optical base. The surfaces of the first mold lens cells have first linear marks thereon extending in a first direction. The second lens array includes second mold lens cells arranged in different directions along the back surface of the optical base. The second mold lens cells have surfaces constituting the back surface of the optical base. The surfaces of the second mold lens cells have second linear marks thereon extending in a second direction different from the first direction.



This beam intensity uniformizing element suppresses generation of an interference pattern and reduces cost.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic trihedral figure of a beam intensity uniformizing element according to an exemplary embodiment of the present disclosure.

FIG. **2** is a schematic diagram of the beam intensity uniformizing element according to the embodiment for showing a method of producing the beam intensity uniformizing element.

FIG. **3** is a schematic diagram of a molding surface of a mold for a molding machine used in the producing method according to the embodiment for showing a method of producing the molding surface of the mold.

FIG. **4** shows an interference pattern generated by the beam intensity uniformizing element according to the embodiment.

FIG. **5** shows an interference pattern generated by a comparative example of a beam intensity uniformizing element in which linear marks extend in the same direction.

## DESCRIPTION OF EMBODIMENTS

Hereinafter, a beam intensity uniformizing element according to an exemplary embodiment of the present disclosure will be described with reference to the drawings. Each of the following exemplary embodiments shows merely a preferred example of the present disclosure. Accordingly, the shapes, structural components, arrangements and connections of the structural components, and the like are merely examples, and are not intended to limit the present disclosure. Therefore, among the components in the following exemplary embodiments, those components that are not included in an independent claim defining the broadest generic concept of the present invention will be explained as arbitrary components.

Also, each figure in the drawings is a schematic figure, which is not always drawn accurately. Also, similar components are indicated by like reference marks throughout the drawings, and duplicate description on them may sometimes be omitted or simplified.

FIG. **1** is a trihedral figure of beam intensity uniformizing element **100** according to an exemplary embodiment of the present disclosure.

Beam intensity uniformizing element **100** is an optical element configured to convert the light intensity distribution of an input light beam and outputs an intensity-distribution-converted light beam. For example, light beam intensity uniformizing element **100** converts a light beam having a Gaussian beam intensity distribution outputted from a laser diode to a light beam having a flat top beam intensity distribution and outputs the converted light beam. Beam intensity uniformizing element **100** includes, as a basic structure, optical base **10** having front surface **10***a* and back surface **10***b* which are opposite to each other, lens array **11** disposed at front surface **10***a* of optical base **10**, and lens array **12** disposed at back surface **10***b* of optical base **10**.

Lens array **11** disposed at front surface **10***a* of optical base **10** includes plural mold lens cells **11** a that are arranged two-dimensionally along front surface **10***a* of optical base **10**. The mold lens cells **11** a are arranged in plural different directions D**100** along front surface **10***a* of optical base **10**. In accordance with the embodiment, sixteen (16) mold lens cells **11***a* are arranged in a matrix with four columns and four rows. The mold lens cells **11***a* have surfaces **11***c* having plural linear marks **11***b* thereon extending in direction D**11**. Surfaces **11***c* constitute front surface **10***a* of optical base **10**. Plural vertical solid lines drawn in the second column of mold lens cells **11***a* counted from the left in FIG. **1** indicate linear marks **11***b* formed on front surface **10***a* of optical base **10**. Although linear marks **11***b* are drawn only in the second column of mold lens cells **11***a* counted from the left for convenience of drawing, linear marks **11***b* have actually been formed on all columns of mold lens cells **11***a*. Details regarding linear marks **11***b* will be described later.

Lens array **12** disposed at back surface **10***b* of optical base **10** includes plural mold lens cells **12***a* that are arranged two-dimensionally along back surface **10***b* of optical base **10**. The mold lens cells **11***a* are arranged in plural different directions D**100** along back surface **10***b* of optical base **10**. In accordance with the embodiment, sixteen (16) mold lens cells **12***a* are arranged in a matrix with four columns and four rows. The mold lens cells **12***a* have surfaces **12***c* having plural linear marks **12***b* thereon extending in direction D**12**. Surfaces **12***c* constitute back surface **10***b* of optical base **10**. Plural horizontal solid lines drawn in the second row of mold lens cells **12***a* counted from the top in FIG. **1** indicate linear marks **12***b* formed on back surface **10***b* of optical base **10**. Although linear marks **12***b* are drawn in only the second row of mold lens cells **12***a* counted from the top for convenience of drawing, linear marks **12***b* have actually been formed on all rows of mold lens cells **12***a*. Details regarding linear marks **12***b* will be described later.

Each of mold lens cells **11***a* disposed on front surface **10***a* of optical base **10** faces a corresponding one of mold lens cells **12***a* disposed on back surface **10***b* of optical base **10**.

A method of producing beam intensity uniformizing element **100** will be described below. FIG. **2** schematically shows processes of producing beam intensity uniformizing element **100**. Molding machine **20** for producing beam intensity uniformizing element **100** includes lower mold **21** and upper mold **22**.

An upper surface of lower mold **21** is molding surface **21***b* for forming lens array **12**. Molding surface **21***b* has a shape for transferring shapes corresponding to surfaces **12***c* of plural mold lens cells **12***a* to back surface **10***b* of optical base **10**.

A lower surface of upper mold **22** is molding surface **22***b* configured to form lens array **11**. Molding surface **22***b* has a shape transferring the surfaces of plural mold lens cells **11***a* to front surface **10***a* of optical base **10**.

Beam intensity uniformizing element **100** is produced by molding a glass material **13** made of optical glass. First, as shown in a figure, glass material **13** is placed on molding surface **21***b* of lower mold **21**. Then, glass material **13** is heated. After the temperature of glass material **13** rises to a temperature at which glass material **13** can be press-molded, glass material **13** is press-molded with lower mold **21** and upper mold **22**. Then, glass material **13** having been press-molded is cooled. Glass material **13** having been press-molded, or beam intensity uniformizing element **100**, is taken out of between lower mold **21** and upper mold **22**.

Plural linear marks **11***b* and **12***b* have been formed on the surfaces of mold lens cells **11***a* and **12***a* of beam intensity uniformizing element **100**, respectively, produced as described above. Linear marks **11***b* and **12***b* are caused by processes of forming the respective molding surfaces **21***b* and **22***b* of lower mold **21** and upper mold **22**. The respective molding surfaces **21***b* and **22***b* of lower mold **21** and upper mold **22** are produced by cutting machining. A working image of the cutting machining is shown in FIG. **3**. In the cutting machining, machining surface **30***a* is cut with cutting tool **31**. While the sag of cutting tool **31** cut into machining surface **30***a* is adjusted by moving cutting tool **31** in upward direction D**3** and downward direction D**4**, cutting tool **31** moves linearly in direction D**5** perpendicular to both upper direction D**3** and lower direction D**4**. Since cutting tool **31** cuts machining surface **30***a* linearly, the cutting work is performed such that cutting of a part of the molding surface for forming the mold lenses in one row is completed, and then cutting tool **31** is moved relative to glass material **13** and started to cut a part of the molding surface for forming mold lenses in an adjacent row. These steps are repeated to produce the molding surface. Therefore, after the cutting process, linear machined marks are formed on machined surface **30***a* at constant pitches corresponding to the cutting pitches at which cutting tool moves. Plural machined marks formed on one machined surface **30***a* are parallel to each other. Use of machined surface **30***a* having these machined marks to produce lens array **11** causes the machined marks to be transferred to the surfaces of mold lens arrays **11** and **12**, or surfaces **11***c* and **12***c* of mold lens cells **11***a* and **12***a*, respectively. The machined marks transferred to surfaces **11***c* and **12***c* of mold lens cells **11***a* and **12***a*, respectively, become linear marks **11***b* and **12***b*, respectively, as shown in FIG. **1**.

Beam intensity uniformizing element **100** has an integrated structure in which two lens arrays **11** and **12** are disposed at front surface **10***a* and back surface **10***b* of optical base **10**, respectively. Extending direction D**11** in which linear marks **11***b* extend on lens array **11** on front surface **10***a* is different from extending direction D**12** in which linear marks **12***b* extend on lens array **12** on back surface **10***b*. As described above, linear marks **11***b* and **12***b* of lens arrays **11** and **12** could be a cause of generating an interference pattern. However, since extending directions D**11** and D**12** of linear marks **11***b* and **12***b* on two lens arrays **11** and **12** are different from each other, the direction of the interference pattern formed by lens array **11** becomes different from the direction of the interference pattern formed by lens array **12**. As a result, the two interference patterns interfere with each other to suppress generation of an interference pattern of beam intensity uniformizing element **100**.

To suppress generation of an interference pattern of beam intensity uniformizing element **100** more effectively, lens arrays **11** and **12** are arranged such that extending direction D**11** of linear marks **11***b* on lens array **11** is perpendicular to extending direction D**12** of linear marks **12***b* on lens array **12**. FIG. **4** shows an interference pattern of beam intensity uniformizing element **100** in which directions D**11** and D**12** are perpendicular to each other. No clear interference pattern is observed in FIG. **4**. FIG. **5** shows an interference pattern of a comparative example of a beam intensity uniformizing element in which directions D**11** and D**12** are the same. A clear interference pattern is observed in FIG. **5**. As shown in FIGS. **4** and **5**, extending direction D**11** of linear marks **11***b* on lens array **11** are perpendicular to extending direction D**12** of linear marks **12***b* on lens array **12**, thereby suppressing the interference pattern of beam intensity uniformizing element **100**.

That is, in a method of suppressing an interference pattern by beam intensity uniformizing element **100** according to the present disclosure, the direction of linear marks **11***b* on lens array **11** are different from the direction of linear marks **12***b* on lens array **12**. Accordingly, it is not necessary to change, as in the conventional manner, the pitches of the linear marks on a mold lens cell by mold lens cell basis. In other words, in beam intensity uniformizing element **100**, pitches of linear marks **11***b* and **12***b* are constant. In this case, it is not necessary to change the cutting pitch in the cutting machining described with reference to FIG. **3**. As a result, the machining time of the cutting machining is reduced, accordingly reducing the cost of beam intensity uniformizing element **100**.

Further, since the cutting pitch is constant, the cutting pitch may be optimized. For example, the cutting pitch may be a minimum pitch of the cutting machine. Cutting by the minimum pitch increases the machining precision of the molding surface, accordingly reducing the light transmission loss in beam intensity uniformizing element **100**.

To obtain a uniform distribution of light intensity, two or more lens arrays are disposed on the optical axis. The integrated structure in which two lens arrays are respectively disposed on front surface **10***a* and back surface **10***b* of optical base **10**, as in beam intensity uniformizing element **100**, guarantees the precision of the relative positions of two lens arrays **11** and **12** at the precision of the molds, accordingly enabling beam intensity uniformizing element **100** to be easily incorporated into a light source device.

## INDUSTRIAL APPLICABILITY

The present disclosure provides such advantageous effects that generation of the interference pattern by the beam intensity uniformizing element can be suppressed and that the cost of the beam intensity uniformizing element can be reduced. The present disclosure is thus applicable particularly to laser light sources with a small size.

## REFERENCE MARKS IN THE DRAWINGS

**10** optical base
**11**, **12** lens array
**11***a*, **12***a* mold lens cell
**11***b*, **12***b* linear mark
**100** beam intensity uniformizing element

The invention claimed is:

**1**. A beam intensity uniformizing element comprising:

an optical base having a front surface and a back surface which are opposite to each other;

a first lens array disposed at the front surface of the optical base; and

a second lens array disposed at the back surface of the optical base, wherein

the first lens array includes a plurality of first mold lens cells arranged in different directions along the front surface of the optical base, the plurality of first mold lens cells having surfaces constituting the front surface of the optical base, the surfaces of the plurality of first mold lens cells having plural first linear marks thereon extending in a first direction, and

the second lens array includes a plurality of second mold lens cells arranged in different directions along the back surface of the optical base, the plurality of second mold lens cells having surfaces constituting the back surface of the optical base, the surfaces of the plurality of second mold lens cells having plural second linear marks thereon extending in a second direction different from the first direction.

**2**. The beam intensity uniformizing element of claim **1**, wherein the first direction is perpendicular to the second direction.

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