United States Patent [19]

Yazaki et al.

[11] **3,823,998**

[45] **July 16, 1974**

[54] **LIGHT VALVE**

[75] Inventors: **Takehito Yazaki; Keiichi Kanatani; Sadao Sakamoto,** all of Osaka, Japan

[73] Assignee: **Sanyo Electric, Co., Ltd.,** Moriguchi-shi, Osaka-fu, Japan

[22] Filed: **May 23, 1973**

[21] Appl. No.: **363,300**

[30] **Foreign Application Priority Data**

June 1, 1972 Japan 47-54837
June 1, 1972 Japan 47-54838

[52] **U.S. Cl.** ..... **350/150,** 350/160, 252/300, 340/173 LS

[51] **Int. Cl.** **G02f 1/26**

[58] **Field of Search** ..... 350/161, 150, 160, 147, 350/149, 157; 340/173 LT, 173 LS, 173.2; 252/300; 423/592, 608

[56] **References Cited**

UNITED STATES PATENTS

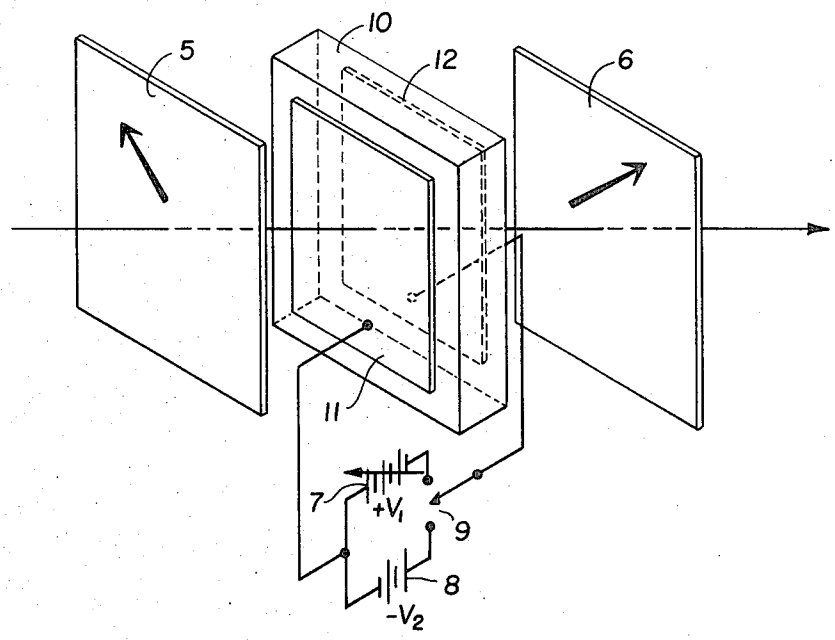
3,619,031	11/1971	Amodel	350/150
3,747,022	7/1973	Manamatsu	252/300

Primary Examiner—Ronald L. Wibert
Assistant Examiner—Michael J. Tokar
Attorney, Agent, or Firm—W. G. Fasse; W. W. Roberts

[57] **ABSTRACT**

A light valve of the present invention comprises an oblique cut single crystal plate of strontium barium niobate (SBN), which is placed in a plane vertical to a light transmission; a plurality of transparent strip electrodes which are placed, at right intersections with each other, on the front and back surfaces of the plate; means for generating an electric field within the single crystal, in parallel with a light transmission direction, in a given region of the plate to be addressed by selectively providing an electric potential to these electrodes; an SBN single crystal plate of the same thickness and orientation, which is juxtaposed with the single crystal plate so that the optical axes of them may be at right angles to each other; and polarizers which are each provided in positions before and behind these both single crystal plates so that light polarization plane thereof may be at right angles to each other. In the light valve of the present invention, the SBN single crystal plate is operated as a longitudinal operation mode electro-optic material, and the birefringence shows a non-linear change and a hysteresis loop by a change in an applied electric field. The residual birefringence is used as an optical read/write memory. Also, a threshold of abrupt non-linear change region of the birefringence hysteresis loop may be used advantageously for selecting a voltage applied to the electrode, whereby cross-talk in addressing is avoided.

16 Claims, 5 Drawing Figures



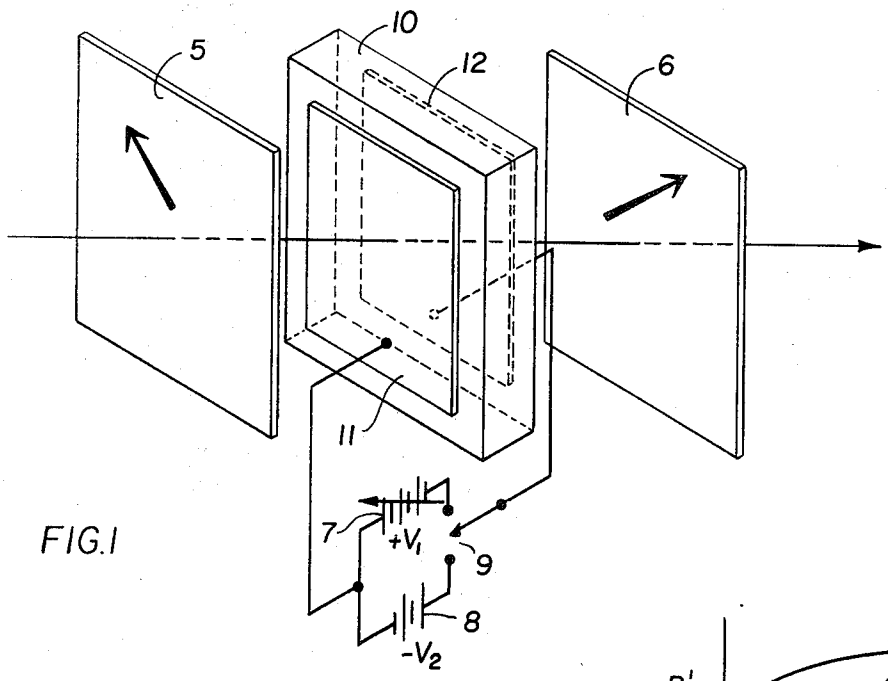


FIG.1

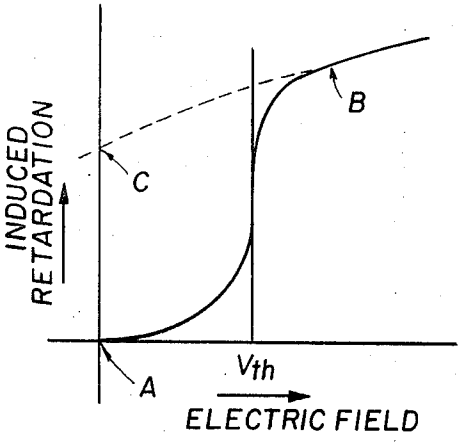


FIG.2

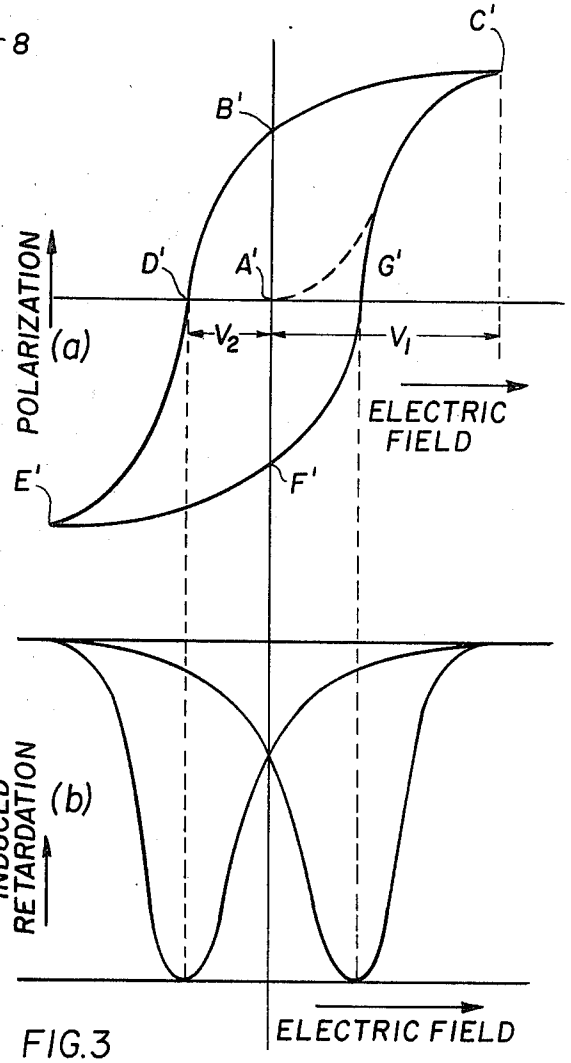


FIG.3

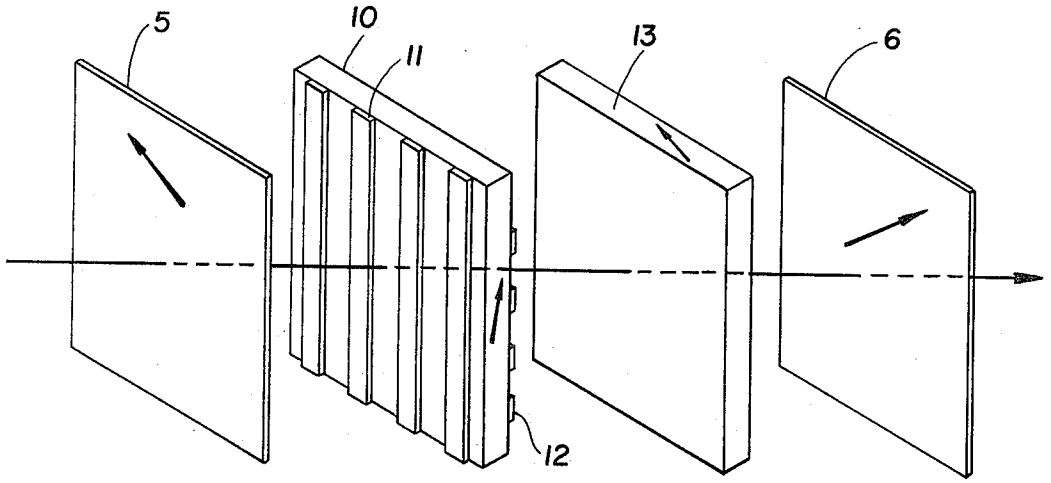


FIG.4

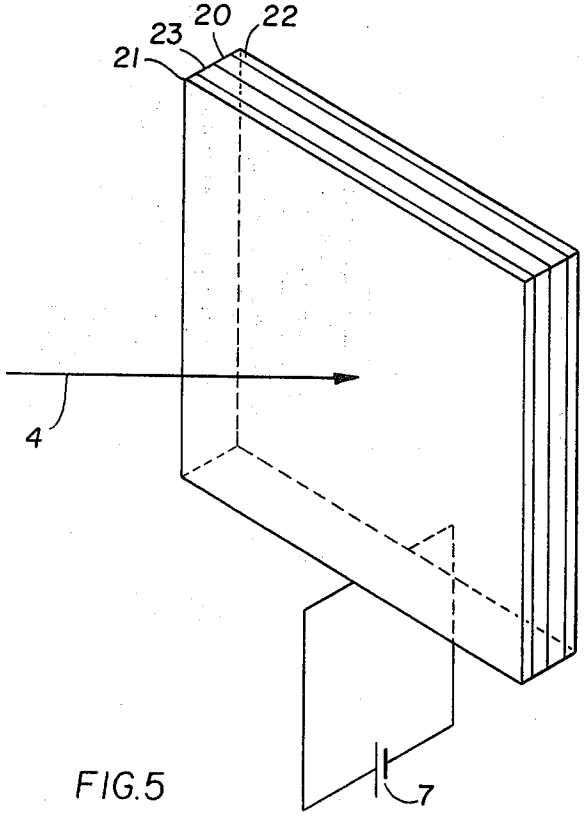


FIG.5

LIGHT VALVE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a light valve and more particularly to a light valve which uses strontium barium niobates as an optical active material.

2. Description of the Prior Art

Various types of light valves or light shutters are employed for the purpose of a pattern generator, optical display in an optical information processing system, etc. Such light valves comprise an electro-optic material in which optical characteristics are controlled by an electric field to be applied, so that transmission of the incident light is controlled in an electronic manner. One of characteristics which are required for the electrooptic materials for use in such light valves is a greater optical response output and a quicker optical response rate. Another desirable characteristic of such electro-optic materials is an longitudinal electro-optic effect. As is well known, the electrooptic materials may be classified as that of a transverse electrooptic effect in which the light transmission direction and the direction of the electric field to be applied for controlling it meet at right angles to each other, and that of a longitudinal electro-optic effect in which the electric field direction is in parallel with the light transmission direction. As is well known to those skilled in the art, the material having the longitudinal electro-optic effect is preferable in that it is possible to employ a two dimensional array or a matrix array for the purpose of electric field applying electrodes.

At present, ferroelectric materials are considered most promising as an electro-optic material for meeting the above-mentioned requirement. Such ferroelectric materials of interest in the prior art are (1) PLZT, (2) $Bi_4Ti_3O_{12}$ and (3) $Gd_2(MoO_4)_3$ or GMO. The common characteristics in these materials are that they use a greater birefringence change accompanied by inversion of spontaneous polarization in the ferroelectric materials. The birefringence change shows a holding characteristic, namely, a memory function due to the electro-optic effect accompanied by inversion of the spontaneous polarization. Such a birefringence change characteristic comprises a certain degree of abrupt change region. The mechanism of the birefringence change accompanied by inversion of the respective spontaneous polarization in these materials will be hereinafter described individually more fully. However, it is understood that in these three kinds of materials the electro-optic effect is produced, due to the fact that the axes of refractive index ellipsoid in two polarization states are respectively inclined.

In order to fully understand these prior arts and the present invention, it will be useful to understand more fully the double refraction phenomenon in the electro-optic materials.

Assume that monochromatic light of wave length λ is transmitted into the crystal of an electro-optic material which is held between two polarizers meeting at a right angle. The light which has been linearly polarized by the polarizer is double-refracted in the crystal and divided into two rays, an ordinary ray and an extraordinary ray, in which polarization planes thereof are mutually placed at a right angle. The two rays pass through the crystal of the material, at different speeds. Therefore, the two rays can not be restored to the original linear polarized light if they are superposed at a place where they have just passed through the crystal. Generally, they are likely to be elliptic. In other words, the phase deviation is caused between the two rays. According to the component of a given direction of the elliptic polarized light picked out by a back polarizers, it is seen that intensity of light passing therethrough changes in accordance with the phase deviation between the two rays received in the crystal. When the polarizers are mutually placed at right angles to each other and the crystal is placed diagonally with respect to these, the intensity of the light which has passed through the optical system can be generally expressed as follows.

$$I_{out} = I_o + I_1 \sin^2 (\pi/\lambda \cdot R_t)$$

wherein I_{out} is the light intensity which has passed through the optical system, $I_o + I_1$ is the intensity of the incident light and I_o is the light, particularly among these, which is leaked from the optical system by scattering, etc. Since I_o is normally smaller as compared with I_1, the description will be given as $I_o = 0$. Namely, I_1 shows the intensity of the incident light. Also, R_t is called retardation, which is a quantity showing the difference, in the optical distance, of two rays passing through the crystal. The optical distance in the crystal of the two rays can be given by $n_1 l$ and $n_2 l$, wherein the length of the crystal through which the light passes is l, a refractive index with respect to the two rays being n_1 and n_2. The retardation is given by $R_t = (n_2 - n_1)l$. Also, the phase difference caused when the two beams pass through the crystal is expressed by $(2\pi/\lambda)R_t$, where λ shows the wave length in vacuum.

Assume that R_t has just become an integer multiple of the wave length of the incident light, namely, $R_t = N\lambda$ has been established by changing the length of the required material crystal. As apparent from the abovementioned equation, $I_{out} = 0$ is given. Thus, the light is not transmitted through the optical system at all. Furthermore, assume that $R_t = (N - \frac{1}{2})$ has been given by changing the length l, then $I_{out} = I_1$ is given. All the incident light is transmitted through the optical system.

According to the abovementioned description, the retardation has been changed by changing the length of the crystal. On the other hand, in the electro-optic material given above, $n_2 - n_1$ is electrically changed with the length of the crystal being kept constant, whereby the retardation R_t can be changed. In the crystal, the direction along which the retardation becomes zero is called an optical axis.

The phenomenon, in which double refraction is different in accordance with a crystallographic orientation, observed in the crystal of a double refraction substance or of a substance having the optical anisotropy, can be explained by the above-mentioned Fresnel ellipsoid. In case of the ferroelectric substance, the main axis of the Fresnel ellipsoid (index ellipsoid) is rotated, in accompany with the direction of the spontaneous polarization. Accordingly, a region with a different polarization axis, or a domain shows variable double refractions when viewed from a specific direction. The symmetry of the crystal determines what domain the ferroelectric substance can carry. The 180° domain has mutually opposing two polarization directions in the common polarization axis. This is the commonest domain wherein the double refraction is not changed if the polarization direction is reversed. The ferroelectric sub-

stance materials of the above-mentioned prior art, namely, PLZT; $Bi_4Ti_3O_{12}$; and GMO change in the double refraction in accompany with the polarization inversion. This is based on the fact that it is not such a simple domain construction. These materials can be said to be special crystals which are lower in crystal symmetry.

In order to fully understand the features of the present invention, it is highly desirable to fully consider the ferroelectric substance materials of the prior art individually with the abovementioned preliminary knowledge thereof.

PLZT is a transparent ceramics which are hot-pressed after having doped a small amount of La into lead zirconium titanate. For example, a more detailed description thereof is seen in J. R. Maldonado and A. H. Meitzler, "Strain Biased Ferroelectric-Photoconductor Image Storage and Display Device", Proc. IEEE. vol. 59, No. 3, 1971, pp 368. The standard mode of operation of the material is illustrated as follows. Basically, two sets of electrode means for causing the electric field in parallel to the light penetrating path of a PLZT mass are provided in the light valve comprising PLZT, so that the light penetrating path is formed between these sets of electrode means. The electric fields vertical as well as parallel to the light penetrating path are produced by selective application of electric potentials upon these two sets of electrode means, whereby the polarization direction of the PLZT is controlled. Various compositions of the ceramic have been proposed and the representative one among them belongs to a trigonal system in the individual fine grained crystal system composing the ceramic. Thus, the 71° domain exists and contributes to the change in the double refraction. In actual application of the PLZT ceramic as an operative device, a "strain bias" is used. More specifically, in the actual application, for example, a transparent substrate to which the ceramic wafer of the PLZT is secured is slacked so that tension or stress may be applied to the ceramics in a vertical direction to the light penetrating path. Accordingly, a similar effect as the vertical or horizontal electric field is provided to the light penetrating path. One of the greatest disadvantages in utilizing the material as a light valve is that the horizontal electric field generating means such as a strain bias method is required as an additional provision. The other disadvantage is that fatigue phenomenon is caused, since the material is not a single crystal but ceramic, the problem of fatigue phenomenon remaining unsolved.

$Bi_4Ti_3O_{12}$ crystal belongs to a monoclinic system at a room temperature, and the electric optical characteristics have been fully described in, for example, S. E. Cummins; "Electrical and optical properties of ferroelectric $Bi_4Ti_3O_{12}$ single crystals", Journal of Applied Physics, 39.5, pp. 2268 (April 1968). The polarization axis is found in $a - c$ plane and domains inclined mutually by 10° exist. The refractive index ellipsoid can be rotated by switching the two domain conditions. The greatest disadvantage in the application as a light valve of the crystal is that the most efficient b plane crystal can not be obtained, since only mica-shaped slice crystals can be obtained.

$Gd_2(MoO_4)_3$ or GMO crystal belongs to an orthorhombic system, the electro-optic characteristic thereof being described in, for example, A. Kumada, "Optical Properties of Gadolinium Molybdate and their device application ", Ferroelectrics, 1972, vol 3, pp. 115 to 123. The a and b axes are replaced by inversion of polarity of the c axis (polarization axis) in this crystal. Accordingly, by inverting in a direction of the c axis (polarization axis), the refractive index ellipsoid is rotated 90° with the polarization axis as a rotating shaft. The greatest disadvantage in applying the crystal as a light valve is that the crystal is deformed by the inversion of the polarization axis. Accordingly, since it is difficult to selectively invert only the optical one portion of the crystal, a matrix device with row and column electrodes in one sheet of crystal can not be obtained. In an actual application as a light valve, the device comprises a plurality of bar-shaped crystals arranged in an array. Since the device is built in such construction, the number of bits for the light penetrating path to be controlled is difficult to be increased.

Another prior art ferroelectric substance material of interest is strontium barium niobate or SBN. The crystal of SBN belongs to a tetragonal system point group 4 mm and is known not as a substance showing a change in birefringence caused by polarization, as described in the foregoing, but rather known as a material which is greatest in a linear electro-optic effect (Pockels effect). The electro-optic effect of SBN crystal is described in, for example, P. V. Lenzo, E. G. Spencer and A. A. Ballman, "Electro-optic Coefficients of Ferroelectric Strontium Barium Niobate", Applied Physics Letters, vol. 11, No. 1 (1967), pp. 23. A transverse light modulator is expected from this crystal. In utilizing in an array as such a transverse light modulator, this material shows the greatest linear electro-optic effect. Being different from the birefringence change accompanied by polarization inversion, the linear electro-optic effect is caused even in a crystal other than the ferroelectric substance, such as CuCl. Generally, it has been known that a birefringence change is very slight in such a material that has a great linear electro-optic effect. However, the linear electro-optic effect is of a high response rate and thus is suitable for the modulation of the laser beam. The ferroelectric crystals utilizing the linear electro-optic effect, including the SBN are required to be supplied with a high electric field in advance, for causing a condition where the polarization direction thereof is forcibly arranged. Since the crystal of the materials belongs to the tetragonal system, the only 180° domain can be considered in the domain construction. Thus, according to the teaching of the prior art, as regards the SBN crystals, it could not be expected at all to cause the birefringence change in accompany with the polarization inversion.

SUMMARY OF THE INVENTION

The present invention provides a longitudinal operation mode light valve wherein a strontium barium niobate single crystal is used as a longitudinal electro-optic effect material utilizing the refringence change caused by polarization inversion, contrary to the expectation in the prior art. An SBN crystal is oblique cut for use a light valve. Inventors have found by experiment that the birefringence change is caused in accompany with the polarization inversion, or the birefringence change is controlled, responsive to a pulse input electric field when such oblique cut SBN crystal is used in a longitudinal mode of operation. Furthermore, the inventors have found that such birefringence change is comparatively abrupt in the electric field change region of a cer-

tain threshold value and the birefringence change shows that of a hysteresis loop.

Accordingly, one aspect of the present invention is to provide a longitudinal operation mode light valve which comprises a crystal comprising strontium barium niobate having an optical read/write memory function.

Another aspect of the invention is to provide a longitudinal operation mode light valve which comprises a crystal comprising strontium barium niobate allowing XY matrix addressing of less cross-talk by skillful use of the electric field of the threshold value area.

One of the greatest advantages of the present invention, as compared with the prior art thereof, is that the invention is capable of accomplishing a pure longitudinal mode of operation without any additional provision for generating an electric field such as a strain bias method. The other advantage thereof is that a cross array of row and column electrodes is provided on both surfaces of an SBN crystal, whereby the addressing of individual locations of a optical memory function on the SBN crystal plate is made possible. Characteristics such as easier single crystal growth of the SBN material, lower optical transmission loss of the single crystal, stronger resistance against fatigue phenomenon, and so on clearly make also this invention more advantageous.

The strontium barium niobate which is used for the purpose of the present invention uses the range of $0.34<x\leqq 0.75$ in a general equation $(Sr_xBa_{1-x})Nb_2O_6$, and preferably x is approximately 0.75 to 0.65. Pb or Ca may also be added to two elements of Sr and Ba. Similarly, La or Bi may be added to two elements of Sr and Ba, in which case Ti or Zr is preferably be added to Nb.

The other objects, aspects, features and advantages of the present invention will become apparent from the following detailed description of the present invention when taken in conjunction with preferred embodiments thereof with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of a light valve comprising an oblique cut strontium barium niobate (SBN) single crystal in accordance with the present invention,

FIGS. **2** and **3** are graphs showing the relationship between an electric field applied to the SBN single crystal of FIG. **1** and the retardation and polarization thereof,

FIG. **4** is an exploded perspective view showing a page composer employing the light valve of the present invention, and

FIG. **5** illustrates a perspective view of another embodiment of the present invention employing a different addressing system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is an exploded perspective view showing a light valve using the longitudinal operation mode electro-optic effect of an oblique cut strontium barium niobate (SBN) single crystal in accordance with the present invention. The SBN composite illustrated comprises an oblique cut SBN crystal plate **10**, and transparent electrodes **11** and **12** provided so as to sandwitch the plate **10**. The electrodes **11** and **12** are connected through a polarity switch **9**, to two adjustable DC power sources **7** and **8** which are in an opposite polarity. Polarizers **5** and **6** are placed on both sides of the composite so that polarization planes are oriented at right angles with each other. Numeral **4** shows an incident light direction. The present inventors have found by experiment by the use of such arrangement, (1) the abovementioned SBN crystal shows the longitudinal electro-optic effect, namely, gives rise to an electrically controllable birefringence change, (2) such birefringence change and thus a retardation change shows hysteresis characteristics, and (3) such change curves includes a particular range showing a comparatively abrupt change, responsive to the applied electric field or voltage. It should be pointed out that the present invention is based on such discoveries by the inventors.

The SBN is generally such a solid solution as shown by a chemical equation of $Sr_sBa_{1-x}Nb_2O_6$ (which may be expressed as SBN-x) wherein the ferroelectric nature or the electro-optic nature changes successively as the value of x, namely, the composition ratio of Sr and Ba changes. A crystal of SBN–0.75–SBN–0.65 has the greatest electro-optic effect and the greatest birefringence change due to polarization inversion in various composition ratios of the SBN crystal. It was found that a preferred crystal orientation in the SBN crystal is that in which the normal direction of light is oriented at 30°–80° with respect to the optical axis.

It was found that the relationship as shown in FIG. **2** exists between the applied electric field and the resultant retardation as a result of measurement of the electro-optic effect by the use of the arrangement shown in FIG. **1** and of the multi-domain crystal of the SBN–0.75 composition. More specifically, the initial state of retardation of the multi-domain crystal is shown by a point A. As the applied electric field is increased, the retardation is increased abruptly at a certain threshold value, for example, the electric field V_{th} and gradually reaches to a linear response region through a point B. Upon reaching of the retardation to the linear response region like the point B, the retardation reaches a point C and remains as it is without returning to the initial point A, even after the electric field is removed. The difference between the birefringence of a point A on a state not polarized, or on a zero polarization state, and the birefringence of a point C of the residual polarization state at the zero electric field; namely, the residual birefringence; remains as it is and is stored in terms of birefringence even after the removal of the applied electric field. This means that the light valve at the point A where the induced birefringence is zero is in an optically OFF condition, while the light valve at the point B or C is in an optically ON condition. Thus, in response to the induced birefringence amount, the intensity of the light can be modulated in case of white and black intensity modulation and color can be modulated in case of color modulation. The characteristic of this memory function has application possibilities as a pattern generator, etc. in an optical memory field. Also, it is not required to keep the electric field applied, for a given time, because of the memory function, if it is used in a display device. Accordingly, an address circuit is simplified brightness of a display is enhanced and power consumption for the electric field application is reduced. Also, the non-linear change of

the induced retardation in the electric field of such a certain threshold value as set forth above can be advantageously used to avoid the effect of the cross-talk especially when the element of the present invention is used for XY matrix driving, as to be more fully described later.

FIGS. 3 (*a*) and (*b*) show the relationship of the polarization of the crystal and retardation changes with respect to a wider range of electric field change in both positive and negative polarities. As apparent from FIG. 3 (*z*), the abovementioned SBN crystal shows the hysteresis characteristic of the polarization with respect to the electric field change of both the positive **9** and negative directions. Referring to FIG. 3 (*a*), the electric field of $+V_1$ volt is applied to the SBN crystal of a point A′ on multi-domain state thereby causing the polarization corresponding to a point C′. Thereafter, the electric field is reduced to zero and thus the residual birefringence corresponding to a point B′ is stored in the SBN crystal. Then, when the electric field of $-V_2$ volt which is of an opposite polarity to the $+V_1$ volt is applied to the SBN crystal of the residual birefringence corresponding to the point B′, the polarization condition of the crystal reaches the point D′, which is equal to the point A′, but not the point E′. Thus, it is seen that the abovementioned SBN crystal allows an optical on and off switch operation to be performed in response to the two electric field pulses of $+V_1$ and $-V_2$. This fact allows for application of the device of the present invention as an optically readable/electrically writable memory.

In a general equation $(Sr_xBa_{1-x})Nb_2O_6$ for expressing the SBN to be used for the purpose of the present invention, the SBN in the range of $0.34 < x < 0.75$ can be used. However, the value of x from 0.75 to 0.65 has been found to be preferable. Also, a solid solution crystal which is expressed by a general equation $(Sr_xBa_yM_{1-x-y})Nb_2O_6$ including three elements of Sr, Ba and M where M is Pb or Ca, instead of two elements of Sr and Ba, can also be used for the purpose of the present invention. Furthermore, a solid solution crystal which is expressed by a general equation $(Sr_xBa_yM'_{1-x-y})(Nb_zM''_{1-z})_2O_6$ including three lements of Sr, Ba and M′, where M′ is La or Bi, instead of two elements of Sr and Ba, and including two elements of Nb and M″, where M″ is Ti or Zr, instead of Nb can also be used for the purpose of the present invention.

FIG. 4 shows an exploded perspective view of a page composer using a light valve of the present invention. The SBN crystal plate **10** of FIG. 4 includes a plurality of strips of column electrodes **11** and row electrodes **12** respectively on both surfaces thereof, these columns and rows of strips being crossed at right angles. Furthermore, an SBN crystal plate **13** for compensation which is identical in thickness and orientation to a crystal plate **10** is placed behind the SBN crystal plate **10** so that the optical axis directions of these crystal plates **10** and **13** may be selected at right angles to each other. The SBN crystal plate **13** for the compensation serves to compensate the retardation of the crystal plate **10,** and simultaneously serves to compensate the retardation change caused by temperature change. The polarizers **5** and **6** are placed before and behind these crystal plates **10** and **13,** polarization planes thereof being crossed at right angles to each other. Numeral **4** shows a transmission direction of the light.

As is well known, the voltage is selectively provided individually to the electrodes **11** and **12** from a column selection circuit and a row selection circuit (not shown). Accordingly, the electric field which is parallel to a light transmission direction is developed in the interior of the SBN crystal plate **10** at the intersection portions of the electrodes **11** and **12** on the selected active condition. The voltage E provided to these electrodes **11** and **12** is so chosen as to be somewhat smaller in an absolute value than the threshold value V_{th} as given in FIG. **2** and so chosen as to be opposite in polarity to each other. Further, double the absolute value is so chosen as to be bigger than the threshold value V_{th}. The voltage of $|2E|$ is applied to a particular intersection area of the SBN crystal **10** where the selected electrodes **11** and **12** cross, while the voltage of $|E|$ is merely applied to the intersections between the selected electrodes **11** or **12** and unselected electrodes **11** or **12.** However, the voltage is not applied at all to the intersections between the unselected electrodes **11** and **12.** As described hereinbefore, in the SBN crystal of the present invention, the residual birefringence is not substantially caused with the voltage $|E|$, while sufficient residual birefringence is caused with the voltage $|2E|$. It is understood that the residual birefringence is selectively caused in the SBN crystal **10** only in the intersection area of the selected electrodes **11** and **12,** and the said area selectively stores an optical ON condition. The stored information can be optically read out in rear of a rear polarizer **6.** The stored information can be erased by applying the electric field $-V_2$ in FIG. **3** (*a*) in an opposite direction to the said area of the SBN crystal.

FIG. **5** illustrates a perspective view of another embodiment of the present invention employing a different addressing system. Generally, the X–Y matrix addressing system as shown in FIG. **4** is complicated in structure. In contrast, FIG. **5** embodiment employs a light addressing system of a simple structure. More specifically, FIG. **5** embodiment comprises a composite comprising a ferroelectric layer **20** and a photoconductor layer **23** deposited on a light incident surface of said ferroelectric layer **20,** sandwiched between a pair of transparent electrodes **21** and **22.** A potential is applied between both electrodes **21** and **22** by a power source **7.** However, because of interposition of the photoconductor layer **23,** which is normally of high resistivity due to no incident light, the ferroelectric layer **20** is not supplied with an electric field large enough to cause polarization switching therein. For the purpose of addressing a desired location in the ferroelectric layer **20,** a light beam **4,** controllably deflectable in a known manner, is directed toward the said specified location or region of the device shown. The said specified region of the photoconductor layer locally decreases in resistivity in response to impingement of the light beam upon the photoconductor layer. As a result, an increased electric field is applied locally to the said specified region of the photoconductor layer, thereby giving rise to polarization switching in the said specified region and thus achieving addressing of the device.

The ferroelectric light valve is now considered promising particularly as a pattern generator or a page composer in an optical or holographic memory system. The present invention will also be used advantageously for such applications. However, other applications thereof to an X–Y matrix addressing display device or an image

storage and processing device, and so on may also be considered.

What is claimed is:

1. A light valve comprising:

an oblique cut monocrystalline plate of $(Sr_xBa_yM'_{1-x-y})(Nb_zM''_{1-z})_2O_6$, where $x + y \leqq 1$, $z \leqq 1$, M' is Pb, Ca, La or Bi, and M'' is Ti or Zr,

means for applying an electric field to said monocrystalline plate in a longitudinal mode of operation for causing polarization switching in said monocrystalline plate, and

a pair of polarizers positioned in front of and in rear of said monocrystalline plate, respectively, the light polarization planes of said polarizers being in a direction vertical to each other.

2. A light valve in accordance with claim 1, in which said monocrystalline plate shows a change in birefringence along a hysteresis loop with respect to a change in said electrical field applied to said monocrystalline plate.

3. A light valve in accordance with claim 1, in which said monocrystalline plate shows a residual birefringence with respect to a change in said electrical field applied to said monocrystalline plate.

4. A light valve in accordance with claim 1, in which said monocrystalline plate shows a non-linear change in birefringence in a specified range of the electrical field applied to said monocrystalline plate.

5. A light valve in accordance with claim 1, in which the value of x and y is chosen in the following range;

$0.34 < x \leqq 0.75$

$0.25 \leqq y < 0.66$

6. A light valve in accordance with claim 1, in which the value of x has been chosen to be approximately 0.75 to 0.65.

7. A light valve in accordance with claim 1, in which the value of x and y has been chosen to be $x + y = 1$.

8. A light valve in accordance with claim 1, in which the value of z has been chosen to be unity.

9. A light valve in accordance with claim 1, in which said monocrystalline plate has been cut at the angles of about 30° to 80° with respect to the optical axis thereof.

10. A light valve in accordance with claim 1, in which said means for electrical field comprises

a plurality of strip electrodes formed on one surface of said monocrystalline plate extending in a row direction, and

a plurality of strip electrodes formed on the other surface of said monocrystalline plate extending in a column direction.

11. A light valve in accordance with claim 10, which further comprises a row addressing means for selectively applying a potential to said row electrodes and a column addressing means for selectively applying a potential to said column electrodes.

12. A light valve in accordance with claim 11, in which said monocrystalline plate shows a non-linear change in birefringence in a specified range of the electrical field applied to said monocrystalline plate, and

the potential fed from said row and column addressing means and applied to said row and column electrodes, respectively, has been chosen to be of such a value that develops an electrical field of a value less than said specified non-linear range, in a polarity opposite to each other, respectively, thereby developing a total electrical field of a value larger than said specified non-linear range at a specified location in said monocrystalline plate addressed as an intersection of the selected row and column electrodes.

13. A light valve in accordance with claim 11, in which said monocrystalline plate shows a residual birefringence with respect to a change in said electrical field applied to said monocrystalline plate, and

the potential fed from said row and column addressing means and applied to said row and column electrodes, respectively, has been chosen to be such a value that causes a residual birefringence at a specified location in said monocrystalline plate addressed as an intersection of the selected row and column electrodes.

14. A light valve in accordance with claim 13, which further comprises means for applying a potential to said row and column electrodes for developing an electrical field in said monocrystalline plate for erasing said residual birefringence in said specified location.

15. A light valve in accordance with claim 1, which further comprises light addressing means.

16. A light valve in accordance with claim 15, in which

said electrical field applying means comprises a pair of electrodes formed on both surfaces of said monocrystalline plate, and

said light addressing means comprises a photoconductor layer interposed between said electrode on the light incident surface and said monocrystalline plate,

said photoconductor layer normally preventing polarization switching in said monocrystalline plate from being caused by said applied electric field, but a decreased value of resistance in a specified region of said photoconductor in response to an incident light beam causing the applied electric field to give rise to polarization switching in said monocrystalline plate, thereby achieving light addressing in said plate.

* * * * *