

LAYERED BENDING ELEMENT LIGHT SWITCH

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to a method for switching light signals in an optical wave-guide on or off at speeds faster than 10^{-11} seconds using light to trigger the switch in which a layered element bends to close the channel. These switches can be arranged to stay latched until unlatched.

2. Description of the Prior Art:

As technology advances communication of three-dimensional drawings, video, and software applications require more information to be communicated faster than ever. Fiber optical channels can handle much more information than wires can. The slowest part of a fiber optic communication channels at present are the fiber optic switching devices. At present fiber optic signals are switched using various methods that are actuated by transistors. United States Patent, number 6,594,411 issued to Yueh Liang Chung et al, on July 15 of 2003, which teaches OPTICAL SWITCH, makes mention of a piezoelectric element. The piezoelectric element is actuated by an electrical signal, which is bound to the 10^{-9} seconds speeds that transistors can accomplish. United States Patent, number 5,703,975 issued to William Miller et al, on December 30, 1997 that teaches INTERFEROMETRIC SWITCH are physically long for the present need for miniaturized components. The components are more than a centimeter in length in William Miller's device. Finally, United States Patent number 7,072,536 issued to Gary

Poovey on July 4, 2006 which teaches LIGHT TRIGGERED LIGHT SWITCH, here included by reference, is as fast as the present invention because it is light triggered, but lacks the latching function.

SUMMARY OF THE INVENTION

LAYERED BENDING ELEMENT LIGHT SWITCH uses the inability of electromagnetic waves to travel through a channel that is dimensionally smaller than the wavelength to turn light off the light signal in a fiber optical channel. Opening up the fiber optical channel to a dimension large enough allows the LAYERED BENDING ELEMENT LIGHT SWITCH to turn on the signal in an optical channel. The LAYERED BENDING ELEMENT LIGHT SWITCH uses bending when exposed to a sufficient electric field of a element constructed of layers of different orientations of piezoelectric material to effect the closing or opening of fiber optical channels. The electric field of light in the channel is the electric field that effects the change in the piezoelectric material. LAYERED BENDING ELEMENT LIGHT SWITCH can switch faster than 10^{-11} seconds. This is 100 times faster than any transistor-actuated switch. LAYERED BENDING ELEMENT LIGHT SWITCH can be made smaller than 30 microns in length, less than three microns in width, and high depending on the specific wavelength to be used in the fiber optic channel. Millions of these switches can be made in the area of one of the INTERFEROMETRIC SWITCH switches described above. LAYERED BENDING ELEMENT LIGHT SWITCH will also be 100 or more times faster than the INTERFEROMETRIC SWITCH. Fiber optic communication will be made 100 or more times faster using the LAYERD BENDING ELEMENT LIGHT SWITCHES and components will be able to be made the size of computer chip components. LAYERED BENDING ELEMENT

LIGHT SWITCH can use the light in one light channel to switch on or off the light in an adjacent light channel. The amount of information that can be transmitted across a fiber optic channel is far greater than can be transmitted across a normal telephone wire. Society needs fast communication of sound pictures and video signals. Currently the switching of these communication signals is limited by the speed of the transistor. Which switches at about 10^{-9} seconds. For society to achieve fast switching of signals the LIGHT TRIGGERED LIGHT SWITCH, here included by reference, and the LAYERED BENDING ELEMENT LIGHT SWITCH are necessary. The LAYERED BENDING ELEMENT LIGHT SWITCHES can be built adjacent to each other so that the bending elements will lock or latch together. This latching function will open the door to computers that use light to process information. The latching can be used to store information and make memory devices. Computers that the LAYERED BENDING ELEMENT LIGHT SWITCH will make possible will be capable of functioning 100 times, or more, faster than current computers. The multiple layers of the bending elements accentuate the bending. Two layers or just a few layers will respond to the electric field, but the amount of action produced will not be as pronounced as in switches with more layers. The latching therefore of the multiple layered bending element switches will be faster and farther than a switch constructed of few layers.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is the LAYERED BENDING ELEMENT LIGHT SWITCH. The electric field of the light in a channel parallel to the piezoelectric element causes the response of the piezoelectric material that shrinks the adjacent channel to dimensions too small to allow the light signal to pass

through the channel. Figure 1A is a drawing of the switch on and Figure 1B is a drawing of the switch in the off position. Figure 2 shows the Layered Element constructed of many layers. Figure 3 is the two LAYERED BENDING ELEMENT LIGHT SWITCHES that are arranged to latch when actuated by the appropriate electric field. The electric field of light in light channels separated by piezoelectric elements causes the piezoelectric elements to bend into contact with each other. The ends of the piezoelectric elements are fashioned to catch on each other becoming latched together. Figure 3A is LAYERED BENDING ELEMENT LIGHT SWITCH arranged to latch in the unlatched state, and Figure 3B is LAYERED BENDING ELEMENT LIGHT SWITCH arranged to latch in the latched state. Figure 4 is a detail of latching switch latches. Figure 4A is a latch for a right angle or near right LAYERED BENDING ELEMENT LIGHT SWITCH arranged to latch. Figure 4B is a latch for a straight angle or near straight. LAYERED BENDING ELEMENT LIGHT SWITCH may be in channels of different dimensions so that different wavelengths of light can be used to actuate them. The widths of the channels may be slightly different or the height of the channels may be slightly different. Three or more Layered elements may be fashioned to latch together also for handling special signal management needs.

BEST MODE FOR CARRING OUT THE INVENTION

The LAYERED BENDING ELEMENT LIGHT SWITCH uses the characteristic of piezoelectric material that the dimensions of the piezoelectric element change when it is influenced by an electric field. The electric field of light in a channel is the electric field that the piezoelectric material responds to in this invention. Light channels are arranged to be made

larger or smaller as the piezoelectric materials change dimensions in response to the influence of the electric field. When a light channel is opened up from being too small to allow light signals to pass through them by the response of the piezoelectric material to the electric field of light passing through the channel, the switch is on. When the channel is made small enough, light signals of certain wavelengths will no longer pass through the smaller channel. When the light signals will not pass through the light channel that has been made smaller, the signal is switched off. Some piezoelectric materials have a crystal orientation that must be aligned with the electric field that will cause it to change shape. Other piezoelectric materials can be heated up in a magnetic or electric field and oriented to respond in the desired direction to the electric field that will be applied. In constructing LAYERED BENDING ELEMENT LIGHT SWITCHES, the piezoelectric elements will be constructed of layers. One layer of the bending element will have a crystal orientation in opposition to the adjacent layer of the piezoelectric element. These layers can be in one layer of material or layers with metal or other material between the piezoelectric material. There can be 2,3,4...many layers involved. The layers alternate in orientation to accentuate the response to the electric field of the light applied to them. The electric field will cause the element to bend as these different orientations of piezoelectric material are affected by the electric field of the light in the channel. Many layers cause the response to be quicker, and more pronounced than fewer layers. Examples of piezoelectric materials that can be oriented in a magnetic or electric field are lead zirconate and lead titanate or lead zirconate titanate, also called PZT. For an example, the electric field in volts to be derived from the power in watts of the light in the channel from a form of

the Poynting vector equation which is written $E = (2\mu_o c P)^{1/2}$. Where μ_o is $4 \pi \times 10^{-7}$ Weber /amp-meter and c is 3×10^8 meters / second. Using this relation it is found that the voltage developed by a 150-milliwatt signal in a fourth of a micron channel is 10 volts. This voltage will be employed to actuate the Latching Fiber Optic Switch. The voltage the light develops will change the dimensions of the 2065 Å channel by 40 Å when lead zecronate titnate is used. Lead zecronate titonate has a piezoelectric strain coefficient of 3.90×10^{-10} meters/volt. 818nm light (8180 Å) commonly used for fiber optics will be able to travel in a channel just bigger than 2045 Å and will not travel down a channel smaller. When the 2065 Å channel changes to 2014 Å light will be shut off of a wave length of 8180 Å or more, while light of a wave length of 8056 Å or less will still pass through. In the present invention, the switching mechanism is a bending piezoelectric element that bends in the presence of an electric field of appropriate orientation and power. Such an element is composed of layers with a flexible metallic film between the layers. The method for fabricating the bending element is as follows: First non-oriented piezoelectric layers are deposited on a substrate that can be a silicon wafer with a metal coating. Then channels are etched in the piezoelectric layer. The flexible metal film is deposited into the channels that were etched. The excess metal film is removed, and the piezoelectric layer is oriented in opposing directions in adjacent layers by opposite polarities in electric fields put on the metal between the layers. An element constructed in this fashion when an electric field of an appropriate light signal interacts with it will bend. As has been discussed if the element bends a sufficient distance the light channel will be closed to the passage of light signals. Further, if tow or more such elements with ends that can latch are bent into a

latched condition the light signal that can be tuned off and the latching switch will maintain the off condition once there is no light in the channel. A latched switch can be unlatched by the application of light in the proper sequence to bend the elements affecting an unlatching. The drawings illustrate the way the LAYERED BENDING ELEMENT LIGHT SWITCH and latching light switches function. In Figure 1A, the arrow numbered 1 is the arrow that indicates the light moving through the light channel into a LAYERED BENDING ELEMENT LIGHT SWITCH on one side. The side that arrow 1 is going into is the on and off side of the light switch. Arrow 2 indicates the light moving through the LAYERED BENDING ELEMENT LIGHT SWITCH on the triggering side. Rectangular channel 4 is the on and off side of the LAYERED BENDING ELEMENT LIGHT SWITCH, the side that the bending element bends toward. Rectangular solid 6 is the straight bending element. The element is not being acted upon by the electric field of a switching signal that would be of sufficient power to cause the element to bend. Rectangular channel 9 is the side of the LAYERED BENDING ELEMENT LIGHT SWITCH that is away from the direction of the bend that the bending element can be caused to bend. Arrow 7 is the light coming out of the LAYERED BENDING ELEMENT LIGHT SWITCH when the bending element is not bent. The switch is on in this position. Arrow 8 is the light coming out of the side away from the direction of the bend of the bending element, which can turn on or off the signal passing through the switch by the electric field of the light passing through switch.

In Figure 1 B, arrow 10 is the light coming into the LAYERED BENDING ELEMENT LIGHT SWITCH that will be shut off by the closing of the channel by the bending element when it is bent. Arrow 12 is indicating the light entering

the side away from the side that the bending element can bend into and shut off the light signal. The light indicated by arrow 12 is of sufficient power to actuate the switch. Light channel 14 is the light channel that the bending element bends into to shut off the signal. Light channel 16 is the side of LAYERED BENDING ELEMENT LIGHT SWITCH away from the direction of the bending element. Bent element 18 is in the bent condition. No light is passing through the side of the switch that the bending element has moved into. The switch is in the off position. Arrow 19 is the light still passing through the side of the LAYERED BENDING ELEMENT LIGHT SWITCH that is away from the direction that the bending element bends to turn off the light signal.

In Figure 2 the layers of the pictured element are numbered 5. In a Layered Bending Element, the layers can be one layer of material with layers that are of different crystal orientations that force the element to bend when exposed to an electric field. There can be a layer of piezoelectric material attached to another material so that the assembly bends when exposed to an electric field. Bending Elements can be constructed of 2,3,4... many layers with or without metal between them. These Layers have opposing orientations so that the layered Bending Element bends when exposed to an electric field. More layers cause the response to the electric field to be quicker and more pronounced than fewer layers.

In Figure 3A, Arrow 20 indicates the light passing into the side of the LAYERED BENDING ELEMENT LIGHT SWITCH that is constructed to allow the signal to be turned on or off if the latching elements are bent and latched. Arrow 22 indicates the light passing into the side away from the side of the

LAYERED BENDING ELEMENT LIGHT SWITCH that the bending elements bend toward when they bend. Rectangular channel 24 is the first side of the LAYERED BENDING ELEMENT LIGHT SWITCH on the side that the bending elements bend toward when they bend. Bend element 26 is the first half of the LAYERED BENDING ELEMENT LIGHT SWITCH that is bent and latched to shut off the light signal. Rectangular channel 28 is the side of the light channel that is away from the side that the bending element can bend toward and shut off the signal. Rectangular channel 30 is the second half of the light channel on the side that the bending and latching elements can bend toward to latch and shut off the light from passing through the channel. Bending element 32 is the second half of the LAYERED BENDING ELEMENT LIGHT SWITCH that is not bent and latched so light can pass through. The switch is on. Rectangular channel 34 is the second half of LAYERED BENDING ELEMENT LIGHT SWITCH that is away from the side of the switch that the bending elements bend toward. Arrows 36 and 38 are the light passing of the side of the LAYERED BENDING ELEMENT LIGHT SWITCH.

In Figure 3B, Arrow 40 is the light entering the LAYERED BENDING ELEMENT LIGHT SWITCH that is constructed to latch on the side that the light signal can be turned on or off when the elements bend and latch. This is the side toward which the bending elements bend, when they bend. Rectangular light channel 44 is the first half of LAYERED BENDING ELEMENT LIGHT SWITCH that the bending element bends into this side of the switch when it bends. Arrow 42 is the light entering the LAYERED BENDING ELEMENT LIGHT SWITCH that has been constructed to latch on the side away from the direction that the bending element bends. Bending element 48 is the first element in the LAYERED BENDING

ELEMENT LIGHT SWITCH that can latch. It is in the unbent state. The switch is in the on state. There is not sufficient power in the switching light to cause the element to bend and latch. Rectangular channel 50 is the second half of the LAYERED BENDING ELEMENT LIGHT SWITCH that can latch away from the direction that the bending element will bend. The light in this side of the LAYERED BENDING ELEMENT LIGHT SWITCH that can latch will not be turned on or off by the bending of the elements. Rectangular light channel 54 is the second half of the channel in LAYERED BENDING ELEMENT LIGHT SWITCH that can latch that the bending elements bend into and causes the light signal to be tuned on or off by the bending of the latching elements. Bending element 52 is the second bending element that latches with bending element 48 when the switch is latched off. It is not bent. There is enough power in the switching light to cause the element to bend and latch. The switch is in the off state. Arrows 56 is the light passing out of the LAYERED BENDING ELEMENT LIGHT SWITCH, which is made to latch in the on state. It will be noted that there is no arrow indicating light is coming out of the switch on the side that the elements bend toward.

Figure 4A is a drawing of two latching elements as they could be made to latch. Bending element 60 is one bending element that would be latched into position when caught by the other element of the pair numbered 62. Figure 4B is a drawing of two latching elements as they could be made to latch. Bending element 64 is one bending element that would be latched into position when caught by the other bending element of the pair number 66. Other latching shapes could be used to perform the desired function of latching once bent into position. Some latching geometry's will work better for LAYERED BENDING ELEMENT LIGHT

SWITCH that are arranged at right angles while others will be better used in a near straight angle configuration. Three or more Layered Elements may be fashioned to latch together for signal management for special applications. The four drawings of the LAYERED BENDING ELEMENT LIGHT SWITCH are schematic drawings. In actual switches, additional layers of material will be used to secure, cover, and align the fiber optic switches in a fiber optic assembly.

WHAT IS CLAIMED IS:

1. An on and off switch for light in an optical wave guide comprised of two parallel light channels with a layered bending element between them made of piezoelectric material that bends in the electric field produced by light of sufficient power present in the channel that A. is on when the element is not bent B. is off when the element is bent.
2. An on and off switch for light in an optical wave guide comprised of many parallel light channels with more than one layered bending element that once bent by the electric field of light of sufficient power can latch together so that the light switch stays in the off state once the light that caused the switching to occur is not present any more that A. is on when the elements are not bent and not latched B. is off when the elements are bent and latched.
3. A light switch as is claimed in claims one or two where the light is switched A. on B. off with light that is causing the switching that is A. a longer wavelength than the light switched B. shorter in wavelength than the light switched C. the same wavelength as the light that is switched.
4. A light switch as is claimed in claim one or two where the layered bending element is composed of many layers of piezoelectric material separated by flexible metal part where the piezoelectric material is aligned with one orientation and the adjacent piezoelectric material aligned in an opposing orientation in the bending element.
5. A latching switch as is claimed in claim two with many piezoelectric elements that meet at A. Acute angles to latch B. Perpendicular angles to latch C. Straight angles to latch

with fixtures on their ends appropriate to the angle that they meet so that once bent by the electric field the elements will latch in the bent state not to change once the electric field is gone.

6. A latching switch as is claimed in claim two with piezoelectric elements that once latched may be unlatched by passing signals of appropriate timing and power to unlatch the latched elements.

7. A light switch as is claimed in claim one or claim two that is of dimensions so that the electromagnetic radiation in the channel is various wave lengths from yards long or angstroms long electromagnetic radiation.

8. A light switch as is claimed in claim one or claim two with a layered bending element with A. only one side composed of piezoelectric material B. one piezoelectric material element with many layers with opposing orientations C. many layers of piezoelectric material with flexible material between them.

9. A light switch as is claimed in claim two that once it is latched it cannot be unlatched.

10. A light switch for light signals as claimed in claims one or two where the light that accomplishes the switching of the light signal in the channel is imposed upon a conductor near the light channel with the signal that is switched in it.