United States Patent [19]

Steward

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[54] **SOLID STATE DISPLAYS**

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[52] **U.S. Cl.**.....**313/109.5,** 313/108 D, 340/336

[51] **Int. Cl.**.....**H01j 7/42**

[58] **Field of Search**.....313/109.5, 108 D; 340/324, 340/336, 343; 235/64.3, 60.15; 315/169

[56] **References Cited**

UNITED STATES PATENTS

3,573,532	4/1971	Boucher	315/169
3,504,214	3/1970	Lake et al.	315/109.5
3,657,587	4/1972	Kegelman	313/109.5

Primary Examiner—John Kominski

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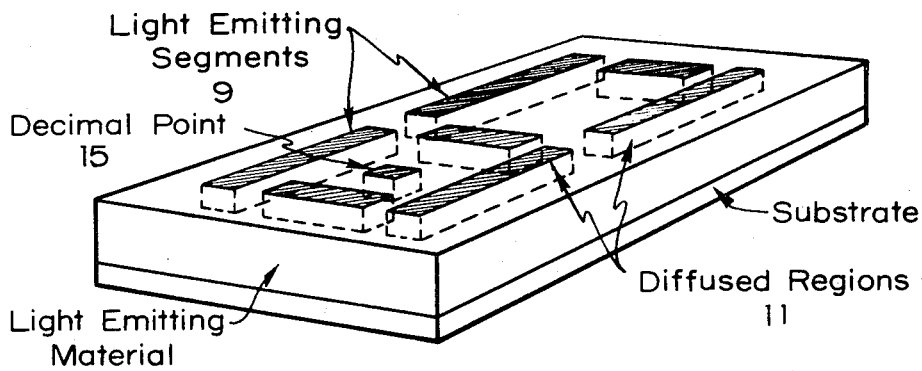
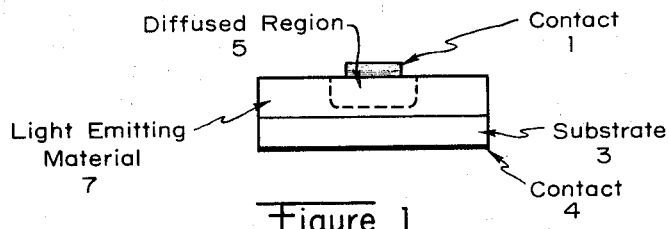
[57] **ABSTRACT**

A decimal point element is located within the boundaries of the charaCter element on a monolithic solid state character chip. When a character string is displayed, only the decimal point is energized on one character chip. This results in wide separation between the decimal point and its nearby characters Hence readability of the decimal point in improved in long character strings.

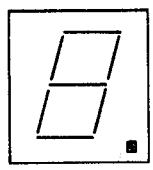
2 Claims, 6 Drawing Figures





PRIOR ART

Figure 1



PRIOR ART

Figure 2

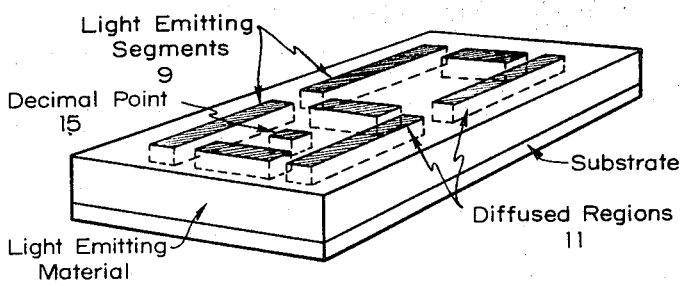
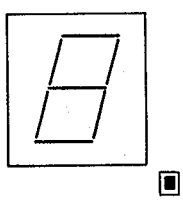


Figure 4



PRIOR ART

Figure 3

PRIOR ART

Figure 5

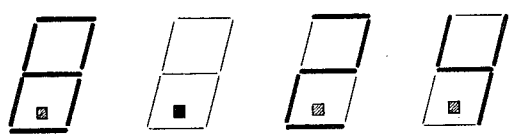


Figure 6

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SOLID STATE DISPLAYS

BACKGROUND AND SUMMARY OF THE INVENTION

The readability of a decimal point in a string of characters depends on the relative position of the decimal point to its nearby characters. In long character strings, for example, it may be difficult to quickly determine the exact location of the decimal point because it blends into the character string and becomes "lost" in the maze of characters. To remedy this, a decimal point is usually displayed well below the lowest portion of the characters. This distance below the character is often one-fifth the character height.

Positioning the decimal point below the characters sometimes increases the manufacturing cost of a display. If a character is formed from a single piece or chip of material, as in monolithic displays, either the chip size must be increased to accommodate both the character and the decimal point, or a special process must be used to provide a separate smaller decimal point chip. Either method increases the product cost.

The present invention locates the decimal point in the lower half of the character font. When a character string is displayed, one character position is dedicated to the decimal point. Thus, readability of long character strings is improved because the decimal point is well separated from its nearby characters.

The solid state displays using the monolithic process, this invention locates both a character and a decimal point in some or all of the display chips. When a character string is displayed, either the decimal point or a selected character is energized in each chip. Thus the same size chip is used to display a character or a decimal point. This eliminates the extra process needed to make a special decimal point chip. Since the decimal point is located within the character boundaries in a chip, a larger chip is not needed to accommodate the decimal point. As a result of this invention, the product cost of solid state displays for medium to long character strings can be decreased.

DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a side view of a light-emitting diode made according to the art.

FIGS. 2 and 3 show conventional methods of incorporating a decimal point in monolithic displays.

FIG. 4 shows a perspective view of an improved monolithic character chip made according to the preferred embodiment of this invention.

FIG. 5 shows a character string using conventional decimal point placement.

FIG. 6 shows the same character string as shown in FIG. 5, but with the improved decimal point placement of this invention instead of the conventional placement.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a light-emitting diode, well-known in the art, is made from a material that emits photons when minority and majority carriers recombine. Such a material is gallium arsenide phosphide. To make a light-emitting diode, an *n*-type alloy of gallium arsenide phosphide 7 is grown epitaxially on a gallium arsenide sustrate 3. A *p* region 5 is then created by diffusing a charged material, such as *p*-type zinc, into the chip. This region is capped with a metal contact 1. The contact provides the anode terminal for the diode while the substrate contact 4 acts as the cathode terminal.

When a forward bias is applied to the diode, the potential barrier at the *p-n* junction is reduced so current can flow. Just as in the operation of a standard diode, electrons are injected into the *p* region and holes are injected into the *n* region. However, when these minority carriers recombine with the majority carriers, energy is given off as photons. Some of these photons are emitted from the surface of the doped gallium arsenide phosphide. Thus the diode emits light in response to forward bias voltage.

The light-emitting regions can be selectively arranged in a monolithic chip by the positioning of the diffused *p* regions. In this manner, chips can be constructed to provide numeric and alphanumeric displays. To provide a numeric display chip, a plurality of light-emitting regions are sometimes arranged in the shape of a rectangular or rhomboidal figure eight. (See FIGS. 2–6.) By forward biasing only selected regions, any digit from 0 to 9 can be displayed. This type of display is commonly called a seven-segment font because the figure eight is usually made by seven linear regions. Sometimes small dot-like light-emitting regions are aligned to form the seven segment font.

A problem with this type of font is decimal point location. To maintain readability of a decimal point in a string of characters, the decimal point is often located below the bottom of the character string. In conventional monolithic displays, either the chip size must be increased to accommodate both the character and the decimal point, as shown in FIG. 2, or a separate smaller chip must be made for the decimal point, FIG. 3. Either process increases the cost of a display.

Referring now to FIG. 4, eight diffused regions 11 are positioned to form a seven-segment display and a decimal point. The decimal point is located within the lower half of the character font to keep the chip the same size as a conventional seven-segment display chip without a decimal point. Since the decimal point is contained in the character chip, no additional process is needed to manufacture a special decimal point chip.

This improved decimal point placement improves the readability of long character strings. As shown in FIG. 5, the readability of a decimal point in a character string using conventional decimal point positioning depends primarily on the vertical separation between the decimal point and the character string. In the improved positioning, as shown in FIG. 6, the readability is increased by greater horizontal spacing between the decimal point and its nearby characters. One character position is dedicated to the decimal point in a string of characters. This invention does require an extra character position to display the decimal point, but the cost of this extra position is less than the extra chip area or assembly time required by conventional displays when used in displays of more than seven characters.

I claim:

1. Visual display apparatus comprising:

a plurality of numeric display means disposed in lineal array to display a plurality of adjacent digits;

the display means being substantially similar and each including regions which emit light in response

to applied excitation and which are arranged in a seven-segment font; and

in each of said display means, an additional region which emits light in response to applied excitation and which is located within the periphery of the surrounding regions for displaying a decimal point when excited in lieu of a digit in the digit place occupied by the associated display means.

2. A display chip as in claim 1 wherein the decimal point is located within the lower area of the font bounded by said regions.

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