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(54) SCALABLE TILED DISPLAY ASSEMBLY FOR FORMING A LARGE-AREA FLAT-PANEL DISPLAY BY USING MODULAR DISPLAY TILES

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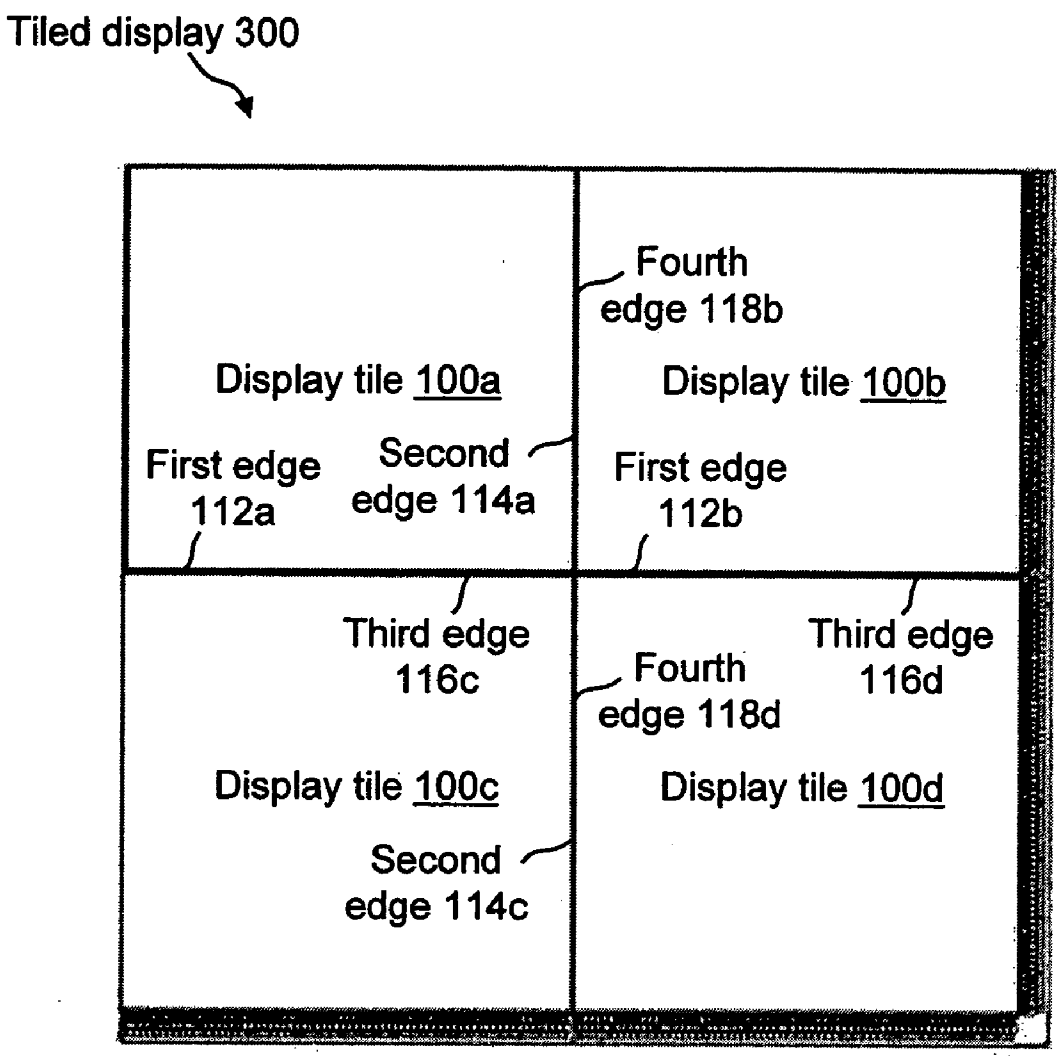
(57) ABSTRACT

A scalable tiled display assembly that includes an array of independently addressed active-matrix organic light-emitting diode (OLED) display tiles cabled to a central control module. Each display tile includes a frame, a driver sub-module, and a flat ribbon cable for connecting the driver sub-module to the display tile. Furthermore, column and row drivers are integrated within each display tile for improved performance and minimal external connections. The invention further includes a method of forming a scalable tiled display system that includes the steps of assembling a plurality of display tile assemblies, determining the viewable area of the display, assembling an array of display tile assemblies according to the desired viewable area, and activating the scalable tiled display system.



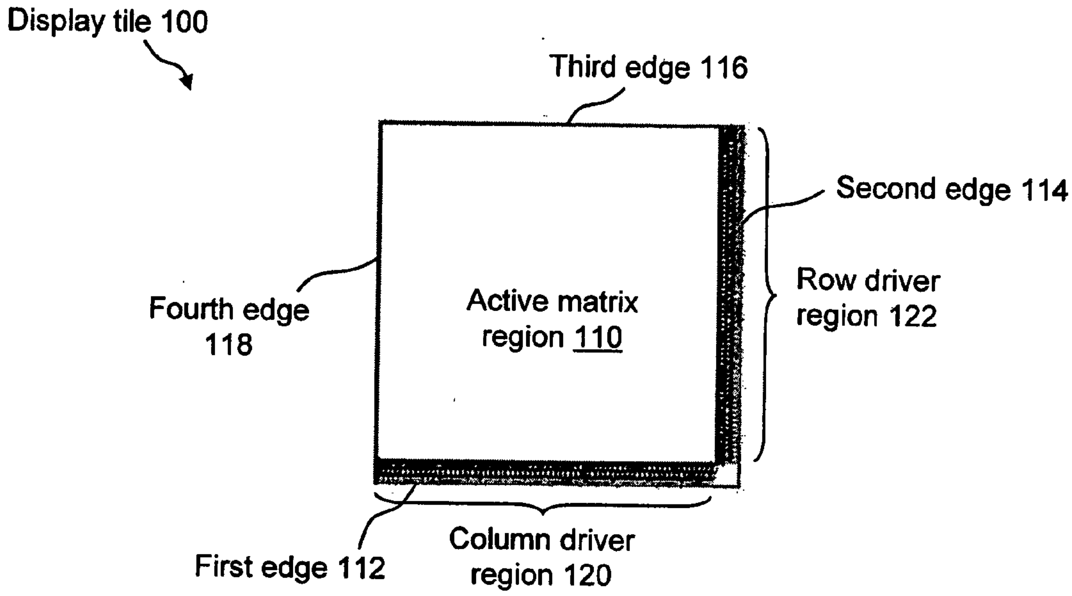

Display tile 100
Third edge 116
Second edge 114
Row driver region 122
Fourth edge 118
Active matrix region 110
First edge 112
Column driver region 120

FIG. 1A

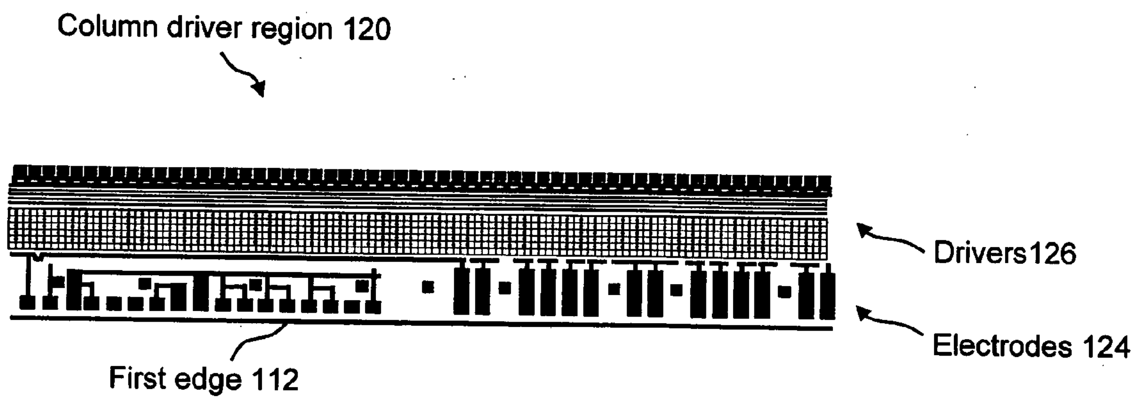

Column driver region 120
Drivers126
Electrodes 124
First edge 112

FIG. 1B

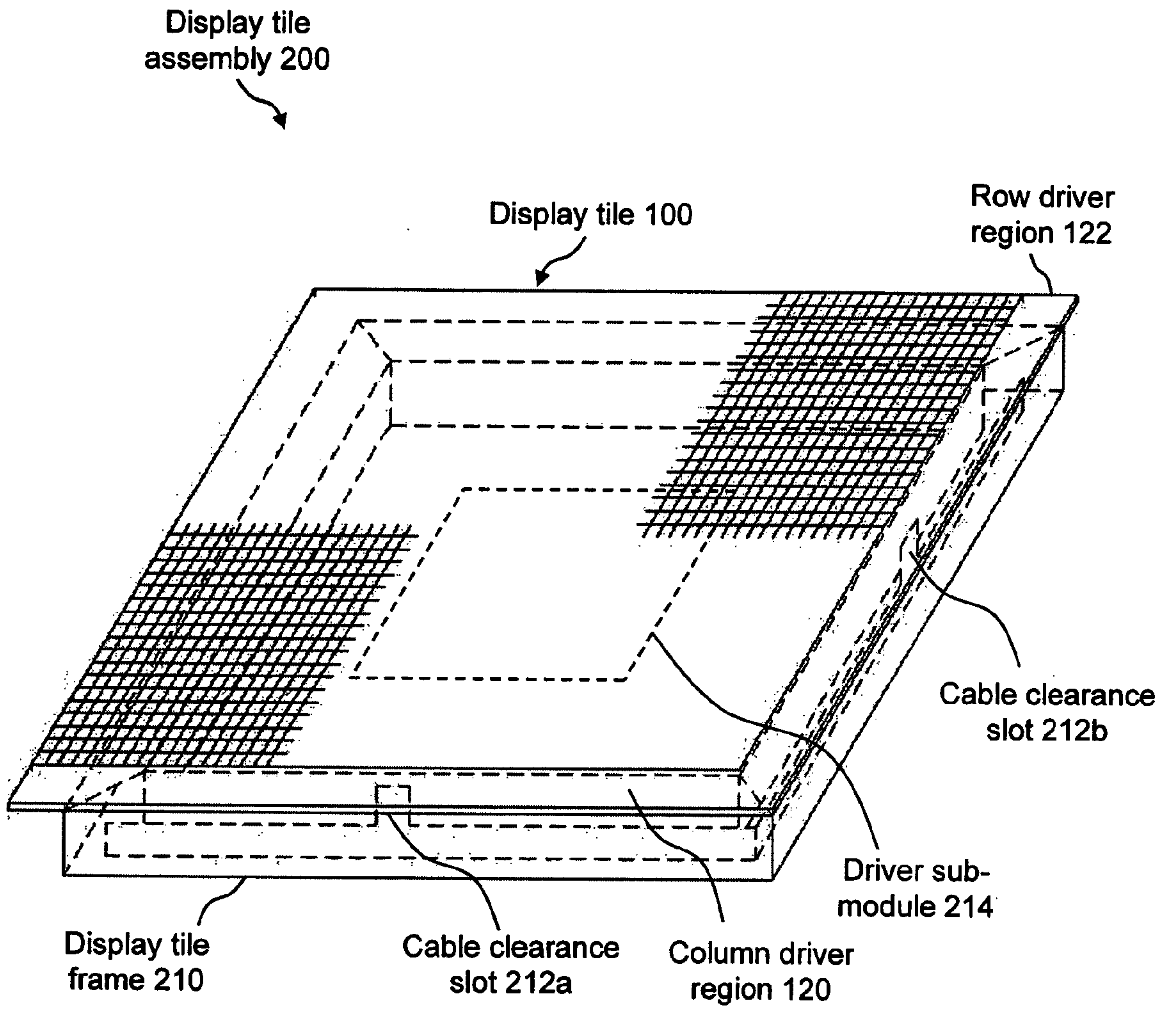

Display tile
assembly 200
Display tile 100
Row driver
region 122
Cable clearance
slot 212b
Driver sub-
module 214
Display tile
frame 210
Cable clearance
slot 212a
Column driver
region 120

FIG. 2

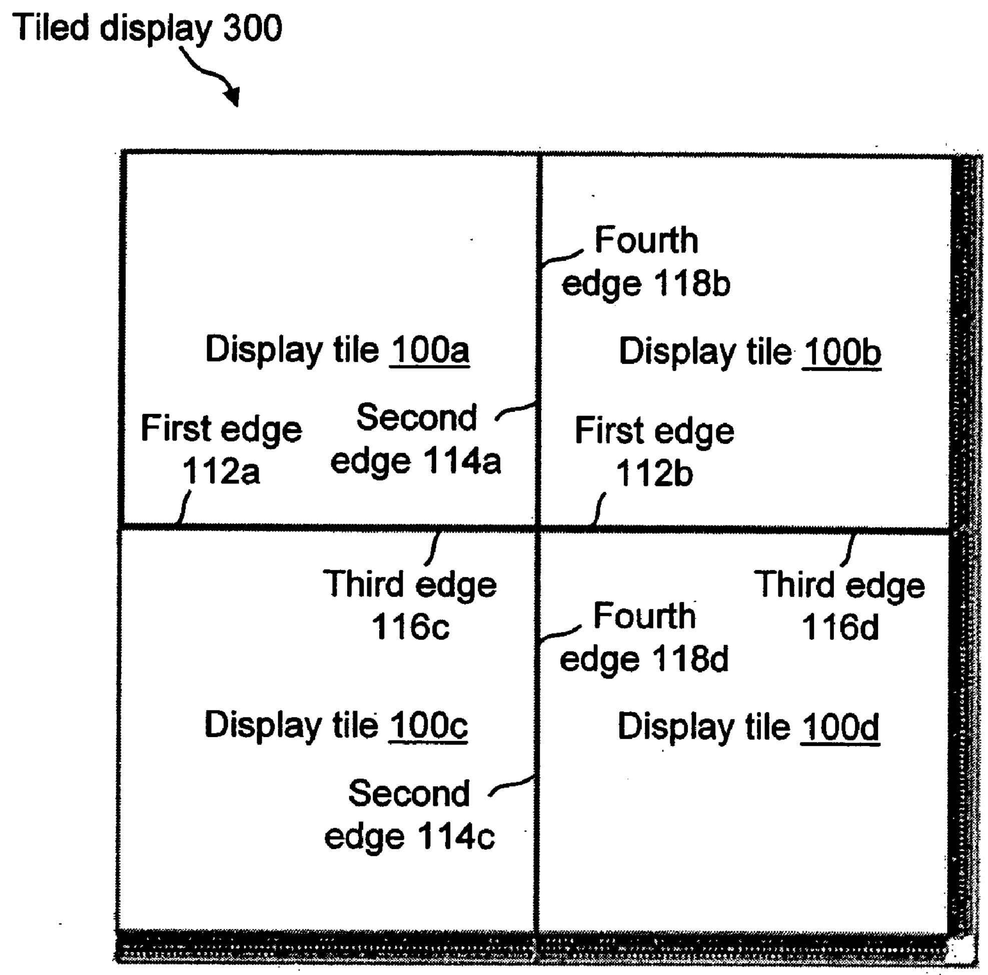

Tiled display 300
Fourth edge 118b
Display tile 100a
Display tile 100b
First edge 112a
Second edge 114a
First edge 112b
Third edge 116c
Fourth edge 118d
Third edge 116d
Display tile 100c
Display tile 100d
Second edge 114c

FIG. 3A

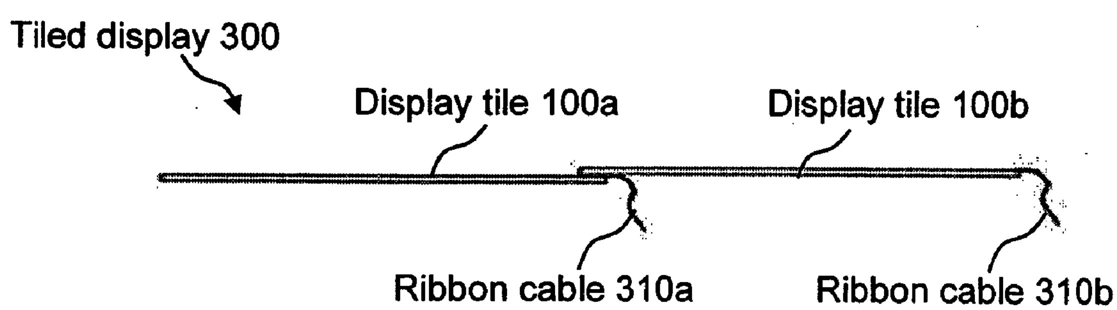

Tiled display 300
Display tile 100a
Display tile 100b
Ribbon cable 310a
Ribbon cable 310b

FIG. 3B

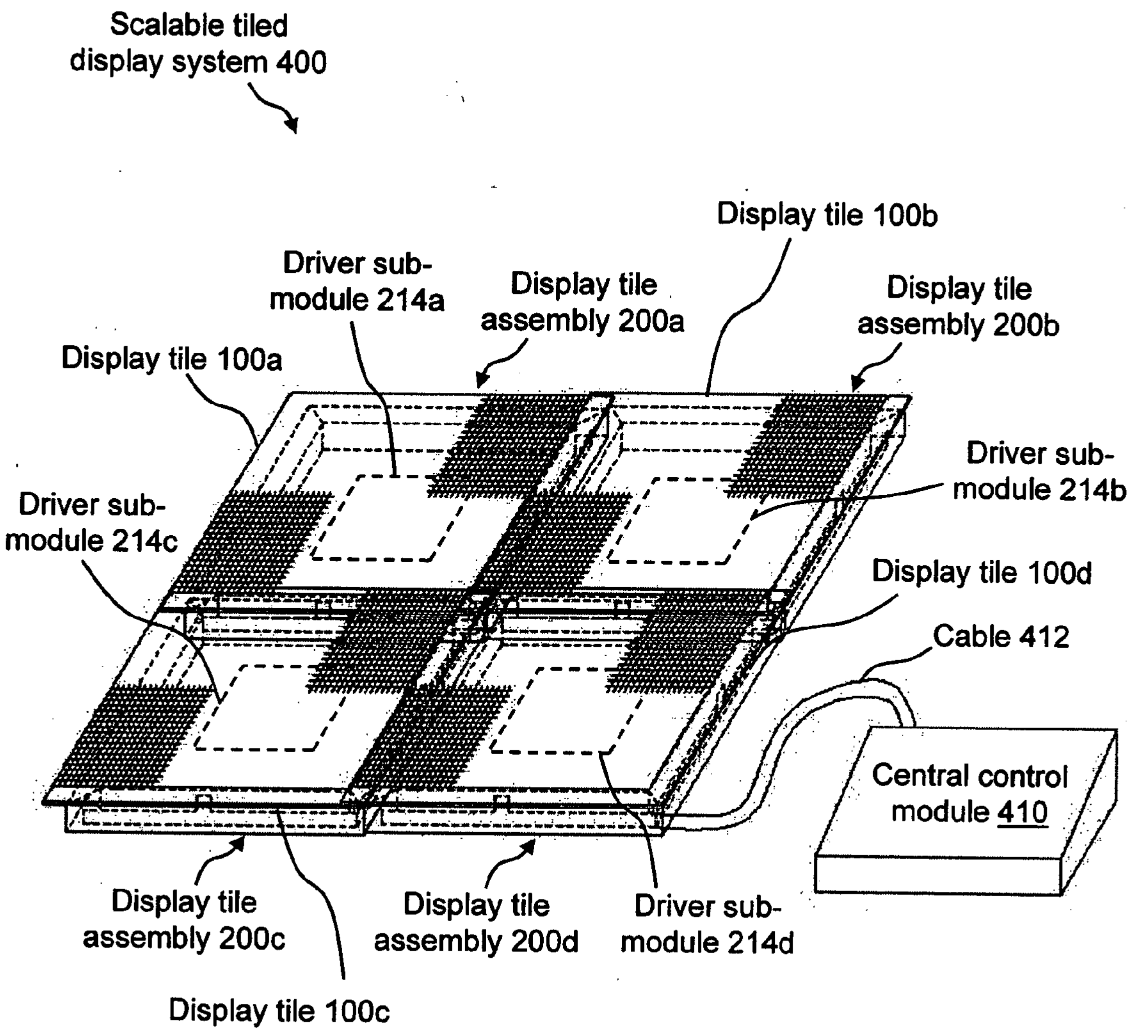

Scalable tiled display system 400
Display tile 100b
Driver sub-module 214a
Display tile assembly 200a
Display tile assembly 200b
Display tile 100a
Driver sub-module 214b
Driver sub-module 214c
Display tile 100d
Cable 412
Central control module 410
Display tile assembly 200c
Display tile assembly 200d
Driver sub-module 214d
Display tile 100c

FIG. 4

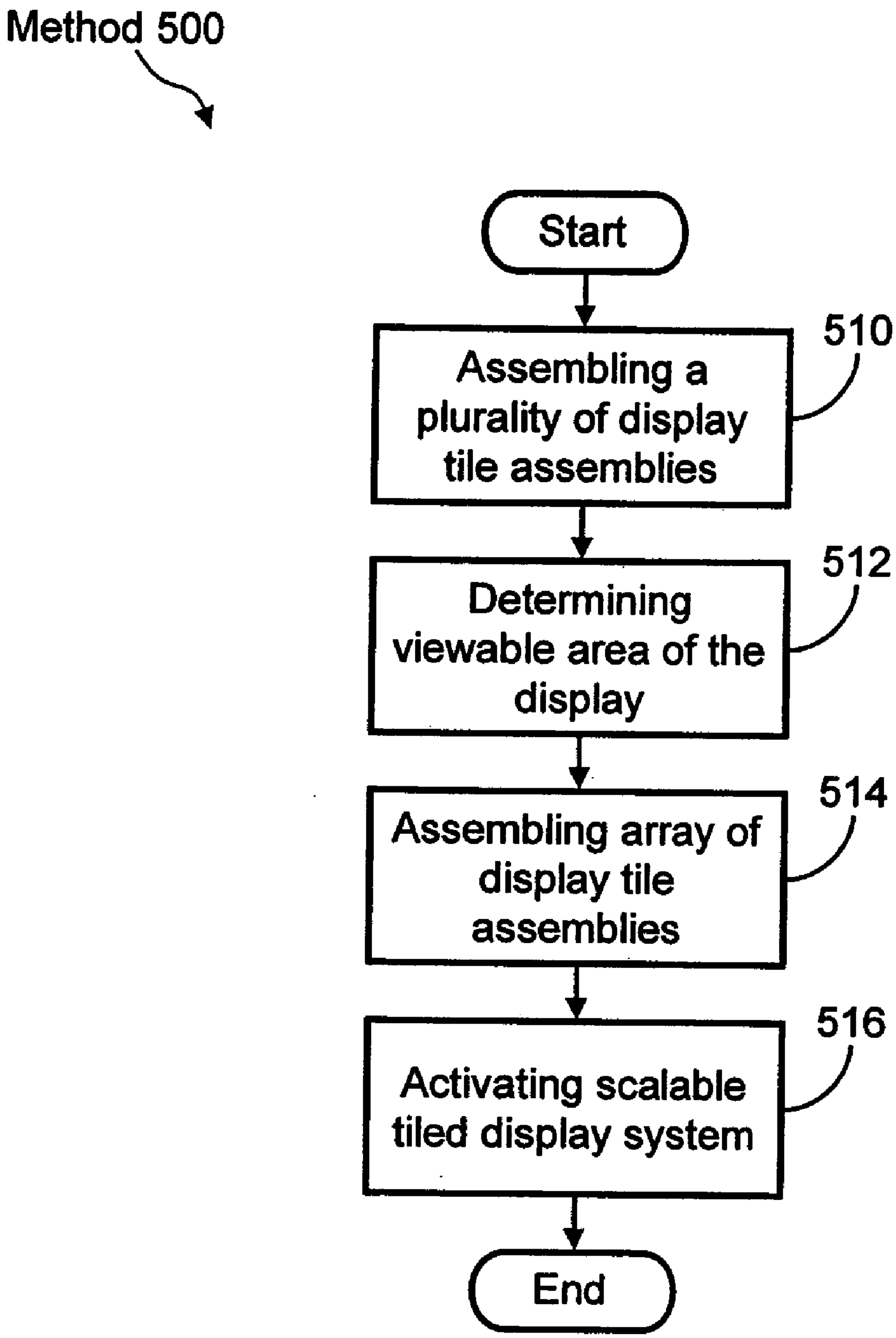

Method 500
Start
510
Assembling a plurality of display tile assemblies
512
Determining viewable area of the display
514
Assembling array of display tile assemblies
516
Activating scalable tiled display system
End

FIG. 5

SCALABLE TILED DISPLAY ASSEMBLY FOR FORMING A LARGE-AREA FLAT-PANEL DISPLAY BY USING MODULAR DISPLAY TILES

FIELD OF THE INVENTION

[0001] The present invention relates to a modular large-screen organic light-emitting diode (OLED) display. In particular, the invention relates to a scalable tiled display assembly for forming a large-area flat-panel display using modular display tiles.

BACKGROUND OF THE INVENTION

[0002] OLED technology incorporates organic luminescent materials that produce intense light of a variety of colors when sandwiched between electrodes and subjected to a DC electric current. These OLED structures can be combined into the picture elements, or pixels, that comprise a display. OLEDs are also useful in a variety of applications as discrete light-emitting devices or as the active element of light-emitting arrays or displays, such as flat-panel displays in watches, telephones, laptop computers, pagers, cellular phones, calculators, and the like. To date, the use of light-emitting arrays or displays has been largely limited to small-screen applications, such as those mentioned above.

[0003] Demands for large-screen display applications that possess higher quality and higher light output has led the industry to turn to alternative display technologies that may replace older light-emitting diode (LED) and liquid crystal displays (LCDs). For example, LCDs fail to provide the bright, high light output, larger viewing angles and speed requirements that the large-screen display market demands. By contrast, OLED technology promises bright, vivid colors in high resolution, high speed reaction and at wider viewing angles. However, the use of OLED technology in large-screen display applications, such as outdoor or indoor stadium displays, large marketing advertisement displays, and mass-public informational displays, is only beginning to emerge. Consequently, the market is now demanding larger displays that have the flexibility to customize display sizes.

[0004] Modular or tiled displays are made from smaller modules or displays that are then combined into larger displays. These tiled displays are manufactured as a complete unit that can be further combined with other tiles to create displays of any size and shape. Two barriers to implementing the tiled approach have been: 1) eliminating the visibility of the seams between tiles; and 2) providing electrical access to the pixels. No practical tiled display system has yet been developed (video walls formed by abutting conventional cathode ray tube (CRT) displays are not considered tiled because of their wide separations between adjacent displays). Accordingly, there is a need for a scalable modular OLED display that is cost-effective, seamless, and is easy to assemble electrically and mechanically.

[0005] An examplary tiled display is described in U.S. Pat. No. 5,644,327, entitled "Tessellated Electroluminescent Display having a Multilayer Ceramic Substrate." The '327 patent describes an electroluminescent display and a combination field emissive and electroluminescent display which are formed as tiles that may be joined together to provide a large-area display device. The exemplary tiles are formed using low-temperature cofired ceramic and metal structures consisting of multiple layers of ceramic circuit-board material laminated to a metal core. Driving circuitry for the displays is mounted on the back of the structures and vias are passed through the structure from the back to the front in order to make connection with the pixel electrodes on the front of the display device.

[0006] Although the tiled display described in the '327 patent provides a means for interconnecting tiles to create a large display system, the '327 patent fails to provide a scalable modular OLED display that is easy to assemble and is low cost.

[0007] It is therefore an object of the invention to provide a scalable modular OLED display that is cost-effective, seamless, and is easy to assemble electrically and mechanically.

[0008] It is another object of this invention to provide a cost-effective way of forming an arbitrarily large flat-panel display.

[0009] It is yet another object of this invention to provide an OLED display module that can be used as a component for easily scaling a flat-panel display to any size.

BRIEF SUMMARY OF THE INVENTION

[0010] The present invention is a scalable tiled display assembly for forming a large-area flat-panel display by using display tiles that are easily assembled in a modular fashion. The scalable tiled display assembly of the present invention is formed of an array of independently addressed display tiles that are assembled in a modular fashion to achieve a seamless large-area flat-panel display of any desired size. Additionally, column and row drivers are integrated within each display tile for improved performance and minimal external connections. Furthermore, the scalable large-area flat-panel display of the present invention is thin, light weight, and low cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **FIG. 1A** illustrates a front view of a display tile that has integrated column and row drivers in accordance with the invention;

[0012] **FIG. 1B** illustrates an expanded view of a column driver region of the display tile of the present invention;

[0013] **FIG. 2** illustrates a perspective view of a display tile assembly in accordance with the invention;

[0014] **FIG. 3** illustrates a front view of a tiled display that is scalable to any size by assembling an array of display tiles in accordance with the invention;

[0015] **FIG. 3B** is an end view of the tiled display of **FIG. 3A**;

[0016] **FIG. 4** illustrates a perspective view of a scalable tiled display system that is scalable to any size by assembling an array of display tile assemblies in accordance with the invention; and

[0017] **FIG. 5** illustrates a flow diagram of a method of forming a scalable tiled display system in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] **FIG. 1A** illustrates a front view of a display tile **100** that has integrated column and row drivers. Display tile **100** is suitable for use in a modular flat-panel display in accordance with the invention. Display tile **100** is a thin (100-150 μm) flexible active matrix OLED display panel that is, for example, 10 to 12 inches square. Display tile **100** includes an active matrix region **110**, which includes electronic circuitry for an array of light-emitting devices, such as OLEDs. Display tile **100** is bounded by a first edge **112**, a second edge **114**, a third edge **116**, and a fourth edge **118**. Display tile **100** further includes a column driver region **120** along first edge **112** and a row driver region **122** along second edge **114**. Column driver region **120** includes integrated column drivers for receiving the display data. Row driver region **122** includes integrated row drivers for receiving the pulsed row signals, as is well known. The design of display tile **100** includes the integrated drivers, which allow for high performance drivers with regard to speed and current capability, as display tile **100** uses cadmium selenide (CdSe) for forming the electronic elements instead of the lower performance amorphous silicon used with LCDs. The integrated row and column drivers of column driver region **120** and row driver region **122** are formed with the same manufacturing process as active matrix region **110**.

[0019] **FIG. 1B** illustrates an expanded view of a column driver region **120** that further includes an exemplary arrangement of electrodes **124** along the outer edge of display tile **100** that allow for electrical connections to an associated exemplary arrangement of drivers **126** for driving active matrix region **110**. In like manner, row driver region **122** includes an arrangement of electrodes **124** and an arrangement of drivers **126**. There is one driver **126** associated with each row and column within active matrix region **110**. There is one electrode **124** associated with each driver **126**.

[0020] With reference to **FIGS. 1A and 1B**, the placement of column driver region **120** and row driver region **122** (with electrodes **124** and drivers **126**) is not limited to two separate edges, respectively. Column driver region **120** and row driver region **122** may both be formed on a single edge only, for example. The width of column driver region **120** and row driver region **122** is any suitable dimension for providing a layout of electrodes **124** and drivers **126** that is practical for making connections to an external cable, for example.

[0021] **FIG. 2** illustrates a perspective view of a display tile assembly **200** in accordance with the invention. Display tile assembly **200** includes display tile **100** mounted atop a display tile frame **210**. Display tile frame **210** further includes multiple cable clearance slots **212** for feeding a cable (not shown) from a driver sub-module **214** to column driver region **120** and row driver region **122** of display tile **100**, for example, a cable clearance slot **212**a for feeding a cable (not shown) from driver sub-module **214** to column driver region **120** and a cable clearance slot **212**b for feeding a cable (not shown) from driver sub-module **214** to row driver region **122**. The individual conductors of the cables, such as standard flat ribbon cables, from driver sub-module **214** are electrically connected to electrodes **124** of column driver region **120** and row driver region **122** via soldering or clamping.

[0022] Driver sub-module **214** provides a second set of active drivers as a signal distribution mechanism for addressing drivers **126** of column driver region **120** and row driver region **122** and, thus, provides the drive data and picture information to display tile **100**. Driver sub-module **214** also provides power and timing signals to its associated tile. Driver sub-module **214** is, for example, a standard printed circuit board with active driver devices. Driver sub-module **214** is located behind display tile **100** and is sized suitably small enough to fit within display tile frame **210**. Display tile frame **210** is formed of any suitable lightweight and rigid material, such as molded plastic or aluminum. Display tile frame **210** forms a physical cage of support for display tile **100** at the edges of display tile **100**.

[0023] **FIG. 3A** illustrates a front view of a tiled display **300** that is scalable to any size by assembling an array of display tiles **100** in accordance with the invention. For example, **FIG. 3A** shows a 2×2 arrangement of a display tile **100**_a_, a display tile **100**_b_, a display tile **100**_c_, and a display tile **100**_d_. Tiled display **300** is not limited to the 2×2 arrangement shown in **FIG. 3A**. Tiled display **300** is scalable to any arbitrary number of display tiles **100** to form a large-area tiled display **300** of any desired dimension.

[0024] In the example of **FIG. 3A**, fourth edge **118**_b_ of display tile **100**_b_ overlaps row driver region **122**_a_ (not visible) at second edge **114**_a_ of display tile **100**_a_, third edge **116**_c_ of display tile **100**_c_ overlaps column driver region **120**_a_ (not visible) at first edge **112**_a_ of display tile **100**_a_, third edge **116**_d_ of display tile **100**_d_ overlaps column driver region **120**_b_ (not visible) at first edge **112**_b_ of display tile **100**_b_, and fourth edge **118**_d_ of display tile **100**_d_ overlaps row driver region **122**_c_ (not visible) at second edge **114**_c_ of display tile **100**_c_. As a result, only active matrix region **110** of each display tile **100** is visible and, thus, tiled display **300** appears as seamless to the viewer thereof.

[0025] **FIG. 3B** is an end view of tiled display **300** of **FIG. 3A**. In this view, the overlap of fourth edge **118**_b_ of display tile **100**_b_ upon row driver region **122**_a_ (not visible) at second edge **114**_a_ of display tile **100**_a_ is evident. Additionally, **FIG. 3B** shows that tiled display **300** includes a plurality of ribbon cables **310**. For example, a ribbon cable **310**_a_ sandwiched between display tile **100**_a_ and display tile **100**_b_ that is mechanically and electrically connected to electrodes **124** (not visible) of display tile **100**_a_. Likewise, a ribbon cable **310**_b_ is mechanically and electrically connected to electrodes **124** (not visible) of display tile **100**_b_. Each display tile **100** is independently powered and addressed via its own ribbon cable **310**. The total thickness of tiled display **300** at the overlap area is in the range of 6 to 10 mils. Alternatively, the ribbon cable electrodes (i.e., electrodes **124**) may be replaced by electrodes formed on the edge on the backside of each display tile **100**. This would allow ribbon cable **310** to come off the back of display tile **100**, rather than be sandwiched between one display tile **100** and the next, thereby reducing the total overlap thickness.

[0026] **FIG. 4** illustrates a perspective view of a scalable tiled display system **400** that is scalable to any size by assembling an array of display tile assemblies **200** in accordance with the invention. For example, **FIG. 4** shows a 2×2 arrangement of a display tile assembly **200**_a_, a display tile assembly **200**_b_, a display tile assembly **200**_c_, and a display tile assembly **200**_d_. Scalable tiled display system **400** further includes a central control module **410** that is electrically connected to the array of display tile assemblies **200** via a cable **412**. More specifically, cable **412** is representative of a bundle of cables that connect central control module **410** to/from all driver sub-modules **214** that are present within scalable tiled display system **400**. On one end each cable within the bundle represented by cable **412** is electrically connected to its associated driver sub-module **214** via soldering or a standard multi-pin cable connector. Similarly, the opposite end is electrically connected to the electronics of central control module **410** via a standard multi-pin cable connector. Central control module **410** serves as the central image processor. Central control module **410** controls the scanning and illumination of the pixels on each display tile **100**.

[**0027**] A second set of ribbon cables **310** (not shown) connects each driver sub-module **214** to electrodes **124** of its respective display tile **100**. Cable **412** also handles the power distribution and timing signals to all driver sub-modules **214** and display tiles **100**. The structure of scalable tiled display system **400** forms physical cages of support (i.e., display tile frames **210**) with the face of the individual display tiles **100** arranged seamlessly along a common visible plane, whereby all substructures and cables are hidden from view.

[**0028**] In operation, central control module **410** addresses each driver sub-module **214** via cable **412** with their respective picture information, i.e., drive data, brightness, and picture information. Central control module **410** serves at the image processor that provides image data that is specific to each display tile **100**, based upon the physical location of each given display tile **100** within the overall scalable tiled display system **400** and, thus, each display tile **100** is independently addressed. Central control module **410** controls the scanning and illumination of the pixels on each display tile **100**. Each driver sub-module **214** then distributes the signals via ribbon cables **310** to its respective display tile, **100** and, thus, addresses its respective column driver region **120** and row driver region **122**. As is well known, row driver elements are excitable one at a time, while column drivers receive the picture data and then store it in local memory, which is then energized by the row gating signals.

[**0029**] **FIG. 5** illustrates a flow diagram of a method **500** of forming a scalable tiled display system **400** in accordance with the invention.

[**0030**] At step **510**, a plurality of display tile assemblies **200** are formed by a flat-panel display manufacturer for use within a scalable tiled display system **400**. At step **512**, the flat-panel display manufacturer (or display system customer) determines the size of the viewable area of the display scalable tiled display system **400** and, thus, determines the required configuration of the array of display tile assemblies **200**. At step **514**, the flat-panel display manufacturer assembles the plurality of display tile assemblies **200** edge-to-edge, according to the configuration determined at step **512**. The flat-panel display manufacturer also connects all ribbon cables **310** between all driver sub-modules **214** and their respective display tiles **100** and connects cable **412** between all driver sub-modules **214** and central control module **410**, accordingly. At step **516**, the user activates scalable tiled display system **400** via central control module **410**, which supplies image data that is specific to each display tile **100**, based upon the physical location of each given display tile **100** within the overall scalable tiled display system **400** and, thus, each display tile **100** is independently addressed. Method **500** ends.

[**0031**] Although the invention has been described in detail in connection with the exemplary embodiments, it should be understood that the invention is not limited to the above disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alternations, substitutions, or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Accordingly, the invention is not limited by the foregoing description or drawings, but is only limited by the scope of the appended claims.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A tiled display structure, comprising a plurality of display tiles arranged in an array, at least one of the plurality of display tiles having a first edge including a column driver region and a second edge including a row driver region, wherein the plurality of display tiles are arranged so that at least one of the first and second edges of the at least one of the plurality of display tiles is overlapped by an edge of another of the plurality of display tiles.

2. The tiled display structure of claim 1, wherein both of the first and second edges of the at least one of the plurality of display tiles are overlapped by edges of other display tiles of the plurality of display tiles.

3. The tiled display structure of claim 1, wherein the display tiles comprise organic light-emitting diode (OLED) devices.

4. The tiled display structure of claim 1, wherein the display tiles are arranged on a display tile frame.

5. The tiled display structure of claim 4, wherein the tile frame comprises at least one via for providing electrical circuitry to the first and second edges.

6. The tiled display structure of claim 5, wherein the electrical circuitry provides electrical connection between the column driver region and the row driver region and a driver sub-module corresponding to the at least one of the plurality of display tiles.

7. The tiled display structure of claim 6, wherein the driver sub-module is located within the display tile frame.

8. The tiled display structure of claim 1, wherein the tiled display structure has a thickness of about 6 to 10 millimeters.

9. An electronic display assembly, comprising:

an array of independently addressable display tiles, wherein each of the independently addressable display tiles comprises:

a display region defining a pixel area having an active region which occupies a portion of the pixel area; and

at least one active edge region adjacent the active region and including at least one of a column driver region and a row driver region,

wherein the independently addressable display tiles are arranged in the array so that the at least one active edge region of one independently addressable display tile overlaps with another edge of another display tile of the array.

10. The electronic display assembly of claim 9, wherein both the column driver region and the row driver region are provided on the at least one active edge region.

11. The electronic display assembly of claim 9, wherein only one of the column driver region and the row driver region is provided on the at least one active edge region.

12. The electronic display assembly of claim 11, wherein the other one of the column driver region and the row driver region is provided on another active edge region of the display tile, the another active edge region being adjacent the at least one active edge region.

13. The electronic display assembly of claim 9, wherein the active region includes at least one light-emitting device.

14. The electronic display assembly of claim 13, wherein the at least one light-emitting device is an organic light-emitting diode.

15. The electronic display assembly of claim 9, wherein each of the column driver region and the row driver region further comprises at least one driver and at least one electrode for driving the active region of each display tile.

16. The electronic display assembly of claim 9, wherein the display region is coupled to the upper surface of the substrate by a plurality of cable structures, the cable structures connecting the active region of each display tile to a corresponding driver sub-module.

17. The electronic display assembly of claim 16, wherein the plurality of cable structures comprises at least one flat ribbon cable.

18. A method of constructing a tiled electronic display structure, comprising:

assembling a plurality of independently addressable display tiles in an array, each of the display tiles having a display region defining a pixel area having an active region which occupies a portion of the pixel area, and at least one active edge region adjacent the active region and having integrated at least one of a column driver region and a row driver region,

wherein the step of assembling the plurality of independently addressable display tiles further comprises arranging the independently addressable display tiles so that the at least one active edge region of one independently addressable display tile overlaps with another edge of another independently addressable display tile of the array.

19. The method of claim 18, further comprising the steps of:

determining a desired viewable area for the electronic display structure; and

accordingly assembling a predetermined number of said plurality of independently addressable display tiles in the array, the number of said display tiles corresponding to the desired viewable area of the electronic display structure.

* * * * *