Title: LIGHT-EMITTING FIBER, AND METHOD FOR MAKING AND TESTING SAME

Abstract: A light-emitting fiber (100) comprises an optical fiber (110) having a number of light-emitting elements (180) disposed along the length of one surface thereof. The light-emitting elements (180) include a segmented hole injecting electrode (122) on which an electro-luminescent material (130), such as an OLED material, is disposed and an electron injecting electrode (140) overlying the OLED layer (130). The segmented hole injecting electrodes (122) are connected together by an electrical conductor (160) disposed on a side surface of the optical fiber. An elongated electrical conductor (150) connects to the electron-injecting electrodes (140) of each light-emitting element (180) and provides a test contact (154) not overlying any light-emitting element (180). After testing utilizing the test contact (154), the elongated conductor (150) is segmented to provide an electrical contact (150) for each light-emitting element (180). The electrodes (122, 140), electro-luminescent material (130) and contacts (150, 152, 154) are deposited on the fibers (110) by mask deposition, preferably utilizing masks (420, 520) adapted to contemporaneously process a plurality of fibers (100).
LIGHT-EMITTING FIBER, AND
METHOD FOR MAKING AND TESTING SAME

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Number 60/182,156 filed February 14, 2000.

The present invention relates to a light-emitting fiber and, in particular, to a
long light-emitting fiber and a method for making and testing same.

It has long been desired that electronic displays be made with larger screen
sizes and also be very thin, ultimately reaching a configuration that may be hung on a
wall. Inherent physical limitations preclude conventional cathode ray tubes, such as
the color picture tubes and display tubes utilized in televisions, computer displays,
monitors and the like, from achieving such desired result. While plasma displays
have been proposed to satisfy such desire, the large glass vacuum envelope they
require is difficult to manufacture, and thus is expensive, which is not desirable.

The entire display screen of such plasma devices must be fabricated as a single
piece and must reproduce many thousands of pixels. Any significant defect that
results in faulty pixels or in a non-uniform brightness across the screen, even if
confined to a relatively small area, renders the entire screen defective. Such defects
cannot be tested or detected until the entire screen is processed, and are either not
susceptible of repair or are very expensive to repair, thereby substantially reducing the
yield and increasing the cost of each satisfactory plasma display.

One attractive approach for producing a large, thin display screen is to provide
an array of a large number of adjacent light-emitting fibers. An advantage of such
light-emitting fiber display is that each fiber is relatively inexpensive and may be
separately tested before assembly into a display. Because defective fibers are detected
and discarded before assembly into a display, the yield of a display which is made
from known good light-emitting fibers is increased and the cost thereof is reduced.
One such fiber display is described in U.S. Patent __________ entitled "FIBER-
BASED FLAT PANEL DISPLAY" (U.S. Patent Application No. 09/418,454 filed
October 15, 1999).
With regard to such fiber-based displays, it is desirable that light-emitting fibers therefor be available that can be fabricated in a variety of ways, such as for improving performance, enhancing processing, enabling testing, facilitating assembly of fibers into a display, and/or reducing cost.

Accordingly, there is a need for a light-emitting fiber that is fabricated in a way that tends to facilitate the testing of such fiber.

To this end, the light-emitting fiber of the present invention comprises a first electrode including a plurality of first electrode segments disposed along the length of a first surface of an optically transparent fiber, wherein the first electrode segments include a layer of an optically-transparent electrically conductive material. An elongated electrical conductor is disposed along the length of the fiber on a second surface thereof, wherein the elongated electrical conductor is in electrical contact with each of the first electrode segments. A light-emitting material is disposed on the plurality of electrode segments and a second electrode is disposed on the light-emitting material. An elongated electrical contact is disposed on said second electrode, wherein at least the elongated electrical contact connects to the second electrode of the light-emitting elements disposed along the length of the fiber.

A method for making a light-emitting fiber comprises:

providing a length of fiber having a plurality of spaced-apart first electrode segments along the length thereof and having an electrical conductor along a side thereof in electrical contact with the plurality of spaced-apart first electrode segments;

depositing a layer of a light-emitting material on the first electrode segments along the fiber;

depositing a second electrode on the layer of light-emitting material and substantially overlying the spaced-apart first electrode segments; and

depositing an elongated electrical contact on the second electrode and extending to overlie the plurality of spaced-apart first electrode segments.

The method may be practiced on one fiber or on an array of a plurality of fibers.
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BRIEF DESCRIPTION OF THE DRAWING

The detailed description of the preferred embodiments of the present invention will be more easily and better understood when read in conjunction with the FIGURES of the Drawing which include:

FIGURES 1A, 1B and 1C are a sequence of schematic diagrams of a top view of portion of an exemplary embodiment of a light-emitting fiber illustrating the fabrication and arrangement thereof;

FIGURES 2A, 2B and 2C are a sequence of schematic diagrams of a top view of portion of an alternative exemplary embodiment of a light emitting fiber illustrating the fabrication and arrangement thereof in accordance with the invention;

FIGURE 3 is a top view schematic diagram of a step in the fabrication of the exemplary light emitting fiber of FIGURES 2A - 2C;

FIGURES 4A through 4G are a sequence of top view schematic diagrams illustrating steps in the fabrication of the exemplary light emitting fiber in accordance with the invention;

FIGURES 5A, 5B and 5C are a sequence of top view schematic diagrams illustrating alternative steps in the fabrication of the exemplary light emitting fiber in accordance with the invention;

FIGURES 6A and 6B are a sequence of top view schematic diagrams illustrating alternative steps to FIGURE 4E for contemporaneously fabricating a plurality of the exemplary light emitting fibers in accordance with the invention;

FIGURES 7A and 7B are a sequence of top view schematic diagrams illustrating alternative subsequent steps to FIGURE 5C for contemporaneously fabricating a plurality of the exemplary light emitting fibers in accordance with the invention;

FIGURES 8A through 8C are a sequence of top view schematic diagrams illustrating alternative steps to FIGURES 4D - 4G and 5B - 5C for contemporaneously fabricating an array of a plurality of the exemplary light emitting fibers in accordance with the invention; and

FIGURES 9 and 10 are schematic diagrams of exemplary masking arrangements useful in contemporaneously processing plural exemplary light emitting
fibers or in processing a single fiber.

In the Drawing, where an element or feature is shown in more than one drawing figure, the same alphanumeric designation may be used to designate such element or feature in each figure, and where a closely related or modified element is shown in a figure, the same alphanumeric designation primed may be used to designate the modified element or feature. It is noted that, according to common practice, the various features of the drawing are not to scale, and the dimensions of the various features are arbitrarily expanded or reduced for clarity.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGURES 1A, 1B and 1C are a sequence of schematic diagrams of a top view of an exemplary embodiment of a light-emitting fiber 100 illustrating the fabrication and arrangement thereof. A plurality of such fibers 100 are arrayed in side-by-side array, preferably being substantially contiguous, and are connected to appropriate electrical driver circuits for selectively and controllably energizing each light-emitting element (pixel) to produce a display for displaying information. Image and/or information are used interchangeably with respect to what is displayed on a display device, and are intended to encompass any and all of the wide variety of displays that a user may desire, including, but not limited to, visual images and pictures, whether still or moving, whether generated by a camera, computer or any other source, whether true, representative or abstract or arbitrary, whether or not including symbols or characters such as alphanumeric characters or mathematical notations, whether displayed in black and white, monochrome, polychrome or full color.

Light-emitting fiber 100 is fabricated on a ribbon or fiber 110 of conventional optically transmissive material, such as glass, borosilicate glass, soda-lime glass, quartz, sapphire, plastic, polymethyl-methacrylate (PMMA), polycarbonate, acrylic, Mylar, polyester, polyimide or other suitable material, to have along its length on one of its surfaces 112 (e.g., a top surface 112) a plurality of light-emitting elements 180. Light-emitting elements 180 include an electro-luminescent material, preferably an Organic Light-Emitting Diode (OLED) material, disposed between suitable
electrodes. A quartz fiber may be preferred if chemical inertness is desired, and a plastic fiber may be preferred if greater flexibility is desired. Such ribbon or fiber is generally referred to herein as an optical fiber, it being understood that the material and physical size and shape of such ribbon or fiber may vary.

Each light-emitting element or OLED "stack" 180 includes at least a hole injecting electrode 122, a layer of light-emitting material 130 and an electron injector electrode 140, and is independently operable to produce one pixel of the image or information to be displayed. Alternatively light emission can occur in the electron (or hole) transport material in a region near the boundary with the hole (or electron) transport layer. In a color display, three physical pixel elements 180 may each produce one of three color sub-pixels that together produce one color pixel of a color image.

FIGURE 1A shows a segmented electrode layer 120 on top surface 112 of optical fiber 110, such as by depositing a conductive layer 120 such as indium tin oxide (ITO), tin oxide, zinc oxide, combinations thereof, or another transparent hole-injecting material. Only a portion of light-emitting fiber 100 is shown in FIGURES 1A-1C. Each segment of ITO layer 120 serves as the hole injecting electrode 122 of OLED light-emitting element or stack 180. The spaces 126 between adjacent ITO electrodes 122 are of sufficient dimension along the length of fiber 110 for receiving an electrical contact 154 thereon for applying a data signal to light-emitting element 180, as described below.

An electrically conductive bus 160, preferably of a highly conductive metal such as aluminum, copper, gold, chromium/gold (Cr Au) or silver, is deposited on or attached to one side 116 of optical fiber 110 and slightly overlaps the ITO either on top surface 112 or on side surface 116 to make electrical contact to each ITO electrode 122 thereon for connecting the hole injecting electrode 122 of each light-emitting element 180 to a select input electrode 124 at one or both ends 118 of optical fiber 110. Electrical bus 160, which couples a select drive signal to the ITO electrodes 122 of each light-emitting element 180 along the length of optical fiber 110, is covered by an insulating layer 170 (not shown in FIGURE 1A).

Next, a layer 130 of OLED material is deposited on segmented electrodes 122,
which OLED layer 130 may or may not be segmented, and need not be segmented. In
the simplest form for fabrication, OLED layer 130 is continuous, as illustrated in
FIGURE 1B. OLED layer or stack 130 does not overlie end ITO electrode 124.
OLED stack 130 typically includes of several different layers of material, each
typically having a thickness of about 500 Å. A segmented layer 140 of electron
injecting material is deposited over OLED layer 130, typically through the same mask
that is utilized for deposition of the OLED hole transport and electron transport layers,
and a relatively durable conductive segmented contact layer 150 is likewise deposited
onto segmented electrode layer 140 with the segments of layers 140 and 150 in
registration. The aligned segment breaks of electrode layer 140 and contact layer 150
overlie spaces 126 of ITO layer 120 close to an edge of each ITO electrode 122. The
segments of ITO layer 120 and of electron injecting/contact layers 140, 150 are thus
of like pitch along the length of optical fiber 110 but are offset so that each segment
of contact layer 150 overlies one ITO electrode 122 and provides a contact 154 to
electrode 140 overlying the space 126 adjacent to the same one ITO electrode 122.
Top electrode 140 may be a layer of magnesium, magnesium/silver, calcium,
calcium/aluminum, lithium fluoride or lithium fluoride/aluminum, or any other stable
electron injector. Contact layer 150 may be aluminum, gold, chromium/gold (Cr Au),
copper or silver, for example, or any other durable high-conductivity material. Top
electrodes 140 and contacts 150 are in one-to-one correspondence with one another
and with ITO contacts 120 along the length of optical fiber 110.

Contacts 154 are durable and provide a durable contact structure to which
probes may be applied for testing and to which conductors providing pixel data
signals are connected, which data signal conductors lie transverse to the length
direction of light-emitting fibers 100 in an array of a display. Because there is no ITO
electrode under the contact 154 portion of contact layer, the application of test probes
and the connecting of such transversely oriented data signal conductors to such
contact 154 cannot cause a short circuit through or damage to OLED layer 130
between the hole injecting electrode 122 and the electron injecting electrode 140 of
any light-emitting element 180. The deposition of contact layer 150 also produces a
contact 152 at the end 118 of optical fiber 110 connecting directly to ITO end
electrode 124 (there is no OLED layer 130 or insulator material overlying ITO electrode 124) and electrical bus 160 at the end 118 of optical fiber 110 to provide a durable contact structure to which conductors providing pixel select signals are connected.

Thus, suitable electrical connections can be made to couple the select signal and the data signal to respective electrodes 122 and 140 of each light-emitting element 180 for controllably and selectively energizing each light-emitting element 180 to produce the pixels of an image to be displayed by a display including a plurality of light-emitting fibers 100 in parallel side-by-side array. These connections are made to the surface of the light-emitting fibers 100 on which the light-emitting elements are formed, and the light emitted thereby passes through the optical fiber 110 away from the light-emitting elements 180 to be observed by a viewer of such display. It is noted that because light-emitting fibers 100 may be of any desired length, and because any desired number of such fibers 100 may arrayed side-by-side, a thin panel display of virtually any desired size (height and width) may be assembled utilizing the present invention.

Particularly in large displays, the lengths of select conductor 160 may become long and the resistance of a thin-film or other deposited conductor 160 may be higher than desired. Conductor 160 may be made thicker than the thicknesses obtainable by deposition of metals, such as by attaching thin strips of metal foil (e.g., 25-50 μm thick) along the length of fiber 100 and connected to each one of the ITO segments 122 by a spot of electrically-conductive epoxy or adhesive. Such strips 160 may be of aluminum, copper, silver, gold or other suitable metal, and may be in place of or in addition to the deposited strips 160. Where a metal foil strip 160 is employed in addition to a deposited conductor 160, the metal foil strip may be attached to deposited conductor 160 by electrically-conductive epoxy or adhesive, or may be simply be compressed against deposited conductor 160 by the (insulated) side of an adjacent fiber 100.

Light-emitting fiber 100 may be tested before being assembled with other like fibers into an array, and it is preferred to do so because faulty light-emitting fibers, which are relatively low in cost in relation to a complete display, may be discarded or
repaired before they are assembled with other like fibers. Fiber 100 may be tested, for example, by applying suitable potential between select contact 124 at end 118 of fiber 100 and the top contact 154 of each OLED stack 180 along the length of fiber 100 and observing a particular operating characteristic thereof, such as current flow at a particular potential, light output at a particular current, and the like. In effect, each pixel element 180 is tested separately, although all or groups of elements may probed simultaneously or sequentially. Where light-emitting elements 180 are small and closely spaced, e.g., on about a 0.75 mm (about 0.030 inch) pitch on a 0.25 mm (about 0.010 inch) wide fiber 110, the probes needed to apply such test potentials are very small and must be placed with close tolerance and gentle force to avoid damage to light-emitting elements 180.

FIGURES 2A, 2B and 2C are a sequence of schematic diagrams of a top view of portion of an alternative exemplary embodiment of a light emitting fiber 100 illustrating the fabrication and arrangement thereof in accordance with the invention. FIGURE 2A illustrates the deposition of a segmented transparent ITO electrode layer 120 on fiber or ribbon 110 to define first electrodes 122 of the individual light-emitting elements to be formed thereon. The spaces between adjacent ITO segments 122 can be very small because they need only provide a space over which a very fine scribe will be made. An ITO electrode segment 124 is also formed at one end 118, and preferably at both ends 118, of fiber 110 to later provide connection for the pixel select signal. End ITO segment 124 is spaced away from the nearest ITO electrode 122 so that a test contact can be provided in that space. A metal conductor 160 is formed on one side of fiber 110 and connects to each of ITO segments 122, 124 in like manner to that described above, thereby electrically connecting all of segments 122, 124 together.

Next, as illustrated in FIGURE 2B, a segmented OLED layer 130 is applied on the hole-injecting ITO electrode segments 122 and in registration therewith. Each OLED segment will eventually become an operable light-emitting element of an individual pixel along a complete fiber 100. Then, an elongated electron-injecting electrode layer 140, which may or may not be segmented in registration with ITO electrodes 122 and OLED segments 130, is deposited along the length of fiber 110 on
all of the OLED segments 130 thereon, preferably slightly spaced away from the side edges thereof. An elongated metal conductive contact layer 150 is deposited on the electrode layer 140, as illustrated in FIGURE 2C, for example. The portion of top metal conductor 150 that is over the space between end ITO segment 124 and the nearest ITO segment 122 thereon provides a contact 154 at one end, or preferably at both ends, of top conductor 150 near one or both ends 118 of fiber 110. As part of the same deposition, a metal contact 152 is deposited on the ITO segment 152 at one end 118, or preferably at both ends 118, of fiber 110.

As a result, all of the OLED light-emitting elements 180 along the length of fiber 110 are connected in parallel because all of their respective hole-injecting electrodes 122 are connected to select signal contacts 152 by conductor 160 and because all of their respective electron-injecting electrodes 140 are connected to data signal contacts 154 by electrode layer 140 and/or conductive metal layer 150. Thus, when operating potential is applied between one of contacts 152 and one of contacts 154, all of the light-emitting elements along the length of fiber 110 are energized and can be tested simultaneously. This parallel connection is temporary, and is broken after test of light-emitting elements 180 of fiber 110 as described below. A further advantage accrues because this test requires only a single probing by only two test probes, one to a select contact 152 and the other to a data contact 154. Should there be a problem with all the light-emitting elements or with those at one end of fiber 110, the contacts 152, 154 at the other end of fiber 110 provide an alternative and redundant set of contacts that may be energized in investigating that condition.

Following testing of the paralleled light-emitting elements 180 of fiber 110, top metal conductor 150 (and top electrode 140 if not formed as a segmented layer 140) are segmented by scribing to leave a plurality of separated light-emitting elements 180 along the length of light-emitting fiber 100. Scribing of conductor 150 (and electrode layer 140) is made transverse to the length of fiber 110 over the spaces between adjacent ones of ITO segments 122 and OLED segments 130, thereby to leave segmented top contacts 150 in one-to-one correspondence and registration with the segmented ITO electrodes 122 and the OLED segments 130 thereon. Scribing can be done using a mechanical scribing instrument, a laser, a fine saw such as a dicing
saw for semiconductor wafers, or other suitable scribing method, however, laser
scribing is preferred.

It is noted that the scribing is made over the spaces between light-emitting
element stacks 180 so that there is no damage to the OLED material 130 or ITO
electrodes thereof. Each stack of ITO electrode 122, OLED segment 130, electron-
injecting electrode segment 140 and top contact segment 150 is a separate and
independently operable light-emitting element 180 along the length of light-emitting
fiber 100. After scribing, however, the edges of OLED material segments 130 along
the scribes are exposed, and so are susceptible to the effects of moisture and oxygen.

Alternatively, the OLED stack may be patterned, for example, by depositing
the OLED material 130 through a mask, so that a discrete OLED segment overlies
each ITO segment 122 is spaced apart from the next adjacent OLED segments. Top
electrode 140 and/or contact 150 are then deposited to completely cover and extend
beyond the edges of each OLED segment, thereby to seal the edges thereof against
moisture and oxygen. The scribing of electrode 140 and/or contact 150 may then be
in the spaces between adjacent OLED segments so that the OLED material is not
exposed as a result of the scribing, and an additional layer of passivating insulating
material is not needed to resist moisture and oxygen intrusion.

Where light-emitting fiber 100 is utilized in a color display, light-emitting
elements 180 emitting three different colors of light, such as red (R), green (G) and
blue (B), are utilized. The three different color light-emitting elements 180R, 180G,
180B are arranged to be in adjacent sets of R, G, B elements, each set providing a
color pixel. Such arrangement of light-emitting elements 180R, 180G, 180B may be
provided by sequencing R, G and B OLED materials 130 along the length of each
light-emitting fiber 100 or may be provided by placing fibers 100 of different colors
side-by-side in an R-G-B sequence, i.e. a red-emitting fiber 100R next to a green-
emitting fiber 100G next to a blue-emitting fiber 100B and so forth. Red-emitting
fiber 100R, green-emitting fiber 100G, and blue-emitting fiber 100B may be
fabricated on ribbons or fibers 100 that are each tinted to the desired color or may
employ different light-emitting materials that respectively emit the desired color.

Suitable small molecule OLED structures are known and include ITO as the
hole injector, green-emitting OLED fabricated from naphthyl-substituted benzidine derivative (NPB) as the hole transport layer, tris-(8-hydroxyquinoline) aluminum (Alq3) as the electron transport layer, and magnesium/silver as the cathode, which are available commercially from Aldrich Chemical Company located in Milwaukee, Wisconsin and are reported by E. W. Forsythe et al in Extended Abstracts of The Fourth International Conference on the Science and Technology of Display Phosphors & 9th International Workshop on Inorganic and Organic Electroluminescence, September 14-17, 1998, at page 53.

Red emission is obtained by doping the Alq3 layer in the foregoing OLED structure doped with 6% 2,3,7,8,12,13,17,18-octaethyl-21H,23H-porphine platinum (II) (PtOEP) as reported by D. F. O’Brien et al in the Extended Abstracts of The Fourth International Conference on the Science and Technology of Display Phosphors & 9th International Workshop on Inorganic and Organic Electroluminescence, September 14-17, 1998, at page 37 et seq. Blue emission is obtained in the foregoing OLED structure by including an additional layer. This OLED structure includes spiro-linked TAD (spiro-TAD) as the hole transport layer, spiro-linked sexiphenyl (spiro-6Φ) as the blue emitter layer, and Alq3 as the electron transport layer as reported by Frank Weissortel et al in Extended Abstracts of The Fourth International Conference on the Science and Technology of Display Phosphors & 9th International Workshop on Inorganic and Organic Electroluminescence, September 14-17, 1998, at page 5 et seq.

Small-molecule OLED materials may be applied by evaporation and polymer OLED materials may be deposited as monomers, for example, using ink jet printing, roller coating, screen printing and the like to deposit mixtures of the OLED material and suitable solvents as is known, and subsequently evaporating the solvent(s) and polymerizing the monomer by heating.

For a polymer OLED structure, ITO may be employed as the hole injector layer and polyethylene dioxythipene, commonly known as PEDOT, doped with polystyrene sulfonic acid (PEDOT:SS) available from by Bayer A.G. located in Ludwigshafen, Germany, or PVK poly-N-carbazole available from Aldrich Chemicals, as the hole transport layer. The electron transport/emissive layer can by a
poly(fluorene)-based polymer for green emission, and other polymers for red and blue emission, as reported by J. H. Burroughes in the Extended Abstracts of The Fourth International Conference on the Science and Technology of Display Phosphors & 9th International Workshop on Inorganic and Organic Electroluminescence, September 14-17, 1998, at page 133 et seq.

Such green-emitting OLED materials typically provide brightness levels of about 100 cd/m² and exhibit power efficiencies of about 1, 11 and 5 lumens/watt for the R, G and B materials, respectively.

An advantage of the fiber 100 of FIGURES 2A - 2C is that, in addition to being able to simultaneously test all the pixel elements along the length of light-emitting fiber 100 with only a single test probing, thereby simplifying testing and reducing the test time, is that none of the pixel elements along the length of fiber 100 need have contact area set aside for test probing. Because such set-aside contact area preferably did not have any ITO layer 120 and any OLED layer 130 so that the operability of the pixel area would be less likely to be damaged or ruined by physical damage caused by a test probe, the size of each light-emitting pixel was necessarily reduced to provide for such contact area. As a result, a light-emitting fiber 100 in accordance with the present invention may have larger light-emitting areas thereby increasing the brightness of the light-emitting elements of fiber 100.

FIGURE 3 is a top view schematic diagram of a step in the fabrication of the exemplary light emitting fiber 100 of FIGURES 2A - 2C. Fiber or ribbon 110 of optically transmissive material is processed to receive a layer of ITO providing segmented ITO hole-injecting electrodes 122 and ITO contact 124, and metal conductor 160 along the side of fiber 110 overlies ITO segments 122 and is electrically connected thereto, as described above. Insulator layer 170 is deposited along one side of fiber 110 to cover metal conductor 160 and preferably extends slightly beyond the edge of conductor 160 to cover the edge of ITO electrode 122. Insulator layer 172 is deposited along the opposite edge of fiber 110 to at least cover the edges of ITO segments 122 proximate the edge of fiber 110. Insulating layers 170, 172 lie along the edges of the top surface 112 of optical fiber 110 to cover the edges of ITO segments 122 proximate thereto. The fiber 110 thus far processed is, for
example, ready for further processing as described below.

FIGURES 4A through 4G are a sequence of top view schematic diagrams illustrating steps in a method for making the exemplary light emitting fiber 100 in accordance with the invention. In FIGURE 4A, an optical fiber or ribbon 110 is provided and a patterned layer 120 of hole-injecting electrode material is deposited on a surface 112 of fiber 110 to form ITO electrode segments 122 and ITO segment 124 thereon. Preferably, ITO segments 122, 124 extend at least to one edge of fiber 110 and are spaced away from the other edge of fiber 110. Also preferably, ITO segment 124 and the ITO segment 122 nearest thereto are spaced apart a distance sufficient to allow a contact 154 to be formed therebetween, as described below. Patterned metal conductor 160 is deposited on a side surface of fiber 110 along the length thereof so as to make electrical contact along the edge of fiber 110 to all of ITO segments 122, 124. To provide a more reliable electrical connection, it is preferred either that metal conductor 160 extend over onto surface 112 of fiber 110 so as to overlap ITO segments 122, 124 or that ITO segments 122, 124 extend over onto the side surface of fiber 110 where conductor 160 will overlap them.

In FIGURE 4C, one or more patterned layers of insulating material is deposited along the length of fiber 110. Preferably, insulating layer 170 is deposited on surface 112 and on the side surface of fiber 110 so as to cover metal conductor 160 and to extend slightly over the edges of ITO segments 122, 124. A layer of light-emitting OLED material 130 is then deposited over ITO segments 122. Preferably, OLED material 130 is deposited in a segmented pattern of like size and shape to that of ITO electrodes 122. In particular, it is preferred that OLED segments 130 be at least as large as are ITO segments 122 to obtain a large pixel size, as is best obtained by OLED segments 130 being slightly larger than ITO segments 122 so as to extend slightly beyond the edges thereof, as illustrated in FIGURE 4D.

In FIGURE 4E, a layer of electron-injecting electrode material 140 is then deposited over light-emitting OLED material 130. Preferably, electron-injecting electrode material 140 is deposited in a segmented pattern of like size and shape to that of light-emitting OLED material 130. In particular, it is preferred that electron-injecting electrode segments 140 be at least as large as are light-emitting OLED
material segments 130 to obtain a large pixel size, as is best obtained by electron-injecting electrode material segments 140 being slightly larger than light-emitting OLED material segments 130 so as to extend slightly beyond the edges thereof. Note that because OLED material 130 preferably extends beyond the edges of ITO segments 122, electron-injecting electrodes 140 that extend beyond the edges of OLED segments 130 do not electrically short or connect to ITO electrodes 122. At this juncture, the OLED stack including a hole-injecting electrode 122, at least one OLED layer 130 and an electron-injecting electrode 140 are formed to provide the light-emitting structure of a light-emitting element.

In FIGURE 4F, a patterned layer of a metal contact material 150 is deposited over substantially the entire length of fiber 110, preferably as a stripe disposed along the center of surface 112 of fiber 110. As illustrated, layer 150 is patterned to provide a contact 152 to ITO segment 124 and conductor 160, thereby connecting to all of ITO segments 122, and to provide an elongated contact 150 that electrically connects to each electrode segment 140 along the length of fiber 110. Contact layer 150 extends into the space between ITO segment 124 and the ITO electrode segment 122 closest thereto to provide a contact 154 that is electrically connected to all of electrode segments 140. As described above, contacts 152, 154 may be provided at either end 118 of fiber 110 or, as is preferred, at both ends 118 of fiber 100.

As a result, all of the light-emitting element OLED stacks 180 are connected in parallel between contacts 152 and 154. At this juncture, all of the light-emitting elements 180 along the entire length of fiber 110 may be tested simultaneously simply by applying an appropriate electrical drive signal across contacts 152, 154. This not only provides the advantage of simultaneous testing of all light-emitting elements 180, but also allows the test probes for applying the electrical signals necessary for testing light-emitting elements 180 to be applied at contacts 152 and 154 which do not overlie OLED material 130. Thus, test probes cannot damage OLED material 130 or the OLED stack of any light-emitting element 180 along fiber 110.

Following the test of the light-emitting elements 180 disposed along the length of fiber 110, contact layer 150 is scribed transverse or cross-wise to the length of fiber 110 at the spaces or gaps between adjacent ones of light-emitting elements 180.
Scribing contact layer 150 provides a transverse insulating gap 158 between each light-emitting stack 180, as shown in FIGURE 4G, thereby breaking the parallel electrical connection of all of the light-emitting elements on fiber 110. As a result, a light-emitting fiber 100 is provided having a plurality of electrically independent light-emitting elements 180 disposed along the length thereof on surface 112 of fiber 110. Scribing gaps 158 in contact layer 150 may be by mechanical scribe or cutter, thermal scribing, chemical scribing or etching, or any other suitable means. Preferably, contact layer 150 is scribed by laser cutting.

Where, for example, optical fiber 110 is about 0.25 mm (about 0.010 inch) wide, electrical bus 160 may overlie ITO electrode 122 by about 25 μm (about 0.001 inch) and insulator 170 may overlie bus 160 and ITO electrode 122 by about 50 μm (about 0.002 inch) along each longitudinal edge of fiber 110. OLED layer 130 may overlie insulators 170, 172 by about 25 μm (about 0.001 inch). Metal top electrode 150 extends beyond the edges of OLED layer 130 and top electrode 140 by at least about 25 μm (about 0.001 inch). Metal electrode 150 thus seals the OLED segments 130 and serves as a passivating layer or moisture barrier therefor. Scribed spaces 148 are typically about 0.1 mm (about 0.004 inch) wide.

FIGURES 5A, 5B and 5C are a sequence of top view schematic diagrams illustrating alternative steps in the fabrication of the exemplary light emitting fiber 100 in accordance with the invention. Prior to FIGURE 5A, fiber 110 has been processed in accordance with FIGURES 4A to 4C providing segmented ITO electrodes 122 on fiber 110. A layer of light-emitting OLED material 130 is deposited along substantially the length of fiber 110 to overlie each one of ITO segments 122. Preferably, OLED material 130 extends to overlap insulating layers 170 and 172 along the edges of fiber 110, so as to cover all of segments 122. In like manner, a layer 140 of electron-injecting material is deposited on OLED material 130. Preferably, electrode layer 140 is slightly larger in width and length than OLED layer 130 so as to completely cover OLED layer 130.

Together, each of ITO segments 122, OLED and electrode layers 130, 140 provide a light-emitting OLED stack 180, and all of the light-emitting stacks 180 along the length of fiber 110 are electrically connected in parallel between ITO
segment 124 and probe pad 142. Probe pad 142 is at the end of electrode layer 140 close to ITO segment 124 on an area of fiber 110 that does not include any ITO segment. Thus, all of the parallel light-emitting stacks 180 along fiber 110 may be electrically tested simultaneously by applying an appropriate electrical signal across the test terminals provided by ITO segment 124 and probe pad 142.

Conveniently, the OLED layer 130 and overlapping electrode layer 140 thereon may be deposited with two depositions through a single mask that is positioned over fiber 110, but is spaced slightly away from it. The mask has a single rectangular opening that is the size, i.e. length and width, of the desired OLED layer 130. An elongated deposition source for depositing the OLED material is spaced away from the mask and fiber 110 and is centered with respect to the longitudinal axis of fiber 110 so as to deposit OLED material centered on fiber 110 in a pattern substantially the same size as the opening in the mask. A second elongated deposition source for depositing the electron-injecting metal is distributed on both sides of the OLED material source, and preferably symmetrically with respect thereto. Because the source of electron-injecting metal is wider than is the source of OLED material, the pattern of electron-injecting metal will be wider than is the pattern of OLED material, so that the electron-injecting electrode 140 will slightly overlap the layer of OLED material 130.

Following electrical testing of the light-emitting stacks along fiber 110, OLED layer 130 and electrode layer 140 are divided into segments by suitably scribing or cutting them crosswise to the length of fiber 110, such as by scribing or cutting as described above to form spaces 148, as illustrated in FIGURE 5B. The scribes are positioned so as to be made over the spaces between adjacent ones of ITO segments 122. Note that because there is no ITO segment under the scribed areas of OLED layer 130 and electrode layer 140, none of OLED stacks 180 will be damaged by the scribing. Moreover, since probe pad 142 is spatially separated from the OLED material 130 and electrode 140 of the closest adjacent light-emitting stack 180, any probing-induced damage to probe pad 142 likewise has no effect on any light-emitting stack 180.

As a result of the scribing to segment OLED layer 130 and electrode layer 140
into segments overlying and registered with ITO segments 122, an edge of the OLED layer is exposed at each end of each OLED material segment 130, i.e. at the scribed gaps 148 between adjacent segments. Exposure of the OLED material to the atmosphere may produce degradation of the OLED material due to the effects of moisture and/or oxygen. As illustrated in FIGURE 5C, a patterned passivation layer 190 of an insulating material is applied to provide a barrier to moisture and/or oxygen. Suitable moisture barrier materials include silicon nitride, silicon dioxide, silicon oxynitride, silicon carbide, diamond-like carbon, and phosphorus-silicate glass. Such materials may be deposited, for example, through a simple mask having openings crosswise to the length of fiber 110 in positions corresponding to the scribed spaces 148 and slightly wider than the width of the scribed spaces 148, so as to seal the spaces 148. If desired, the mask may be arranged to also provide a strip of passivating material 190 deposited along the longitudinal edges of fiber 110.

Thereafter, processing may continue as described in relation to FIGURE 4F with deposition of a patterned metal contact layer 150 providing segmented contacts 150, 152, 154 as described above.

FIGURES 6A and 6B are a sequence of top view schematic diagrams illustrating alternative steps to FIGURE 4E for contemporaneously fabricating a plurality of the exemplary light emitting fibers 100 in accordance with the invention.

In FIGURE 6A, a plurality of fibers 110 are arrayed in side-by-side abutting arrangement with their respective ends 118 in line. In this array, light-emitting elements 180 on all of the fibers 110 are likewise aligned. Preferably, fibers 110 are attached to a planar faceplate (not visible) once they are properly aligned. After the fibers 110 are so arrayed, the crosswise scribing of metal contact layer 150 along dotted line 149 is done in one operation for all of fibers 110, thereby to produce spaces or gaps 148 between adjacent light-emitting elements 180 of a plurality of light-emitting fibers 100 in side-by-side array as in a display or display module.

Electrical interconnection of the array of side-by-side light-emitting fibers 100 is provided by depositing stripes of metal conductor 200 transverse or crosswise to the lengths of fibers 100 and overlying segmented electrodes 140 and/or contacts 150 of the light-emitting elements 180 that are in the same relative positions along the length
of fibers 100. Conductors 200, which serve to couple data signals to the light-emitting elements 180 in like positions along each of fibers 100, may be deposited using a simple mask having crosswise rectangular openings at a pitch corresponding to the pitch of the light-emitting elements 180 along fibers 100. Advantageously, fibers 100 are simultaneously processed, including both the scribing operation and the data bus 200 deposition operation, using the method of FIGURES 6A and 6B.

In addition, it is desirable that crosswise stripes of passivating insulation 190 be deposited on the array of fibers 100 of FIGURE 6A - 6B to cover the scribed spaces 148. FIGURES 7A and 7B are a sequence of top view schematic diagrams illustrating alternative steps to FIGURE 5C for contemporaneously fabricating a plurality of the exemplary light emitting fibers 100 in accordance with the invention. Following the scribing of spaces 148 to segment contact layer 150 and electrode layer 140, and/or OLED layer 130, if present in the spaces to be scribed, whether such scribing is done for individual fibers 100 or for a plurality of fibers 100 in side-by-side array, the fibers 100 are placed in side-by-side array, preferably on a faceplate, as described above, if not already so arrayed. A simple mask having crosswise rectangular openings is then utilized for depositing strips of insulating passivation material 190 across the plurality of fibers 100 to passivate the scribed spaces 148 between the light-emitting elements 180 along the lengths of fibers 100, as illustrated in FIGURE 7A.

Electrical interconnection of the array of side-by-side light-emitting fibers 100 is provided by depositing stripes of metal conductor 200 transverse or crosswise to the lengths of fibers 100 and overlying segmented electrodes 140 and/or contacts 150 of the light-emitting elements 180 that are in the same relative positions along the length of fibers 100, as illustrated in FIGURE 7B and utilizing a mask having rectangular crosswise openings, all as described above.

The foregoing description is of a fiber 100 wherein the OLED layer 130, electrode layer 140 and contact layer 150 are spaced away from the longitudinal edges of fiber 110 so as to not depend upon the insulator layers 170 and/or 172 having sufficient dielectric strength at the corner edge of fiber 110 to withstand as high a potential as on the flat areas other than such corner. This spacing away of layers 130,
140, 150 simply avoids the imposition of relatively high potentials on the portions of insulators 170, 172 that are most likely to breakdown at a lower voltage. Specifically, in the preferred arrangement, OLED layer 130, electrode layer 140 and contact layer 150 preferably overlap the insulators 170, 172 as little as possible, and do not overlap the insulator 170, 172 in the region where they overlap ITO layer 120. In the event that insulation layers 170, 172 have sufficiently high dielectric strength, such spacing away of layers 130, 140, 150 is not necessary and can be avoided, thereby allowing simpler and less precise masks to be employed.

It is noted that the arrangement of fibers 100 described in relation to FIGURES 6A, 6B, 7A and 7B advantageously allows the testing of individual fibers 100 and of each light-emitting element 180 along the length of each fiber 100, when the array of a plurality of light-emitting fibers 100 is assembled.

FIGURES 8A through 8C are a sequence of top view schematic diagrams illustrating alternative steps to FIGURES 4D -4G and 5B - 5C for contemporaneously fabricating a side-by-side array of a plurality of the exemplary light emitting fibers 100 in accordance with the invention. A plurality of optical fibers 110, each having segmented ITO electrodes 122 along its length and having an ITO segment 124 at one or both ends, all on the same surface, are placed in side-by-side array with their respective ends in line and with their respective corresponding ITO electrodes 122 also aligned, as illustrated in FIGURE 8A. Each fiber 110 also includes a metal conductor 160 on one side thereof for connecting all of ITO segments 122 together and to ITO segment 124. Preferably, an insulating layer covers the edges of ITO segments 122 and conductor 160 along the longitudinal edges of fibers 110, as do insulators 170, 172 described above. For purposes of illustration, display 10 is shown to include only five fibers 100, whereas an actual display would likely include a larger number of fibers 100. Likewise, each fiber 110 is shown to include only five ITO segments 122 from which are produced five light-emitting elements 180 on each light-emitting fiber 100, whereas an actual fiber 100 would likely include a much larger number of light-emitting elements 180, typically several hundred elements 180.

A rectangular area of a layer of OLED material 130 is deposited onto all of fibers 110 to cover all of ITO segments 122 thereof, as illustrated in FIGURE 8B, and
a like area of layers of electron-injecting material 140 and contact material 150 are
deposited on the layer of OLED material 130. ITO segments 124 at one or both ends
118 of fibers 110 are not covered by OLED material 130 or electrode material 140 of
contact material 150. At the same time, contact material may be deposited on ITO
segments 124 to produce contacts 152 at one or both ends 118 of each fiber 110.

As thus far described, a plurality of light-emitting OLED elements 180 have
been formed along the lengths of each of light-emitting fibers 100, wherein the array
of fibers 100 together are a display 10 or module of a display 10 illustrated in
FIGURE 8B. All of the light-emitting elements 180 of all of the fibers 100 have one
electrode 140 connected in common at contact layer 150. All of the light-emitting
elements 180 on a particular fiber 100 have their respective ITO electrodes 122
connected in common to ITO segment 124 or contact 152 of that particular fiber 100.

Advantageously, at this juncture, all of fibers 100 may be simultaneously
tested by applying suitable electrical signals between ones or all of contacts 152 (or
ITO segments 124) and contact layer 150. I.e. the test signals can be applied to all of
contacts 152 (segments 124) at the same time to simultaneously test all of fibers 100,
or may be applied to one or more of contacts 152 (segments 124) to test one or more
of fibers 100 simultaneously. Thus, display 10 may be tested by testing either one
line or plural lines of light-emitting elements 180 at one time.

If display 10 or module 10 is found satisfactory, then electrode layer 140 and
contact layer 150 may be scribed crosswise to the length of fibers 100 and at locations
corresponding to the spaces between adjacent ones of ITO segments 122, i.e. along
dotted scribe lines 149, to produce spaces or gaps 148 defining transverse conductors
200, as illustrated in FIGURE 8C. In addition, a patterned insulating layer 190 of
passivation material (not shown) may be applied at least over scribed spaces 148 to
act as a barrier to moisture and/or oxygen reaching OLED layer 130.

Light emitted by light-emitting element 180 passes through optical fiber 110
to be observed by a viewer of the display 10 including light-emitting fiber 100. While
the light is generated in OLED material 130, it passes through the ITO or other thin
material of electrode 120. The presence of top electrode 140 and/or contact layer 150
overlying OLED layer 130 desirably reflects light from OLED material 130 and so
tends to increase the light output of light-emitting fiber 100.

Display 10 thus includes a plurality of light-emitting fibers 100 in side-by-side adjacent array, each fiber 100 having a plurality of light-emitting elements 180 disposed along the length thereof. The top contacts 150 of the light-emitting elements 180 in like position along each fiber 100 are connected to a conductor 200 to which a data signal containing pixel value information is applied, and the contacts 152 at the end(s) of fibers 100 are select contacts to which a select signal can be applied to enable operation of light-emitting elements 180 along the fiber 100 to which such select signal is applied. As a result, the combination of select signals and data signals can control independently the electrical signal applied to each individual light-emitting element 180 of display 10 for the display of images or information thereon.

Display 10 made in accordance with FIGURES 8A - 8C may be a color display or a monochrome display in which the same OLED material 130 is utilized for all of the light-emitting elements. In such color display 10, a "white-emitting" OLED material is utilized, and the three colors needed to produce color images are provided by tinging the fiber or ribbon 110 of optical material on which the light-emitting elements 180 are formed. Thus fibers 100 would be formed on fibers arrayed in, for example, sequence of red-tinted fiber 110, green-tinted fiber 110, blue-tinted fiber 110, and so forth. Because of limitations of the light-producing efficiency of currently available OLED materials, color displays employing three different OLED materials that emit light in the desired three different colors are preferred.

Alternatively, either OLED layer 130 and/or electrode layer 140 may be deposited as a pattern of OLED segments and/or electrode segments each overlying and registered with an ITO segment 122 on fiber 110, thereby forming a plurality of separate light-emitting elements 180 thereon. Such patterned segments can be formed utilizing an appropriate mask or masks, and may be formed on an individual fiber 110 or on a side-by-side array of a plurality of fibers 110, as is convenient, and may deposit the same or a different OLED material for any given segment. The method of depositing a layer of a light-emitting material may include depositing a pattern of segments of light-emitting material 130 on and in registration with the ITO electrode segments 122, and may also include depositing a pattern of segments of at least two
different light-emitting materials 130, wherein adjacent ones of the segments of like light-emitting material 130 are in a line either along or across the length of fibers 110. In addition or alternatively, depositing a second electrode layer 140 may include depositing a pattern of segments of electron-injecting electrode material 140 on the light-emitting material 130 and in registration with the first electrode segments 122. The layer of a light-emitting material 130 may be deposited in a pattern of alternating stripes of at least two different light-emitting materials 130 on and in registration with the ITO electrode segments 122, wherein the stripes are disposed either along or across the length of fibers 110.

Where the fibers 110 are arrayed and processed as a group to form a display 10 of light-emitting fibers 100 across which are formed conductors 200 in the same operation, as illustrated by FIGURES 6B, 7B and 8B - 8C, an additional fiber 110 referred to as a "dummy fiber" may be placed alongside the group of fibers 110 that will remain as part of display 10. The dummy fiber, which need not have all the features of fibers 110 or even be of an optically transmissive material, is placed next to the fiber 110 closest to the edge of display 10 so that it can later be removed without disturbing the fibers 100 that are part of display 10. When the crosswise conductor 200 is formed to extend not only across the light-emitting fibers 110 that are part of display 10 but onto the dummy fiber. The portions of conductors 200 on the dummy fiber provide contacts that can be probed in applying the data signals to light-emitting elements 180 in testing of light-emitting fibers 100 and/or display 10. After testing, the dummy fiber is removed, so that any damage caused by the test probes has no effect on the operability or reliability of the fibers 100 and display 10.

It is noted that conductors 150 and 200 can be of reasonable size and thickness and provide the levels of drive signals necessary to test all of the light-emitting elements at one time. Consider, for example, and exemplary light-emitting fiber 100 that is 0.5 mm (about 0.020 inch) wide and 82 cm (about 32 inches) long. A top conductor 150 having a thickness of less than about 1300Å is sufficient for operating all of the light-emitting elements 180 on such fiber 100 at a current density of 1 ma/cm² with a voltage drop of less than about 1 volt, which is adequate for test purposes. Because crosswise conductors 200 are much shorter than the length of
fibers 100, typically about 12.5 cm (about 5 inches) or less, conductors 200 may be much thinner than conductors 150 to provide a similar voltage drop. Select bus conductor 160, on the other hand, is as long as is fiber 100 and so must be sized to have lower voltage drop even when all light-emitting elements are operating. For example, for the 82-cm long exemplary fiber 100 that is 0.5 mm (about 0.020 inch) square, an about 38 μm thick (about 1.5 mil thick) select bus conductor 160 of copper, aluminum, silver or gold conducting a peak current of one ampere would exhibit a maximum voltage drop of <0.4 volt if driven from a contact 152 at only one end of fiber 100 and of <0.1 volt if driven from contacts 152 at both ends of fiber 100.

A further advantage of the foregoing methods is that the masks utilized for deposition of the various layers of OLED material 130, electrode material 140, conductor 150, 160, 200 and insulators 170, 172, 190 are all of relatively simple arrangement and need not be to close tolerance. In addition, the placement of these masks in relation to the fibers or fibers onto which material is to be deposited need not be to close tolerance, i.e. the method for making light-emitting fibers 100 does not require masks that must be precisely aligned or registered, either transversely or longitudinally, with respect to optical fiber 110. This not only greatly simplifies the processing, but makes the process more likely to have a high yield of suitable fibers and displays. Only in the step of the method illustrated in FIGURE 2B where the OLED material segments 130 must be registered with the underlying ITO segments 122 on fiber 110 is precise alignment of the deposition mask required.

FIGURES 9 and 10 are schematic diagrams of exemplary masking arrangements useful in contemporaneously processing plural exemplary light emitting fibers 100 or in processing a single fiber 100. Mechanical mask 420 shown in FIGURE 9 has a peripheral masking portion 422 and transverse bridging masking portions 424 bridging between opposite edges of mask 420 to define plural mask openings 426 through which insulator material such as forming passivating strips 190 is deposited on a plurality of light-emitting fibers 100 that are arranged in side-by-side touching relationship, as illustrated. Bridging mask portions 424 extend in a direction transverse to the long dimension of fibers 100. Bridging mask portions 424 block areas of each of fibers 100 on which insulator 190 is not deposited, thereby to define
the spaces 426 overlying scribed spaces 148 over which insulator 190 is deposited. Insulator 190 may be deposited by any convenient method, such as by sputtering or evaporation. For example, on an optical fiber of about 0.25 mm (about 0.010 inch) width, mask openings 426 may be about 0.25 mm (about 0.010 inch) long in the direction along the length of fibers 100 and on a pitch of about 0.75 mm (about 0.030 inch), thereby to define light-emitting element contact areas that are about 0.25 by 0.50 mm (about 0.010 by 0.020 inch). Three such light-emitting areas provide a complete full-color pixel for a color display, which pixel is a square about 0.75 by 0.75 mm (about 0.030 by 0.030 inch).

FIGURE 10 is a mechanical mask 520 of similar shape and size to mask 420 of FIGURE 9 but differently dimensioned for defining the shape and size of contacts 200 transverse to light-emitting fibers 100. Mechanical mask 520 has a peripheral masking portion 522 and transverse bridging masking portions 524 bridging between opposite edges of mask 520 to define plural mask openings 526 through which conductive metal such as aluminum, copper, gold or other suitable metal is deposited for forming conductors 200 across a plurality of fibers 100 that are arranged in side-by-side touching relationship, as illustrated. Bridging mask portions 524 extend in a direction transverse to the long dimension of fibers 100. Bridging mask portions 524 block areas of each of fibers 100 on which metal conductor 200 is not deposited, thereby to define the data signal conductors 200. Conductor metal may be deposited by any convenient method, such as by sputtering or evaporation. For example, on an optical fiber of about 0.25 mm (about 0.010 inch) width, mask bridging portions 524 may be about 0.25 mm (about 0.010 inch) long in the direction along the length of fibers 100 and on a pitch of about 0.75 mm (about 0.030 inch), thereby to define conductors 200 that are about 0.50 mm (about 0.020 inch) wide.

While the present invention has been described in terms of the foregoing exemplary embodiments, variations within the scope and spirit of the present invention as defined by the claims following will be apparent to those skilled in the art. For example, other materials and dimensions may be utilized is making the light-emitting fibers according to the invention. The masks described herein may be of any convenient length and desirably are of a length for deposition of the various materials.
to be made contemporaneously along the entire length on an optical fiber. In addition, the masks may be of any convenient width for contemporaneously processing a desired number of optical fibers. Further, rotatable cylindrical masks may be utilized where it is desired to process an optical fiber of very long length using an in-line continuous process.

In addition, for example, the masks of FIGURES 9 and 10 may be utilized for processing a single fiber by making the dimension "W" of the openings therein to correspond to the width of the desired deposited material on a single fiber or on a given number of fibers.
WHAT IS CLAIMED IS:

1. A light-emitting fiber comprising:
   a length of a fiber of an optically transparent material;
   a first electrode including a plurality of first electrode segments
   disposed along the length of a first surface of said fiber, wherein said first
   electrode segments include a layer of an optically-transparent electrically
   conductive material;
   an elongated electrical conductor disposed along the length of said
   fiber on a second surface thereof that is contiguous to the first surface thereof,
   wherein said elongated electrical conductor is in electrical contact with each of
   said first electrode segments along the length of said fiber;
   a light-emitting material disposed on said plurality of electrode
   segments;
   a second electrode disposed along the length of said fiber on said light-
   emitting material, whereby each said first electrode segment, said light-
   emitting material and said second electrode provide a light-emitting element
   adapted to emit light responsive to an electrical signal; and
   an elongated electrical contact disposed along the length of said fiber
   on said second electrode, wherein at least said elongated electrical contact
   connects to the second electrode of the light-emitting elements disposed along
   the length of said fiber,
   whereby the light-emitting elements are adapted to emit light
   responsive to an electrical signal applied to said elongated electrical conductor
   and said elongated electrical contact.

2. The light-emitting fiber of claim 1 wherein said elongated electrical contact
   includes a portion not overlying a first electrode segment and adapted for
   receiving an electrical signal.
3. The light-emitting fiber of claim 1 wherein after an electrical signal is applied to said elongated electrical conductor and said elongated electrical contact, at least one of said second electrode and said elongated electrical contact is segmented to define a plurality of light-emitting elements each having a second electrode segment corresponding to and overlying one of said first electrode segments.

4. The light-emitting fiber of claim 1 wherein portions of said light-emitting material not covered by said elongated electrical contact is covered with a layer of moisture resistant material, wherein said moisture resistant material includes at least one of silicon nitride, silicon dioxide, silicon oxynitride, silicon carbide, diamond-like carbon, and phosphorus-silicate glass.

5. A method for making a light-emitting fiber having a plurality of light-emitting elements thereon comprising:

   providing a length of fiber having a plurality of spaced-apart first electrode segments along the length thereof and having an electrical conductor along a side thereof in electrical contact with the plurality of spaced-apart first electrode segments;

   depositing a layer of a light-emitting material on the first electrode segments along the fiber;

   depositing a second electrode on the layer of light-emitting material and substantially overlying the spaced-apart first electrode segments; and

   depositing an elongated electrical contact on the second electrode and extending to overlie the plurality of spaced-apart first electrode segments.

6. The method of claim 5 further comprising applying an electrical signal to the electrical conductor along the side of the fiber and the elongated electrical conductor, segmenting at least said elongated electrical contact into segments corresponding to and overlying the first electrode segments.
7. A method for making an array of a plurality of light-emitting fibers each having a plurality of light-emitting elements thereon comprising:
   placing in side-by-side adjacent array a plurality of fibers, each having a plurality of spaced-apart first electrode segments along the length thereof and an electrical conductor along a side thereof in electrical contact with the plurality of spaced-apart first electrode segments depositing a layer of a light-emitting material on the plurality of first electrode segments of the plurality of fibers;
   depositing a second electrode layer on the layer of light-emitting material; and depositing an electrical contact layer on the second electrode layer and extending to overlie the plurality of spaced-apart first electrode segments of the plurality of fibers.

8. The method of claim 7 further comprising applying an electrical signal to the electrical conductor along the side of the fiber and the electrical contact layer, then segmenting at least said electrical contact layer into segments disposed crosswise to the plurality of fibers, each electrical contact layer segment corresponding to and overlying the first electrode segments in corresponding positions along each of the plurality of fibers.

9. The method of claim 5 or 7 further comprising depositing at least one layer of insulating material to insulate the first spaced-apart electrode segments from at least one of the second electrode layer and the electrical contact layer and/or to cover any of the layer of light-emitting material not covered by the electrical contact layer.

10. The method of claim 7 wherein said depositing a layer of a light-emitting material includes depositing a pattern of alternating stripes or segments of at least two different light-emitting materials on and in registration with the first electrode segments, wherein the stripes or segments of like light-emitting material are disposed either along or across the fibers.