layer from about 400 Å to greater than about 1500 Å thick with about 400-1000 Å being preferred, and about 500 Å still more preferred.

[0091] Thus, while there may be substantial variation in the type, number, thickness and order of the layers that are present, dependent on whether the device includes a single heterostructure or a double heterostructure, whether the device is a SOLED or a single OLED, whether the device is a TOLED or an IOLED, whether the OLED is intended to produce emission in a preferred spectral region, or whether still other design variations are used, the present invention is directed to those devices in which the OLED is comprised of a heterostructure for producing electroluminescence wherein the heterostructure includes a cathode comprising an electrically conductive non-metallic layer in low-resistance electrical contact with a semiconductive organic layer.

[0092] The non-metallic cathodes of the present invention may be incorporated into an optoelectronic device that is included in a vehicle, a computer, a television, a printer, a large area wall, theater or stadium screen, a billboard or a sign.

[0093] The subject invention as disclosed herein may be used in conjunction with co-pending applications: "High Reliability, High Efficiency, Integratable\Organic Light Emitting Devices and Methods of Producing Same", Ser. No. 08/774,119 (filed Dec. 23, 1996); "Novel Materials for Multicolor LED's", Ser. No. 08/850,264 (filed May 2, 1997); "Electron Transporting and Light Emitting Layers Based on Organic Free Radicals", Ser. No. 08/774,120 (filed Dec. 23, 1996); "Multicolor Display Devices", Ser. No. 08/772,333 (filed Dec. 23, 1996); "Red-Emitting Organic Light Emitting Devices (LED's)", Ser. No. 08/774,087 (filed Dec. 23, 1996); "Driving Circuit For Stacked Organic Light Emitting Devices", Ser. No. 08/792,050 (filed Feb. 3, 1997); "High Efficiency Organic Light Emitting Device Structures", Ser. No. 08/772,332 (filed Dec. 23, 1996); "Vacuum Deposited, Non-Polymeric Flexible Organic Light Emitting Devices", Ser. No. 08/789,319 (filed Jan. 23, 1997); "Displays Having Mesa Pixel Configuration", Ser. No. 08/794,595 (filed Feb. 3, 1997); "Stacked Organic Light Emitting Devices", Ser. No. 08/792,046 (filed Feb. 3, 1997); "High Contrast Transparent Organic Light Emitting Device Display", Ser. No. 08/821,380 (filed Mar. 20, 1997); "Organic Light Emitting Devices Containing A Metal Complex of 5-Hydroxy-Quinoxaline as A Host Material", Ser. No. 08/838,099 (filed Apr. 15, 1997); "Light Emitting Devices Having High Brightness", Ser. No. 08/844,353 (filed Apr. 18, 1997); "Organic Semiconductor Laser", Ser. No. 60/046,061 (filed May 9, 1997); "Organic Semiconductor Laser", Ser. No. 08/859,468 (filed May 19, 1997); "Saturated Full Color Stacked Organic Light Emitting Devices", Ser. No. 08/858,994 (filed May 20, 1997); "An Organic Light Emitting Device Containing a Hole Injection Enhancement Layer", Ser. No. 08/865,491 (filed May 29, 1997); "Plasma Treatment of Conductive Layers", Serial No. PCT/US97/10252; (filed Jun. 12, 1997; Patterning of Thin Films for the Fabrication of Organic Multi-Color Displays", Serial No. PCT/US97/10289 (filed Jun. 12, 1997); "Double Heterostructure Infrared and Vertical Cavity Surface Emitting Organic Lasers", Ser. No. 60/053,176 (filed Jul. 18, 1997); "Oleds Containing Thermally Stable Asymmetric Charge Carrier Materials", Ser. No. 08/929,029 filed (Sep. 8, 1997), "Light Emitting Device with Stack of Oleds and Phosphor Downconverter", Ser. No. 08/925,403 (filed Sep. 9, 1997), "An Improved Method for Depositing Indium Tin Oxide Layers in Organic Light Emitting Devices", Ser. No. 08/928,800 (filed Sep. 12, 1997), "Azlactone-Related Dopants in the Emissive Layer of an Oled" (filed Oct. 9, 1997), Ser. No. 08/948,130, "A Highly Transparent Organic Light Emitting Device Employing A Non-Metallic Cathode", (filed Nov. 3, 1997), Ser. No. 08/064,005 (Provisional), "A Highly Transparent Organic Light Emitting Device Employing a Non-Metallic Cathode", (filed Nov. 5, 1997), Ser. No. 08/964,863, "Low Pressure Vapor Phase Deposition of Organic Thin Films" (filed Nov. 17, 1997), Attorney Docket No.10020/37, "Method of Fabricating and Patterning Oleds", (filed Nov. 24, 1997), Attorney Docket No. 10020/14; "Method for Deposition and Patterning of Organic Thin Film", (filed Nov. 24, 1997), Attorney Docket No. 10020/25, and "Oleds Doped with Phosphorescent Compounds" (filed Dec. 1, 1997), Ser. No. 08/980,986, "Organic Vertical-Cavity Surface-Emitting Laser Confirmation", (filed Jan. 22, 1998), Ser. No. 09/010,594; "Electron Transporting and Light Emitting Layers Based on Organic Free Radicals", (filed Feb. 18, 1998), Ser. No. 09/025,660; and "Aluminum Complexes Bearing Both Electron Transporting and Hole Transporting Moieties" (filed Apr. 1, 1998), Attorney Docket No. 10020/66; each co-pending application being incorporated herein by reference in its entirety. The subject invention may also be used in conjunction with the subject matter of each of co-pending U.S. patent application Ser. Nos. 08/354,674, 08/613,207, 08/632,322 and 08/693,359 and provisional patent application Serial Nos. 60/010,013, 60/024,001 and 60/025,501, each of which is also incorporated herein by reference in its entirety.

[0094] In addition, while the highly transparent non-metallic cathodes of the present invention are illustrated with embodiments in which the highly transparent non-metallic cathode is incorporated into an OLED, substantially any type of optoelectronic device having an anode and a cathode may include a highly transparent non-metallic cathode fabricated in accord with the present invention. In particular, the non-metallic cathodes of the present invention may be included in an OLED, a solar cell, a phototransistor, a laser or a photodetector.

[0095] This invention will now be described in detail with respect to showing how certain specific representative embodiments thereof can be made, the materials, apparatus and process steps being understood as examples that are intended to be illustrative only. In particular, the invention is not intended to be limited to the methods, materials, conditions, process parameters, apparatus and the like specifically recited herein.

EXAMPLES OF THE INVENTION

Example 1

[0096] OLEDs were prepared using known procedures except that the OLEDs included a non-metallic ITO cathode layer rather than a metallic cathode layer. In addition, an electron injecting interface layer was present between the ITO cathode and an Alq_3 electron transporting layer. The ITO/Borosilicate substrates that were obtained commercially had an ITO thickness of about 1500 Å. The organic layers were thermally deposited in a standard bell-jar evaporator at pressures of 1×10^{-6} torr. The alpha-NPD layer was