tially lower than that of the organic electroluminescent element) is employed adjacent to a reflective layer in combination with the light scattering layer to prevent low angle light from striking the reflective layer, and thereby minimize absorption losses due to multiple reflections from the reflective layer. The particular arrangements, however, may still result in reduced sharpness of the device.

[0015] There is a need therefore for an improved organic light-emitting diode device structure that avoids the problems noted above and improves the efficiency and sharpness of the device.

SUMMARY OF THE INVENTION

[0016] In accordance with one embodiment, the invention is directed towards an organic light-emitting diode (OLED) device, comprising: a substrate; an OLED comprising first and second electrodes and one or more layers of organic light-emitting material formed between the electrodes, wherein at least one electrode comprises a transparent electrode, the transparent electrode and layer(s) of organic light-emitting material having a first refractive index range; and an encapsulating cover; wherein at least one of the substrate or cover comprises a transparent substrate or cover having a second refractive index and through which light from the OLED is emitted; and further comprising a light scattering layer located between the substrate and cover, and a transparent low-index element having a third refractive index lower than each of the first refractive index range and second refractive index and located between the scattering layer and the transparent substrate or cover.

Advantages

[0017] The present invention:has the advantage that it increases the light output from, and improves the sharpness of, an OLED device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** illustrates a cross section of a top-emitter OLED device having a scattering layer according to one embodiment of the present invention;

[0019] **FIG. 2** illustrates a cross section of a top-emitter OLED device having a scattering layer according to an alternative embodiment of the present invention;

[0020] **FIG. 3** illustrates a cross section of a top-emitter OLED device having a scattering layer according to another embodiment of the present invention;

[0021] **FIG. 4** illustrates a cross section of a top-emitter OLED device having a scattering layer according to another embodiment of the present invention;

[0022] **FIG. 5** illustrates a cross section of a bottom-emitter OLED device having a scattering layer according to yet another embodiment of the present invention;

[0023] **FIG. 6** illustrates a cross section of a top-emitter OLED device having scattering particles according to another embodiment of the present invention;

[0024] **FIG. 7** illustrates a cross section of a top-emitter OLED device having a reflective scattering surface according to another embodiment of the present invention;

[0025] **FIG. 8** illustrates a cross section of a bottom-emitter OLED device having a scattering surface according to another embodiment of the present invention;

[0026] **FIG. 9** illustrates a cross section of a top-emitter OLED device having a refractive scattering layer showing light paths according to an embodiment of the present invention;

[0027] **FIG. 10** illustrates a cross section of a top-emitter OLED device having a scattering layer and raised areas according to an embodiment of the present invention;

[0028] **FIG. 11** illustrates a cross section of a top-emitter OLED device having a scattering layer and raised areas according to an alternative embodiment of the present invention;

[0029] **FIG. 12** illustrates a cross section of a top-emitter OLED device having a scattering layer, a protection layer, and a short-reduction layer together with raised areas according to an alternative embodiment of the present invention;

[0030] **FIG. 13** illustrates a cross section of a prior-art bottom-emitter OLED device;

[0031] **FIG. 14** illustrates a cross section of a prior-art top-emitter OLED device;

[0032] **FIG. 15** illustrates a cross section of a prior-art bottom-emitter OLED device having a scattering layer;

[0033] **FIG. 16** illustrates a cross section of a top-emitter OLED device having a scattering layer; and

[0034] **FIG. 17** is a graph demonstrating the loss in sharpness due to a scattering layer in a prior-art active-matrix bottom-emitting OLED device.

[0035] It will be understood that the figures are not to scale since the individual layers are too thin and the thickness differences of various layers too great to permit depiction to scale.

DETAILED DESCRIPTION OF THE INVENTION

[0036] Referring to **FIG. 1**, in accordance with one embodiment, a top-emitting organic light-emitting diode. (OLED) device comprises a substrate **10**; an OLED comprising a first reflective electrode **16** and a second transparent electrode **12**, one or more layers **14** of organic light-emitting material formed between the electrodes **12** and **16**, and an encapsulating transparent cover **20** through which light from the OLED is emitted. Either one of the first or second electrodes **12** or **16** may be pixellated to form distinct light emitting areas. The transparent electrode **12** and layer(s) **14** of organic light-emitting material have a first refractive index range, and the transparent cover **20** has a second refractive index. A light scattering layer **22** is located between the substrate and cover, in this embodiment between the transparent electrode **12** and the cover **20**. As employed herein, a light scattering layer is an optical layer that tends to randomly redirect any light that impinges on the layer from any direction. Transparent low-index element **18** having a third refractive index lower than each of the first refractive index range and second refractive index is located between the scattering layer **22** and the transparent cover **20**. As used herein, a transparent electrode is one that passes