US 20050212405A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0212405 A1**

Negley (43) **Pub. Date: Sep. 29, 2005**

(54) **SEMICONDUCTOR LIGHT EMITTING DEVICES INCLUDING FLEXIBLE FILM HAVING THEREIN AN OPTICAL ELEMENT, AND METHODS OF ASSEMBLING SAME**

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(21) Appl. No.: **10/811,598**

(22) Filed: **Mar. 29, 2004**

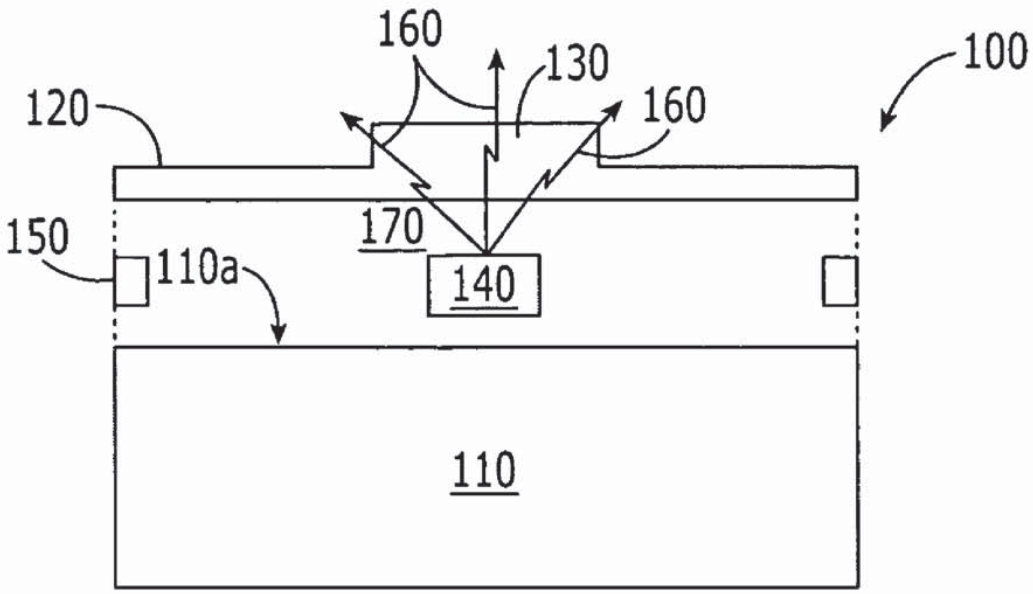
Publication Classification

(51) **Int. Cl.**[7] **H01L 33/00**

(52) **U.S. Cl.** **313/502**; 313/501

(57) **ABSTRACT**

Semiconductor light emitting devices include a substrate having a face, a flexible film that includes therein an optical element, on the face, and a semiconductor light emitting element between the substrate and the flexible film and configured to emit light through the optical element. The face can include a cavity therein, and the semiconductor light emitting element may be in the cavity. The flexible film extends onto the face beyond the cavity, and the optical element overlies the cavity.



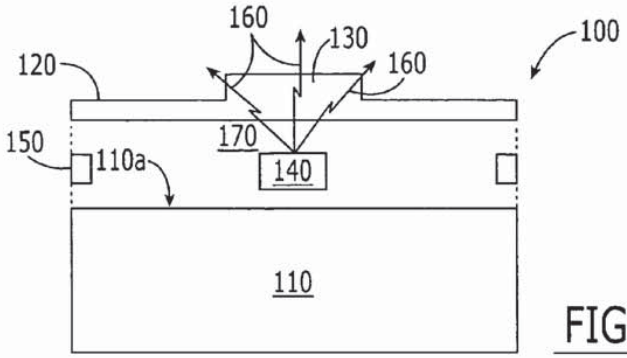


FIG. 1

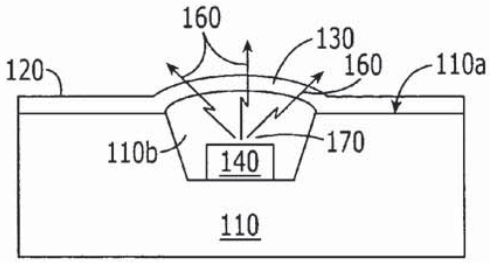


FIG. 2

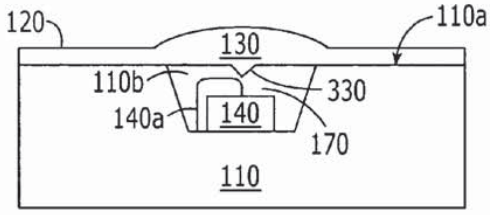


FIG. 3

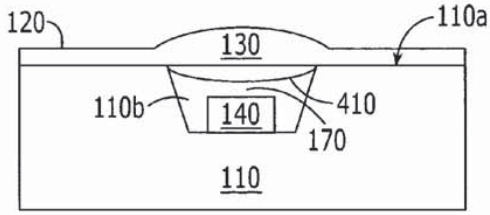


FIG. 4

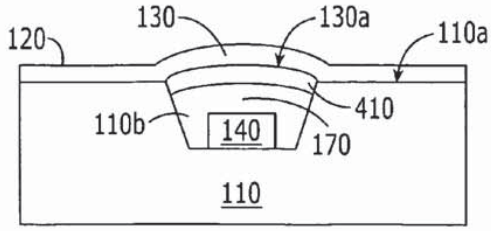


FIG. 5

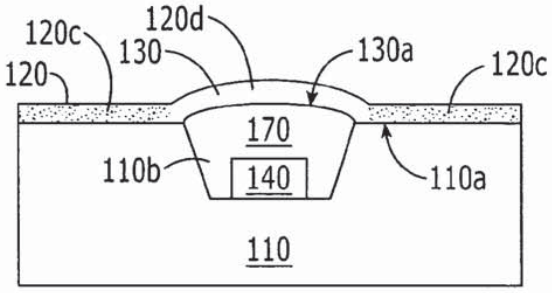


FIG. 6

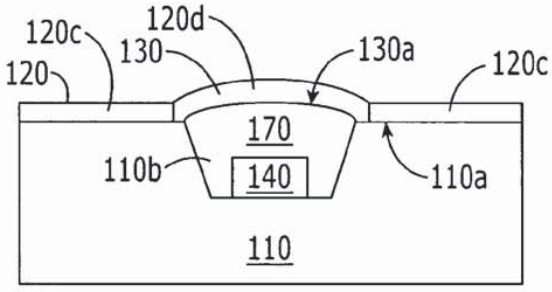


FIG. 7

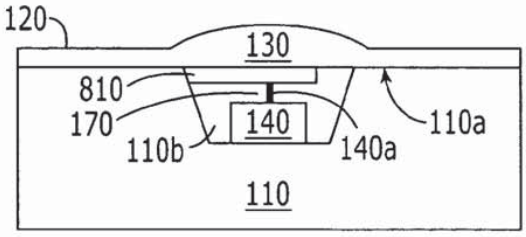


FIG. 8

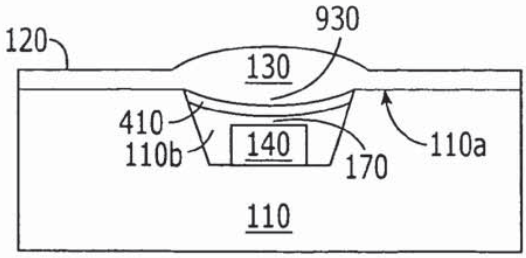


FIG. 9

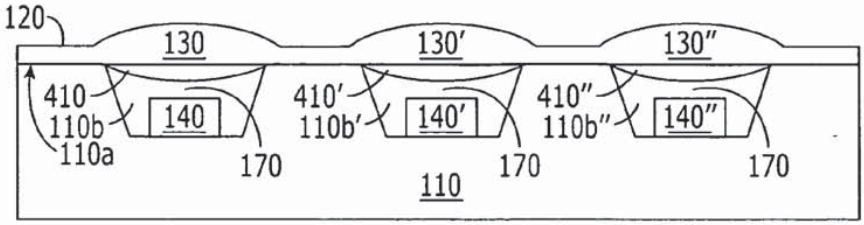


FIG. 10

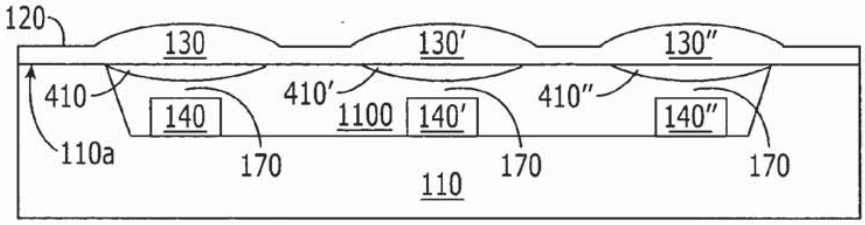


FIG. 11

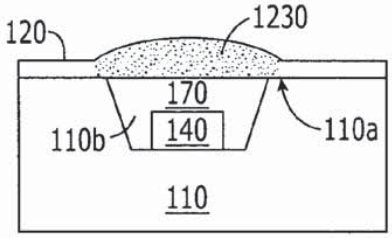


FIG. 12

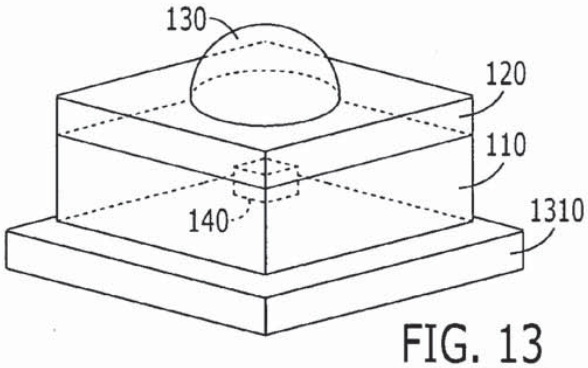


FIG. 13

SEMICONDUCTOR LIGHT EMITTING DEVICES INCLUDING FLEXIBLE FILM HAVING THEREIN AN OPTICAL ELEMENT, AND METHODS OF ASSEMBLING SAME

FIELD OF THE INVENTION

[0001] This invention relates to semiconductor light emitting devices and fabricating methods therefor, and more particularly to packaging and packaging methods for semiconductor light emitting devices.

BACKGROUND OF THE INVENTION

[0002] Semiconductor light emitting devices, such as Light Emitting Diodes (LEDs) or laser diodes, are widely used for many applications. As is well known to those having skill in the art, a semiconductor light emitting device includes a semiconductor light emitting element having one or more semiconductor layers that are configured to emit coherent and/or incoherent light upon energization thereof. It is also known that the semiconductor light emitting element generally is packaged to provide external electrical connections, heat sinking, lenses or waveguides, environmental protection and/or other functions for the semiconductor light emitting device. Packaging may be provided, at least in part, by at least partially surrounding the semiconductor light emitting device with a dome-shaped transparent plastic shell.

[0003] For example, it is known to provide a two-piece package for a semiconductor light emitting device wherein the semiconductor light emitting element is mounted on a substrate of, for example, alumina, aluminum nitride and/or other materials, which include electrical traces thereon, to provide external connections for the semiconductor light emitting element. A second substrate, which, for example, may be silver plated copper, is mounted on the first substrate, for example using glue, surrounding the semiconductor light emitting element. A lens may be placed on the second substrate over the semiconductor light emitting element. Light emitting diodes with two-piece packages as described above are described in application Ser. No. 10/446,532 to Loh, entitled Power Surface Mount Light Emitting Die Package, filed May 27, 2003, assigned to the assignee of the present invention, the disclosure of which is hereby incorporated herein by reference in its entirety as if set forth fully herein.

[0004] It is often desirable to incorporate phosphor into a semiconductor light emitting device, to enhance the emitted radiation in a particular frequency band and/or to convert at least some of the radiation to another frequency band. Phosphors may be included in a semiconductor light emitting device using many conventional techniques. In one technique, phosphor is coated inside and/or outside the plastic shell. In other techniques, phosphor is coated on the semiconductor light emitting device itself, for example using electrophoretic deposition. In still other techniques, a drop of a material such as epoxy that contains phosphor therein may be placed inside the plastic shell, on the semiconductor light emitting device and/or between the device and the shell. This technique may be referred to as a "glob top". The phosphor coatings may also incorporate an index matching material and/or a separate index matching material may be provided. LEDs that employ phosphor coatings are described, for example, in U.S. Pat. Nos. 6,252,254; 6,069,440; 5,858,278; 5,813,753; 5,277,840; and 5,959,316.

[0005] Unfortunately, the packaging for a semiconductor light emitting device may be costly and, in some cases, more costly than the semiconductor light emitting element itself. Moreover, the assembly process also may be costly, time consuming and/or subject to failures.

SUMMARY OF THE INVENTION

[0006] Some embodiments of the present invention provide semiconductor light emitting devices that include a substrate having a face, a flexible film that includes therein an optical element, on the face, and a semiconductor light emitting element between the substrate and the flexible film and configured to emit light through the optical element. In some embodiments, an optical coupling media, such as optical gel, is provided between the optical element and the semiconductor light emitting element. In some embodiments, the face includes a cavity therein, and the semiconductor light emitting element is in the cavity. The flexible film extends onto the face beyond the cavity, and the optical element overlies the cavity. In some embodiments, an optical coupling media is provided in the cavity. Semiconductor light emitting devices may be assembled, according to various embodiments of the present invention, by mounting a semiconductor light emitting element on a substrate face, and attaching a flexible film that includes therein an optical element to the substrate face such that, in operation, the semiconductor light emitting element emits lights through the optical element. An optical coupling media may be placed between the semiconductor light emitting element and the optical coupling element.

[0007] Many different configurations of optical elements may be provided according to various embodiments of the present invention. In some embodiments, the optical element includes (i.e., comprises) a lens. In other embodiments, the optical element includes a prism. In other embodiments, the flexible film includes a first face adjacent the substrate and a second face remote from the substrate, and the optical element includes a first optical element on the first face, and a second optical element on the second face, both of which are located such that the light emitting element emits light through the first optical element and the second optical element. In some embodiments, the optical element includes phosphor and/or other optical emission enhancing and/or converting elements. In still other embodiments, the optical element includes an optical scattering element. Combinations and subcombinations of these and/or other optical elements also may be provided. Moreover, an optical coupling media may be provided between the optical element and the semiconductor light emitting element in any of these embodiments.

[0008] Many configurations of the flexible film also may be provided according to various embodiments of the present invention. For example, in some embodiments, at least a portion of the flexible film that overlies the cavity is transparent to the light, and at least a portion of the flexible film that extends onto the face beyond the cavity is opaque to the light. In other embodiments, at least a portion of the flexible film that overlies the cavity includes a first material and at least a portion of the flexible film that extends onto the

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