PASSIVATION OF ORGANIC DEVICES

FIELD OF THE INVENTION

The present invention pertains to organic devices and more specifically to the formation of passivated organic devices on plastic substrates.

BACKGROUND OF THE INVENTION

At the present time devices utilizing organic displays, such as polymer light emitting devices, are potential candidates for a great variety of virtual and direct view type displays, such as digital watches, telephones, lap-top computers, pagers, cellular telephones, calculators and the like. Unlike, inorganic semiconductor light emitting devices, organic light emitting device are generally simple and relatively easy and inexpensive to fabricate. Also, a variety of colors and large-area devices are easily attained.

Conventional organic LEDs are built on glass substrates because of the low permeability of glass to oxygen and water vapors. This and other forms of degradation, are a detriment to the overall reliability of organic LEDs. It is proposed in the present invention to utilize plastic as a supporting substrate for the formation of organic LEDs. Traditionally plastic is susceptible to the permeation of oxygen and moisture to some extent. In the instance where the organic LED is formed on a plastic substrate, there presents the need to reduce and eliminate the diffusion of oxygen and moisture through the plastic substrate which, as previously stated, leads to degradation of the organic LED. Furthermore, additional organic components of the LED may also be subject to adverse reactions with oxygen or water.

In general, a two-dimensional organic LED array for image manifestation apparatus applications as known in the art is composed of a plurality of organic LEDs (one or more of which form a pixel) arranged in rows and columns. Each individual organic LED in the array is generally constructed with a light transmissive first electrode, an organic electroluminescent medium deposited on the first electrode, and a metallic electrode on top of the organic electroluminescent medium. In forming an organic LED, generally a layer of reactive metal is utilized as a cathode to ensure efficient electron injecting electrodes and low operating voltages. However, in the formation of organic LEDs on a plastic substrate, not only is the substrate susceptible to the permeation of oxygen and moisture, but the reactive metals are also susceptible to oxygen and moisture, especially during operation, since oxidation of the metal limits the lifetime of the devices. A hermetic seal about the array itself is normally required to achieve long term stability and longevity. In hermetically sealing the array, several types of hermetic seals are utilized, the most common of which are inorganic materials, such as metals and the like. Accordingly, when forming the organic LED on a plastic substrate, the permeation of oxygen and water vapors to the organic LED must be stopped by hermetically sealing the plastic substrate from the organic LED and by hermetically sealing the array itself.

A further problem that occurs in the fabrication and passivation of organic devices is a result of the fact that the organic layers of the organic devices can not withstand very high temperatures (i.e. generally greater than approximately 100° C.). In many instances, even approaching the critical temperatures of the organic layers, especially if the elevated temperatures are maintained for relatively long periods of time, can degrade the organic materials and reduce the reliability and/or the longevity.

In the formation of organic LEDs, several types of hermetic seals for sealing the array itself are utilized to protect the organic device from oxygen and water vapors. As previously stated, the most common of the hermetic seals utilized today are comprised of inorganic materials, such as metal cans or metallized plastic sealers. These types of seals are very expensive to fabricate and require extensive labor to assemble. In addition, metal cans are large and heavy so that they severely limit the applications of organic devices.

A more recent means of hermetically sealing organic devices is to overcoat them with an inorganic material, such as a ceramic, dieletric or metal, to achieve a hermetic seal about the organic device. However, the organic devices are very susceptible to the high temperatures normally required in the deposition of these materials. Thus, the ceramic, dielectric or metal material generally must be deposited by PECVD methods in order to meet the low temperature criteria. The major problem with this method of sealing is that during the PECVD deposition there is a strong possibility of radiation damage to the organic device.

Accordingly, it is highly desirable to devise a relatively inexpensive and convenient method of forming organic devices on a plastic substrate in which there exist a first hermetic seal between the plastic substrate and the ambient atmosphere to protect the plastic substrate from the permeation of oxygen, moisture and other atmospheric elements, thereby damaging the organic LED, and a second hermetic seal about the array of organic devices to protect it from damage by similar atmospheric elements.

It is a purpose of the present invention to provide a new and improved method for overcoating plastic substrates to prevent the permeation therethrough of oxygen and moisture.

It is another purpose of the present invention to provide a new and improved method of forming a passivating organic device on a plastic substrate.

It is a still further purpose of the present invention to provide a new and improved method of forming a passivating organic device on a plastic substrate which is relatively convenient and inexpensive to perform.

SUMMARY OF THE INVENTION

The above problems and others are at least partially solved and the above purposes and others are realized in a method of forming organic devices positioned on a supporting transparent plastic substrate including the step of depositing a multi-layer overcoating on the plastic substrate. The multi-layer overcoating is composed of thin alternating layers of a robust transparent polymer film and a transparent inorganic material such as silicon monoxide, silicon oxide, silicon dioxide or silicon nitride, which are deposited on at least one planar surface of the plastic substrate. The multi-layer overcoating is deposited on at least one planar surface of the plastic substrate and the organic LED is formed thereon. Alternatively, the multi-layer overcoating is deposited on all planar surfaces of the plastic substrate thereby encapsulating the plastic substrate in the alternating layers of the transparent inorganic material and the polymer film prior to forming the organic LED thereon. This multi-layer overcoating serves to reduce and eliminate the diffusion of oxygen and moisture through the plastic substrate, thereby damaging the organic LED formed thereon.

In a preferred embodiment the polymer film layer and the inorganic dielectric material layer each rely on a different mechanism for protection against permeation of oxygen and moisture through the plastic substrate. The polymer film