ULTRATHIN BARRIER LAMINATES AND DEVICES

TECHNICAL FIELD

The present disclosure relates to ultrathin barrier laminates and methods of making and using the same.

BACKGROUND

Many electronic devices such as organic light emitting diodes (OLEDs), organic and inorganic photovoltaics (PV), quantum dot (QD) devices require protection from oxygen and/or water ingress. Barrier coatings or films have been developed to protect electronic devices, for example, in the field of flexible electronics. Available barrier coatings or films generally are a stack of continuous layers including a substrate and a barrier film overlaying the substrate, where the substrate and barrier film as a whole can provide protection for electronic devices.

SUMMARY

There is a need to reduce the thickness of barrier coatings or films. However, web handling and converting thin continuous films may become more difficult as the substrate thickness decreases. For example, maintaining web tensions and managing thermal loads and expansion of the web may lead to wrinkling and binding of thin substrates in a roll-to-roll coating process. The present disclosure provides barrier assemblies including ultrathin barrier laminates and methods of making the same that can overcome the above challenges.

Briefly, in one aspect, the present disclosure describes an article including a thermoplastic polymer skin layer having opposite first and second major surfaces, and a barrier stack coated on the first major surface of the skin layer. The thermoplastic polymer skin layer and the barrier stack form an integral protective layer, and the integral protective layer has a thickness no greater than about 12.7 micrometers. A removable carrier film has a major surface releasably attached to the second major surface of the thermoplastic polymer skin layer. The removable carrier film is at least 2 times thicker than the integral protective layer to support the integral protective layer.

In another aspect, the present disclosure describes an optoelectronic device having a major surface. A thermoplastic polymer skin layer has opposite first and second major surfaces, and a barrier stack is coated on the first major surface of the thermoplastic polymer skin layer. The thermoplastic polymer skin layer and the barrier stack form an integral protective layer. The

integral protective layer has a thickness no greater than about 12.7 micrometers. The barrier stack of the integral protective layer is attached to the major surface of the optoelectronic device.

In another aspect, the present disclosure describes a method including providing a removable carrier film having a major surface, and providing a thermoplastic polymer skin layer disposed on the major surface of the removable carrier film. The thermoplastic polymer skin layer has opposite first and second major surfaces, and the second major surface of the thermoplastic polymer skin layer is releasably attached to the major surface of the removable carrier film. A barrier stack is coated on the first major surface of the skin layer. The thermoplastic polymer skin layer and the barrier stack form an integral protective layer having a thickness no greater than about 12.7 micrometers.

Various unexpected results and advantages are obtained in exemplary embodiments of the disclosure. One such advantage of exemplary embodiments of the present disclosure is that barrier assemblies having one or more strippable or removable layers which can be removed and result in ultrathin laminated barrier structures at end use, while at the same time, the thicker, multi-layered structure of the barrier assemblies can enable web handling and coating in roll-to-roll processes.

Various aspects and advantages of exemplary embodiments of the disclosure have been summarized. The above Summary is not intended to describe each illustrated embodiment or every implementation of the present certain exemplary embodiments of the present disclosure. The Drawings and the Detailed Description that follow more particularly exemplify certain preferred embodiments using the principles disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure may be more completely understood in consideration of the following detailed description of various embodiments of the disclosure in connection with the accompanying figures, in which:

FIG. 1 is a schematic side view of a multi-layer film, according to one embodiment.

FIG. 2 is a schematic side view of a multi-layer film, according to one embodiment.

FIG. 3A is a schematic side view of a barrier assembly, according to one embodiment.

FIG. 3B is an enlarged portion of the barrier assembly of FIG. 3A.

FIG. 4A is a schematic side view of an electronic device by applying the barrier assembly of FIG. 3A to the electronic device, according to one embodiment.

CLAIMS

1. An article comprising:

a thermoplastic polymer skin layer having opposite first and second major surfaces;

a barrier stack coated on the first major surface of the thermoplastic polymer skin layer, the thermoplastic polymer skin layer and the barrier stack forming an integral protective layer, the integral protective layer having a thickness no greater than about 12.7 micrometers; and

a removable carrier film having a major surface releasably attached to the second major surface of the thermoplastic polymer skin layer, the removable carrier film being at least 2 times thicker than the integral protective layer to support the integral protective layer.

2. The article of claim 1, wherein the barrier stack comprises an inorganic barrier layer and a first crosslinked polymer layer.

3. The article of claim 2, wherein the first crosslinked polymer layer is disposed on the first major surface of the thermoplastic polymer skin layer, and the inorganic barrier layer is disposed on the first crosslinked polymer layer.

4. The article of claim 3, wherein the barrier stack further comprises a second crosslinked polymer layer, and the inorganic barrier layer is sandwiched by the first and second crosslinked polymer layers.

5. The article of claim 1, wherein the thickness of the integral protective layer is in the range from about 0.254 micrometers to about 12.7 micrometers.

6. The article of claim 1, wherein the thickness of the thermoplastic polymer skin layer is in the range from about 0.254 micrometers to about 10.2 micrometers.

7. The article of claim 1, wherein the thickness of the barrier stack is in the range from about 5 nm to about 10 micrometers.

8. The article of claim 1, wherein the thermoplastic polymer skin layer comprises one or more thermoplastic polymers selected from the group consisting of polyester, polyolefin, polyacrylate, polyamide, polycarbonate, polyurethane, and polystyrene.

9. The article of claim 8, wherein the thermoplastic polymer skin layer includes polyethylene terephthalate (PET) or polyethylene naphthalate (PEN).

10. The article of claim 1, wherein the removable carrier film comprises a stack of polymer layers including a frontmost layer attached to the second major surface of the thermoplastic polymer skin layer and an interior layer attached to the frontmost layer on the opposite side thereof.

11. The article of claim 10, wherein the frontmost layer has a polymer composition B comprising a blend of propylene copolymer and styrenic block copolymer, a blend of propylene copolymer and an ethylene alpha olefin copolymer, or a blend of propylene copolymer and an olefin block copolymer.

12. The article of claim 10, wherein the interior layer has a polymer composition A comprising a semi-crystalline polyester.

13. The article of claim 10, wherein the frontmost layer is attached to the interior layer via an interlayer layer therebetween having a composition C, the frontmost layer has a weaker attachment to the second major surface of the thermoplastic polymer skin layer than to the interior layer such that the removable carrier film tends to irreversibly delaminate from the integral protective layer along a delamination surface corresponding to an interface between the frontmost layer and the thermoplastic polymer skin layer.

14. The article of claim 13, wherein the attachment of the frontmost polymer layer to the second major surface of the thermoplastic polymer skin layer is characterized by a first peel force, and wherein the attachment of the frontmost polymer layer to the underlying layer is characterized by a second peel force, and wherein the second peel force is at least two times the first peel force.

15. The article of claim 1, wherein the integral protective layer has a water vapor transmission rate (WVTR) less than about 0.005 g/m^2/day at 38° C and 100% relative humidity.

16. An optoelectronic device, comprising a major surface, and the article of claim 1, the barrier stack of the article being attached to the major surface of the optoelectronic device.

17. An optoelectronic device comprising:

a major surface;

a thermoplastic polymer skin layer having opposite first and second major surfaces;

a barrier stack coated on the first major surface of the thermoplastic polymer skin layer, the thermoplastic polymer skin layer and the barrier stack forming an integral protective layer, the integral protective layer having a thickness no greater than about 0.5 mil (12.7 microns),

wherein the barrier stack is attached to the major surface of the optoelectronic device.

18. The optoelectronic device of claim 16 or 17, further comprising an adhesive layer, and the barrier stack is attached to the major surface of the optoelectronic device by the adhesive layer.

19. The optoelectronic device of claim 18, wherein the adhesive layer includes an optical clear adhesive or a barrier adhesive.

20. The optoelectronic device of claim 17, which is an organic light-emitting diode (OLED) device comprising a major surface, and the barrier stack is attached to the major surface via the adhesive layer.

21. The optoelectronic device of claim 18, which is a light-wavelength conversion device comprising a polymer matrix layer having quantum dot particles embedded in the polymer matrix layer, the major surface being the surface of the polymer matrix layer, wherein the barrier stack is directly attached to the surface of the polymer matrix layer without any adhesive therebetween.

22. A method comprising:

providing a removable carrier film having a major surface;

providing a thermoplastic polymer skin layer disposed on the major surface of the removable carrier film, the thermoplastic polymer skin layer having opposite first and second major surfaces, and the second major surface of the thermoplastic polymer skin layer being releasably attached to the major surface of the removable carrier film; and

coating a barrier stack on the first major surface of the thermoplastic polymer skin layer, wherein the thermoplastic polymer skin layer and the barrier stack form an integral protective layer having a thickness no greater than about 0.5 mil (12.7 microns).

23. The method of claim 22, further comprising removing the removable carrier film from the integral protective layer by delamination along an interface therebetween.