EXTENSIBLE BARRIER FILMS, ARTICLES EMPLOYING SAME AND METHODS OF MAKING SAME

FIELD

The present disclosure relates to barrier films. The present disclosure further provides articles employing these barrier films and methods of making these barrier films.

BACKGROUND

Many electronic devices are sensitive to environmental gases and liquids and are prone to degradation on permeation of the environmental gases and liquids such as oxygen and water vapor. Inorganic or hybrid inorganic/organic layers have been used in thin films for electrical, packaging and decorative applications to prevent the degradation. For example, multilayer stacks of inorganic or hybrid inorganic/organic layers can be used to make barrier films resistant to moisture permeation. Multilayer barrier films have also been developed to protect sensitive materials from damage due to water vapor. The water sensitive materials can be electronic components such as organic, inorganic, and hybrid organic/ inorganic semiconductor devices. While the technology of the prior art may be useful, there exists a need for better barrier films useful for packaging electronic components.

SUMMARY

In one aspect, the present disclosure provides a barrier film comprising an inorganic barrier layer having two opposing major surfaces; a first organic layer in direct contact with one of the opposing major surfaces of the barrier layer; a second organic layer in direct contact with the other of the opposing major surfaces of the barrier layer; and a substrate in direct contact with the first organic layer or the second organic layer; wherein the barrier layer comprises buckling deformations with average spacing smaller than average spacing of the buckling deformations in the first or second organic layer.

In another aspect, the present disclosure provides a barrier film comprising: an inorganic barrier layer having two opposing major surfaces, wherein the barrier layer comprises buckling deformations; a first organic layer in direct contact with one of the opposing major surfaces of the barrier layer; a second organic layer in direct contact with the other of the opposing major surfaces of the barrier layer; and a substrate in direct contact with the first organic layer or the second organic layer; wherein each of the first organic layer and the second organic layer has a conformable surface conforming to a shape of the barrier layer; and wherein each of the first organic layer and the second organic layer has a substantially flat surface disposed opposite to and spaced apart from the conformable surface.

In another aspect, the present disclosure provides an article comprising a device disposed on the barrier film of the present disclosure, wherein the barrier film is stretched to no less than 1% relative to its unstretched state.

In another aspect, the present disclosure provides a method of making the barrier film of the present disclosure, comprising: depositing a barrier layer between a first organic layer and a second organic layer to form a layer construction; and applying heat to the layer construction.

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

DEFINITIONS

For the following defined terms, these definitions shall be applied for the entire Specification, including the claims, unless a different definition is provided in the claims or elsewhere in the Specification based upon a specific reference to a modification of a term used in the following definitions:

The terms "a", "an", and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a material containing "a compound" includes a mixture of two or more compounds.

The term "layer" refers to any material or combination of materials on or overlaying a substrate.

The term "separated by" to describe the position of a layer with respect to another layer and the substrate, or two other layers, means that the described layer is between, but not necessarily contiguous with, the other layer(s) and/or substrate.

The term "(co)polymer" or "(co)polymeric" includes homopolymers and copolymers, as well as homopolymers or copolymers that may be formed in a miscible blend, *e.g*., by coextrusion or by reaction, including, *e.g*., transesterification. The term "copolymer" includes random, block, graft, and star copolymers.

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 side view of an exemplary barrier film according to the present invention.

FIG. 2 is a side view of an embodiment of barrier film according to the present invention.

While the above-identified drawings, which may not be drawn to scale, set forth various embodiments of the present disclosure, other embodiments are also contemplated, as noted in the Detailed Description. In all cases, this disclosure describes the presently disclosed invention by way of representation of exemplary embodiments and not by express limitations. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of this disclosure.

What is claimed is:

1. A barrier film comprising:

(a) an inorganic barrier layer having two opposing major surfaces;

(b) a first organic layer in direct contact with one of the opposing major surfaces of the barrier layer; and

(c) a second organic layer in direct contact with the other of the opposing major surfaces of the barrier layer;

(d) a substrate in direct contact with the first organic layer or the second organic layer;

wherein the barrier layer comprises buckling deformations with average spacing smaller than average spacing of the buckling deformations in the first or second organic layer.

2. A barrier film comprising:

(a) an inorganic barrier layer having two opposing major surfaces, wherein the barrier layer comprises buckling deformations;

(b) a first organic layer in direct contact with one of the opposing major surfaces of the barrier layer;

(c) a second organic layer in direct contact with the other of the opposing major surfaces of the barrier layer; and

(d) a substrate in direct contact with the first organic layer or the second organic layer;

wherein each of the first organic layer and the second organic layer has a conformable surface conforming to a shape of the barrier layer; and

wherein each of the first organic layer and the second organic layer has a substantially flat surface disposed opposite to and spaced apart from the conformable surface.

3. The barrier film of any of claims 1 to 2, wherein the substrate is heat-shrinkable.

4. The barrier film of claim 3, wherein the heat-shrinkable substrate shrinks at a predetermined temperature.

5. The barrier film of claim 3, wherein the heat shrinkable substrate comprises an organic polymer.

6. The barrier film of any one of claims 1 to 5, wherein the barrier layer comprises at least one selected from the group consisting of individual metals, two or more metals as mixtures, inter-metallics or alloys, metal oxides, metal and mixed metal oxides, metal and mixed metal fluorides, metal and mixed metal nitrides, metal and mixed metal carbides, metal and mixed metal carbonitrides, metal and mixed

metal oxynitrides, metal and mixed metal borides, metal and mixed metal oxy borides, metal and mixed metal silicides, and combinations thereof.

7. The barrier film of claim 6, wherein the barrier layer comprises metal oxide.

8. The barrier film of claim 7, wherein the metal oxide is selected from the group of silicon oxides, aluminum oxides, titanium oxides, indium oxides, tin oxides, indium tin oxide (ITO), halfnium oxide, tantalum oxide, zirconium oxide, zinc oxide, niobium oxide, and combinations thereof.

9. The barrier film of any one of the preceding claims, wherein the first organic layer or the second organic layer comprises an acrylate.

10. The barrier film of any one of the preceding claims, wherein the barrier film has a water vapor transmission rate of less than 0. 1 g/m^2/day after 5% uniaxial stretch.

11. The barrier film of any one of the preceding claims, wherein the barrier film has a water vapor transmission rate of less than 0. 1 g/m^2/day after 10% uniaxial stretch.

12. An article comprising a device disposed on a barrier film of claims 1 to 11, wherein the barrier film is stretched to no less than 1% relative to its unstretched state.

13. A method of making the barrier film of claims 1 to 11, comprising:

depositing a barrier layer between a first organic layer and a second organic layer to form a layer construction; and

applying heat to the layer construction.

14. The method of claim 13, wherein forming the layer construction further comprises depositing the first organic layer or the second organic layer on a substrate.