Summary

[0006] A subwavelength structured surface gradient solution is therefore desired. Preferably, the solution provides a relatively low reflection (i.e., average reflection over the visible range less than 1 (in some embodiments, less than 0.5) percent) and durable characteristics to enhance the viewing quality of display devices.

[0007] ~~In one aspect, the~~The present disclosure describes a material comprising sub-micrometer particles dispersed in a polymeric matrix, wherein the material has a major surface, wherein the sub-micrometer particles have particle sizes of at least 75 nm (in some embodiments, in a range from 75 nm to 500 nm (in some embodiments, 100 nm 300 nm, or even 150 nm to 250 nm)), wherein a portion of the sub-micrometer particles protrude from the major surface by up to 90 (in some embodiments, 80, 70, 60, or even up to 50) percent of their respective particle sizes (in some embodiments, 80, 70, 60, or even up to 50) percent of their respective particle sizes (i.e., at least the specified percent from where the respective particle protrudes from the polymeric matrix), wherein the protruding sub-micrometer particles each have an exposed outer surface wherein less than 50 (in some embodiments, less than 40, 30, 25, 20, 15, 10, 5, or 1; or zero) percent of the exposed outer surface is covered by organic material. In one aspect, the present disclosure describes a material comprising sub-micrometer particles dispersed in a polymeric matrix, wherein the material has a major surface, wherein the sub-micrometer particles have particle sizes of at least 75 nm, wherein a portion of the sub-micrometer particles protrude from the major surface by up to 90 percent of their respective particle sizes, wherein the protruding sub-micrometer particles each have an exposed outer surface, wherein less than 50 percent of the exposed outer surface is covered by organic material. Optionally, the sub-micrometer particles are covalently bonded to the polymeric matrix. Optionally, at least some of the sub-micrometer particles are functionalized with at least one silane coupling agent (e.g., a silane coupling agent comprising at least one of monofunctional or multifunctional (e.g., difunctional) groups (e.g., acrylate, epoxy, silanol, or vinyl)).

[0008] ~~In another aspect, the~~The present disclosure describes a material comprising sub-micrometer particles dispersed in a polymeric matrix, wherein the material has a major surface, wherein the sub-micrometer particles have particle sizes of at least 75 nm (in some embodiments, in a range from 75 nm to 500 nm (in some embodiments, 100 nm 300 nm, or even 150 nm to 250 nm)), wherein a portion of the sub-micrometer particles protrude from the major surface in a range from 50 nm to 200 nm (in some embodiments, 75 nm to 175 nm, or even 100 nm to 150 nm), and wherein a portion of the sub-micrometer particles protrude from the major surface by up to 90 (in some embodiments, 80, 70, 60, or even up to 50) percent of their respective particle sizes. Optionally, the protruding sub-micrometer particles each have an exposed outer surface wherein less than 50 (in some embodiments, less than 40, 30, 25, 20, 15, 10, 5, or 1; or zero) percent of the exposed outer surface is covered by organic material. In another aspect, the present disclosure describes a material comprising sub-micrometer particles dispersed in a polymeric matrix, wherein the material has a major surface, wherein the sub-micrometer particles have particle sizes of at least 75 nm, wherein a portion of the sub-micrometer particles protrude from the major surface in a range from 50 nm to 200 nm, wherein a portion of the sub-micrometer particles protrude from the major surface by up to 90 percent of their respective particle sizes, wherein the protruding sub-micrometer particles each have an exposed outer surface, and wherein less than 50 percent of the exposed outer surface is covered by organic material. Optionally, the sub-

micrometer particles are covalently bonded to the polymeric matrix. Optionally, at least some of the sub-micrometer particles are functionalized with at least one silane coupling agent (e.g., a silane coupling agent comprising at least one of monofunctional or multifunctional (e.g., difunctional) groups (e.g., acrylate, epoxy, silanol, or vinyl)).

[0009] ~~In another aspect, the~~The present disclosure describes a material comprising sub-micrometer particles dispersed in a polymeric matrix, wherein the material has a major surface, wherein a portion of the sub-micrometer particles protrude from the major surface by up to 90 (in some embodiments, 80, 70, 60, or

even up to 50) percent of their respective particle sizes, and wherein the sub-micrometer particles are covalently bonded to the polymeric matrix. In some embodiments, the sub-micrometer particles have particle sizes of at least 20 nm (in some embodiments, in a range from 20 nm to 500 nm (in some embodiments, 75 nm to 500 nm, 100 nm 300 nm, or even 150 nm to 250 nm)). Optionally, at least some of the sub-micrometer particles are functionalized with at least one silane coupling agent (e.g., a silane coupling agent comprising at least one of monofunctional or multifunctional (e.g., difunctional) groups (e.g., acrylate, epoxy, silanol, or vinyl)).

[0010] In some embodiments, the average spacing (i.e. distance between the closest edges of two particles) between the protruding sub-micrometer particles is in a range from 5 nm to 300 nm (in some embodiments, 10 nm to 300 nm, 20 nm to 300 nm, 30 nm to 300 nm, 40 nm to 300 nm, 50 nm to 275 nm, 75 nm to 250 nm, or even 100 nm to 225 nm).

[0011] In some embodiments, materials described herein are in the form of a layer. In another aspect, the present disclosure describes an article comprising a substrate having first and second generally opposed major surfaces with a layer of the material described herein on the first major surface.

[0012] In another aspect, the present disclosure provides a method of making ~~material or~~the article described herein, the method comprising:

providing a layer comprising sub-micrometer particles dispersed in a polymeric precursor matrix;

at least one of drying or curing the layer; and

etching the ~~at least one of~~ dried or cured layer, as applicable, to provide the ~~material or~~ article. described herein.

[0013] Optionally, articles described herein further comprise a functional layer (i.e., at least one of a transparent conductive layer or a gas barrier layer) disposed between the first major surface of a substrate and a layer of material described herein. Optionally, articles described herein further comprise a functional layer (i.e., at least one of a transparent conductive layer or a gas barrier layer) disposed on a layer of material described herein.

[0014] Optionally, articles described herein further comprise a (second) layer of material (including a described herein and those described in PCT Appl. Nos. US2011/026454, filed February 28, 2011, and US. Pat. Appl. Nos. 61/452,403 and 61/452,430, filed March 14, 2011, the disclosures of which are incorporated herein by reference) on the second major surface of a substrate. Optionally, articles described herein further comprise a functional layer (i.e., at least one of a transparent conductive layer or a gas barrier layer) disposed between the second major surface of a substrate and a (second) layer of material. Optionally, articles described herein further comprise a functional layer (i.e., at least one of a transparent conductive layer or a gas barrier layer) disposed on a (second) layer of material.

[0015] When light enters multilayer substrates, the reflectivity of the light undergoes a period change according to the wavelength of the incident light. The reflection behavior with specific repeating period is referred to as an interference fringe. The greater the difference in the index of refraction among the