modification of a material's surface chemical composition and/or its surface geometric structure.

In another method, anti-reflective structures may be used to reduce the reflection (or glare) of light and increase the transmission of light through a material.

However, there is a need to provide improved materials that offer one or more of the above properties. There is also a need to provide transparent materials that overcome, or at least ameliorate, one or more of the disadvantages described above.

Summary

In the present disclosure, there is provided a textured polymer substrate comprising nano-sized surface features which are integrally formed on at least one surface of the polymer substrate, said polymer substrate surface having at least one substantially amorphous oxide layer deposited thereon which conforms to said surface features.

In one aspect, there is provided a textured polymer substrate comprising nano-sized surface features which are integrally formed on at least one surface of the polymer substrate, said polymer substrate surface having at least one amorphous oxide layer deposited thereon, wherein said amorphous oxide layer comprises an oxide of a metal selected from titanium, cobalt, aluminum and composites thereof.

Advantageously, the nano-sized surface features of the disclosed polymer substrate may provide anti-reflective properties to the polymer material. The nano-sized surface features may reduce or substantially prevent scattering of incident light falling on said polymer substrate. The nano-sized surface features may improve the transmittance of electromagnetic ("EM") radiation through the polymer substrate, for instance, the transmittance of the EM radiation in the visible light spectrum.

Advantageously, the amorphous oxide layer may be selected to provide the disclosed polymer substrate with an anti-fogging property by presenting hydrophilicity or hydrophobicity. The anti-reflective and anti-fogging properties may be expressed additively or synergistically. It has been surprisingly found that amorphous metal oxide, in particular, amorphous (non-crystalline) titanium (II) oxide (TiO_2) may be particularly useful for conferring an anti-fogging property to the disclosed textured polymer substrate. Advantageously, the amorphous titanium oxide layer can be readily deposited without the use of heat-intensive techniques e.g., pulsed laser ablation, sputtering, or thermal chemical

vapor deposition (TCVD), which may otherwise deform the polymer substrate. In one embodiment, the amorphous oxide may be advantageously deposited by an Atomic Layer Deposition (ALD) technique, which can be performed at temperatures not exceeding glass transition temperatures of the polymer substrate. Further advantageously, the use of ALD affords precise thickness control of the metal oxide layer, which allows the deposited layer to exhibit a substantially even thickness across coated surfaces. This is important because an uneven coating could destroy the fidelity of the topological features and adversely affect the optical as well as anti-reflective properties of the coated surface features.

The disclosure relates to a method of preparing a polymer substrate, said method comprising the steps of: imprinting a surface of said polymer substrate with a patterned mold to integrally form a patterned surface having an array of micro-sized structures; embossing said patterned surface to form a hierarchical array, wherein nano-sized surface features are integrally formed on said micro-sized structures; and depositing an amorphous oxide layer over said polymer substrate surface.

In another aspect, there is provided a method of preparing a polymer substrate, said method comprising the steps of: imprinting a surface of said polymer substrate with a patterned mold to integrally form a patterned surface having an array of micro-sized structures; embossing said patterned surface to form a hierarchical array, wherein nano-sized surface features are integrally formed on a surface of said micro-sized structures; and depositing an amorphous oxide layer over said polymer substrate surface, wherein said amorphous oxide layer comprises an oxide of a metal selected from titanium, cobalt, aluminum and composites thereof.

Advantageously, the disclosed method provides a means for texturing polymer-based substrates to impart anti-reflective and anti-fogging properties, which may be expressed additively. In particular, the disclosed imprinting step and embossing step may act in cooperation to form hierarchical structures, wherein nano-sized surface features are integrally embossed on a surface of micron-sized structures already imprinted on the polymer substrate surface. Advantageously, the patterned surface may be selectively engineered as one exhibiting biomimetic properties, e.g., moth's eye, lotus leaf, by

imprinting corresponding topographical surface features thereon. For instance, molds having hexagonal patterns may be used to provide an ommatidium, or ommatidia-like pattern on the polymer substrate surface.

The disclosed method further provides means for obtaining anti-fogging properties by deposition of an amorphous oxide layer. In embodiments, the amorphous oxide layer may comprise a metal oxide (e.g., TiO_2) or composites of metal oxides, metal-Si oxides to thereby confer superhydrophilicity or superhydrophobicity to the coated polymer substrate.

Claims

1. A textured polymer substrate comprising nano-sized surface features which are integrally formed on at least one surface of the polymer substrate, said polymer substrate surface having at least one amorphous oxide layer deposited thereon, wherein said amorphous oxide layer comprises an oxide of a metal selected from titanium, cobalt, aluminum and composites thereof.

2. The textured polymer substrate of claim 1, wherein said nano-sized surface features are formed on a one-dimensional array or a single array or
on a hierarchical array.

3. The textured polymer substrate of claim 2, wherein said polymer substrate surface comprises an array of micro-sized structures integrally formed on said polymer substrate, each micro-sized structure having at least one surface with nano-sized surface features imprinted thereon;
wherein the micro-sized structures are geometrically selected to be biomimetic.

4. The textured polymer substrate of claim 3, wherein said array of micro-sized structures comprises tessellated structures selected from the group consisting of: trigonal, tetragonal, square, rhombic, pentagonal, hexagonal, heptagonal, octagonal, nonagonal, decagonal, undecagonal, dodecagonal, tridecagonal and tetreadecagonal structures.

5. The textured polymer substrate of claim 3 or claim 4, wherein said array of micro-sized structures comprises ommatidium or ommatidia-like structures.

6. The textured polymer substrate of claim 3, wherein said micro-sized structures comprises at least one diameter dimension of between about 1 to about 15 microns.

7. The textured polymer substrate of any one of the preceding claims, wherein at least a height dimension, or at least a width dimension, or both, of said nano-sized surface features is lesser than 390 to 700 nm.

8. The textured polymer substrate of any one of the preceding claims, wherein said amorphous oxide layer has a substantially uniform thickness
deposited by a chemical vapor deposition process, characterized in that said process is performed at a temperature below the glass transition temperature of said polymer substrate.

9. The textured polymer substrate of any one of the preceding claims, wherein said amorphous oxide layer is deposited by Atomic Layer Deposition.

10. The textured polymer substrate of any one of the preceding claims, wherein said polymer substrate is substantially optically transparent.

11. The textured polymer substrate of any one of the preceding claims, wherein said amorphous oxide layer comprises amorphous titanium oxide.

12. A method of preparing a polymer substrate, said method comprising the steps of:

imprinting a surface of said polymer substrate with a patterned mold to integrally form a patterned surface having an array of micro-sized structures;

embossing said patterned surface to form a hierarchical array, wherein nano-sized surface features are integrally formed on a surface of said micro-sized structures; and

depositing an amorphous oxide layer over said polymer substrate surface, wherein said amorphous oxide layer comprises an oxide of a metal selected from titanium, cobalt, aluminum and composites thereof.

13. The method of claim 12, wherein said depositing step comprises atomic layer deposition.

14. The method of claim 12 or 13, wherein said imprinting step is performed at a temperature above the glass transition temperature of said polymer substrate.

15. The method of any one of claims 12 to 14, wherein said embossing step is performed at a temperature lower than the glass transition temperature of said polymer substrate.

16. The method of any one of claims 12 to 15, wherein the mold of said imprinting step is selected to provide tesallated polygonal structures on said patterned surface;
wherein said polygonal structures are micro-sized structures.

17. The method of claim 16, wherein said embossing step comprises contacting at least a surface of said micro-sized polygonal structures with a second mold to integrally form a plurality of nano-sized surface features, thereby forming a hierarchical array.

18. The method of claim 17, wherein the nano-sized surface features comprises structures selected from the group consisting of: nano-cones, nano-pyramids, nano-cylinders, nano-needles, nano-blades, and combinations thereof.

19. The method of any one of claims 12 to 18, wherein said amorphous oxide layer is amorphous titanium oxide.

20. The method of claim 19, wherein said deposition step is undertaken to obtain a thickness of said amorphous titanium oxide layer of from about 10 to 50 nm.