least two or three adjacent tiles, or even in most tiles or every tile of the article, may include at least one lengthwise groove that is parallel to an edge of the tile and parallel to a fixed in-plane axis, which axis may be a down-web direction of the article. Each tile may have a width that is narrow (e.g. 0.2 to 5 mm, or less than 1 mm, or from 0.2 to 1 mm), and equal to an integer multiple of a lengthwise groove pitch to avoid or reduce ineffective fragmented cube corners, and vertical surfaces, along the tile edge. Each array may have a plane of cant and a primary plane of entrance angularity, and the primary planes of entrance angularity for the multiple tiles may be more evenly distributed in azimuthal angle than the planes of cant.

~~The present application further discloses, *inter alia*,~~A first aspect of the present invention provides an article~~s~~ having a structured surface that defines a reference plane having an in-plane axis, the structured surface including a plurality of cube corner arrays arranged into a plurality of tiles, the article including first, second, and third tiles. The first, second, and third tiles are defined by respective first, second, and third cube corner arrays, the first, second, and third cube corner arrays having respective first, second, and third primary planes of entrance angularity, each oriented differently relative to the in-plane axis. The first, second, and third tiles each includes one tile edge parallel to the in-plane axis. Each of the first, second, and third cube corner arrays includes one given groove parallel to the in-plane axis.

The first, second, and third tiles may each be elongated parallel to the in-plane axis. For each of the first, second, and third tiles, the given groove may be one of a plurality of lengthwise grooves that define a lengthwise groove pitch, and each of the first, second, and third tiles may have a width equal to an integer multiple of the respective lengthwise groove pitch. The widths of the first, second, and third tiles may each be in a range from 0.2 mm to 5 mm, or from 0.2 mm to 1 mm, or from 0.5 mm to 1 mm. The plurality of tiles may include additional tiles other than the first, second, and third tiles, the additional tiles having corresponding additional cube corner arrays, and all of the additional cube corner arrays may include one given groove parallel to the in-plane axis.

Cube corners in each of the first, second, and third cube corner arrays may be canted and characterized by a base triangle having an ordered set of base angles, and the ordered sets of base angles for the first and second cube corner arrays may be equal to each other, and the ordered sets of base angles for the first and third cube corner arrays may be permutations of each other. The concept of an ordered set of base angles is discussed further below.

The ordered sets of base angles for the first, second, and third cube corner arrays may alternatively be equal to each other. The plurality of tiles may then further include a fourth tile defined by a fourth cube corner array, and the fourth cube corner array may have a fourth primary plane of entrance angularity that is not parallel to any of the first, second, or third primary planes of entrance angularity, and cube corners in the fourth cube corner array may be canted and

characterized by a base triangle having an ordered set of base angles that is a permutation of the ordered set of base angles for the first cube corner array. The fourth tile may be elongated parallel to the in-plane axis, and the fourth cube corner array may include one lengthwise groove parallel to the in-plane axis.

All of the cube corner arrays in the plurality of cube corner arrays may have respective primary planes of entrance angularity, the primary planes of entrance angularity may define at least 4 unique orientations relative to the in-plane axis. The cube corner arrays associated with the at least 4 unique orientations may each include one lengthwise groove parallel to the in-plane axis, and may be characterized by respective ordered sets of base angles, every two of such ordered sets of base angles either being equal to each other or being permutations of each other. The primary planes of entrance angularity may also define at least 5 unique orientations relative to the in-plane axis. The cube corner arrays associated with the at least 5 unique orientations may be characterized by respective ordered sets of base angles, every two of such ordered sets of base angles either being equal to each other or being permutations of each other. The primary planes of entrance angularity may also define at least 6 unique orientations relative to the in-plane axis. The cube corner arrays associated with the at least 6 unique orientations may be characterized by respective ordered sets of base angles, every two of such ordered sets of base angles either being equal to each other or being permutations of each other.

The first and second tiles may have tile edges that meet along a boundary, and facets of a row of cube corners on the first tile near the boundary and facets of a row of cube corners on the second tile near the boundary may collectively form a composite groove, the composite groove being parallel to the in-plane axis. The composite groove may have a composite groove angle that differs from a groove angle of the given groove of the first cube corner array and that also differs from a groove angle of the given groove of the second cube corner array.

The structured surface may provide a uniformity index at a 30 degree entrance angle of at least 4, or at least 5, or at least 6. The structured surface may provide a uniformity index at a 40 degree entrance angle of at least 2, or at least 3, or at least 4, or at least 5.

~~The present application also discloses~~A second aspect of the present invention provides an articles having a structured surface that includes a plurality of cube corner arrays arranged into a corresponding plurality of tiles, the structured surface defining a reference plane having an in-plane axis. The cube corner array for each of the plurality of tiles have a given groove set whose grooves extend parallel to the in-plane axis, the cube corner array for each of the plurality of tiles have associated therewith a plane of cant and a primary plane of entrance angularity. Unique ones of the primary planes of entrance angularity for the plurality of tiles are more evenly distributed in azimuthal angle than unique ones of the planes of cant.

The unique ones of the primary planes of entrance angularity may have a minimum angular separation PhiMin1 and the unique ones of the planes of cant may have a minimum angular separation PhiMin2, and PhiMin1 may be greater than PhiMin2, or PhiMin1 may be at least 2 times PhiMin2. The unique ones of the primary planes of entrance angularity have a maximum angular separation PhiMax1, and the unique ones of the planes of cant may have a maximum angular separation PhiMax2, and PhiMax1 may be less than PhiMax2. An angular distribution metric PhiADM1 (described below) for the unique ones of the primary planes of entrance angularity may be greater than the corresponding angular distribution metric PhiADM2 (also described below) for the unique ones of the planes of cant.

The plurality of tiles may each be elongated parallel to the in-plane axis. The tiles may have respective widths that are in a range from 0.2 mm to 5 mm, or from 0.2 mm to 1 mm, or from 0.5 mm to 1 mm. The given groove set for each tile may be a lengthwise groove set for such tile. The structured surface may have N unique primary planes of entrance angularity associated respectively with N unique ones of the cube corner arrays, and N may be 4, 5, or 6. The plurality of tiles may include a first, second, and third tile comprising respective first, second, and third arrays of canted cube corners, and the first, second, and third arrays may have associated therewith respective first, second, and third planes of cant no two of which are parallel to each other. For each of the first, second, and third arrays, the given groove set may be a lengthwise groove set that defines a lengthwise groove pitch, and each of the first, second, and third tiles may have a width equal to an integer multiple of the respective lengthwise groove pitch.

The structured surface may provide a uniformity index at a 30 degree entrance angle of at least 4, or at least 5, or at least 6. The structured surface may provide a uniformity index at a 40 degree entrance angle of at least 2, or at least 3, or at least 4, or at least 5.

~~The present application also discloses~~A third aspect of the present invention provides an articles having a structured surface, the structured surface being segmented into a plurality of tiles, the article including at least a first, second, and third tile comprising respective first, second, and third arrays of canted cube corners. The first, second, and third arrays have associated therewith respective first, second, and third planes of cant no two of which are parallel to each other. Cube corners in the first, second, and third arrays are characterized by base triangles having respective first, second, and third ordered sets of base angles, and the first and second ordered sets of base angles may be equal to each other, and the first and third ordered sets of base angles may be permutations of each other.

Each of the first, second, and third arrays may have a groove set whose grooves extend parallel to an edge of its respective tile. Each of the first, second, and third arrays may be defined by three sets of parallel grooves that intersect each other to form cube corners. The article may also include a fourth tile comprising a fourth array of canted cube corners, and the fourth array

7. The article of claim 1, wherein cube corners in each of the first, second, and third cube corner arrays are canted and characterized by a base triangle having an ordered set of base angles, and wherein the ordered sets of base angles for the first, second, and third cube corner arrays are equal to each other.

8. The article of claim 7, wherein the plurality of tiles further includes a fourth tile defined by a fourth cube corner array, the fourth cube corner array having a fourth primary plane of entrance angularity that is not parallel to any of the first, second, or third primary planes of entrance angularity, and wherein cube corners in the fourth cube corner array are canted and characterized by a base triangle having an ordered set of base angles that is a permutation of the ordered set of base angles for the first cube corner array.

9. The article of claim 8, wherein the fourth tile is elongated parallel to the in-plane axis, and the fourth cube corner array includes one lengthwise groove parallel to the in-plane axis.

10. The article of claim 1, wherein all of the cube corner arrays in the plurality of cube corner arrays have respective primary planes of entrance angularity, the primary planes of entrance angularity defining at least 4 unique orientations relative to the in-plane axis.

11. The article of claim 10, wherein the cube corner arrays associated with the at least 4 unique orientations each include one lengthwise groove parallel to the in-plane axis and are characterized by respective ordered sets of base angles, every two of such ordered sets of base angles either being equal to each other or being permutations of each other.

~~12. The article of claim 10, wherein the primary planes of entrance angularity define at least 5 unique orientations relative to the in-plane axis.~~

~~13. The article of claim 12, wherein the cube corner arrays associated with the at least 5 unique orientations are characterized by respective ordered sets of base angles, every two of such ordered sets of base angles either being equal to each other or being permutations of each other.~~

~~14. The article of claim 12, wherein the primary planes of entrance angularity define at least 6 unique orientations relative to the in-plane axis.~~

~~15. The article of claim 14, wherein the cube corner arrays associated with the at least 6 unique orientations are characterized by respective ordered sets of base angles, every two of such ordered sets of base angles either being equal to each other or being permutations of each other.~~

~~16~~12. The article of claim 1, wherein the first and second tiles have tile edges that meet along a boundary, and wherein facets of a row of cube corners on the first tile near the boundary and facets of a row of cube corners on the second tile near the boundary collectively form a composite groove, the composite groove being parallel to the in-plane axis.

~~17~~13. The article of claim ~~16~~12, wherein the composite groove has a composite groove angle that differs from a groove angle of the given groove of the first cube corner array and that also differs from a groove angle of the given groove of the second cube corner array.

~~18~~14. The article of claim 1, wherein the structured surface provides a uniformity index at a 30 degree entrance angle of at least 4, or at least 5, or at least 6.

~~19. The article of claim 1, wherein the structured surface provides a uniformity index at a 40 degree entrance angle of at least 2, or at least 3, or at least 4, or at least 5.~~

~~20~~15. An article having a structured surface that includes a plurality of cube corner arrays arranged into a corresponding plurality of tiles, the structured surface defining a reference plane having an in-plane axis, the cube corner array for each of the plurality of tiles having a given groove set whose grooves extend parallel to the in-plane axis, the cube corner array for each of the plurality of tiles having associated therewith a plane of cant and a primary plane of entrance angularity, and wherein unique ones of the primary planes of entrance angularity for the plurality of tiles are more evenly distributed in azimuthal angle than unique ones of the planes of cant.

~~21~~16. The article of claim ~~20~~15, wherein the unique ones of the primary planes of entrance angularity have a minimum angular separation PhiMin1 and the unique ones of the planes of cant have a minimum angular separation PhiMin2, and wherein PhiMin1 is greater than PhiMin2.

~~22~~17. The article of claim ~~20~~15, wherein PhiMin1 is at least 2 times PhiMin2.

~~23. The article of claim 15, wherein the tiles have respective widths that are in a range from 0.2 mm to 5 mm.~~

~~24~~18. The article of claim ~~20~~15, wherein the given groove set for each tile is a lengthwise groove set for such tile.

~~25~~19. The article of claim ~~20~~15, wherein the structured surface has N unique primary planes of entrance angularity associated respectively with N unique ones of the cube corner arrays, and wherein N is 4, 5, or 6.

~~26~~20. The article of claim ~~20~~15, wherein the plurality of tiles includes a first, second, and third tile comprising respective first, second, and third arrays of canted cube corners, the first, second, and third arrays having associated therewith respective first, second, and third planes of cant no two of which are parallel to each other.

~~27~~21. The article of claim ~~26~~20, wherein for each of the first, second, and third arrays, the given groove set is a lengthwise groove set that defines a lengthwise groove pitch, and each of the first, second, and third tiles has a width equal to an integer multiple of the respective lengthwise groove pitch.

~~28~~22. The article of claim ~~20~~15, wherein the structured surface provides a uniformity index at a 30 degree entrance angle of at least 4, or at least 5, or at least 6.

~~29. The article of claim 20, wherein the structured surface provides a uniformity index at a 40 degree entrance angle of at least 2, or at least 3, or at least 4, or at least 5.~~

~~30~~23. The article of claim ~~20~~15, wherein the plurality of tiles are each elongated parallel to the in-plane axis.

~~31~~24. An article having a structured surface, the structured surface being segmented into a plurality of tiles, the article comprising:

a first, second, and third tile comprising respective first, second, and third arrays of canted cube corners, the first, second, and third arrays having associated therewith respective first, second, and third planes of cant no two of which are parallel to each other;

wherein cube corners in the first, second, and third arrays are characterized by base triangles having respective first, second, and third ordered sets of base angles;

wherein the first and second ordered sets of base angles are equal to each other; and

wherein the first and third ordered sets of base angles are permutations of each other.

~~32~~25. The article of claim ~~31~~24, wherein each of the first, second, and third arrays has a groove set whose grooves extend parallel to an edge of its respective tile.

~~33~~26. The article of claim ~~31~~24, wherein each of the first, second, and third arrays is defined by three sets of parallel grooves that intersect each other to form cube corners.

~~34. The article of claim 31, further comprising:~~

~~a fourth tile comprising a fourth array of canted cube corners, the fourth array having associated therewith a fourth plane of cant that is not parallel to any of the first, second, or third planes of cant.~~

~~35. The article of claim 34, wherein the fourth array is characterized by a base triangle having a fourth ordered set of base angles, the fourth ordered set of base angles being the same as the third ordered set of base angles.~~

~~36. The article of claim 31, wherein the structured surface provides a uniformity index at a 30 degree entrance angle of at least 4, or at least 5, or at least 6.~~

~~37. The article of claim 31, wherein the structured surface provides a uniformity index at a 40 degree entrance angle of at least 2, or at least 3, or at least 4, or at least 5.~~