CLAIMS

1. A light extraction film having internal nanostructures and external microstructures, comprising:

a flexible substantially transparent film;

a low index nanostructured layer applied to the flexible substantially transparent film;

a high index planarizing backfill layer applied over the nanostructured layer; and

external optical microstructures applied to the flexible substantially transparent film on a side opposite the nanostructured layer.

2. The light extraction film of claim 1, wherein the external optical microstructures comprise one-dimensional microstructures.

3. The light extraction film of claim 1, wherein the external optical microstructures comprise two-dimensional microstructures.

4. The light extraction film of claim 1, wherein nanostructured layer comprises one-dimensional nanostructures and the external optical microstructures comprise one-dimensional microstructures orthogonal to the one-dimensional nanostructures.

5. The light extraction film of claim 4, wherein the one-dimensional nanostructures and the one-dimensional microstructures are each linear structures.

6. The light extraction film of claim 1, wherein the low index nanostructured layer comprises nanoparticles applied in a surface layer manner to the flexible substantially transparent film.

7. The light extraction film of claim 1, wherein the low index nanostructured layer comprises photonic crystal structures or linear gratings.

8. The light extraction film of claim 1, further comprising a protective layer applied over the backfill layer.

9. The light extraction film of claim 1, wherein the external optical microstructures comprise microlens arrays.

10. The light extraction film of claim 1, wherein the external optical microstructures comprise curve sided cone structures.

11. A method for making a light extraction film having internal nanostructures and external microstructures, comprising:

providing a flexible substantially transparent film;

applying a low index nanostructured layer to the flexible substantially transparent film;

applying a high index planarizing backfill layer over the nanostructured layer; and

applying external optical microstructures to the flexible substantially transparent film on a side opposite the nanostructured layer.

12. The method of claim 11, wherein the external optical microstructures comprise one-dimensional microstructures.

13. The method of claim 11, wherein the external optical microstructures comprise two-dimensional microstructures.

14. The method of claim 11, wherein nanostructured layer comprises one-dimensional nanostructures and the external optical microstructures comprise one-dimensional microstructures orthogonal to the one-dimensional nanostructures.

15. The method of claim 11, further comprising applying a protective layer over the backfill layer.

16. The method of claim 11, wherein the nanostructured layer and the external optical microstructures are contained within two films laminated together.

17. The method of claim 11, wherein the nanostructured layer and the external optical microstructures are formed using sequential microreplication processes.

18. The method of claim 11, wherein the nanostructured layer and the external optical microstructures are formed in a single microreplication process using two structured and synchronized tools.

19. The method of claim 11, wherein the nanostructured layer and the external optical microstructures are formed using an extrusion process.

20. The method of claim 11, wherein the nanostructured layer and the external optical microstructures are each formed using a laser ablation process.

CLAIMS

1. A light extraction film having internal nanostructures and external microstructures, comprising:

a flexible substantially transparent film having a major surface and in-plane directions parallel with the major surface;

a low index nanostructured layer applied to the flexible substantially transparent film and having nanostructures;

a high index planarizing backfill layer applied over the nanostructured layer; and

external optical microstructures applied to the flexible substantially transparent film on a side opposite the nanostructured layer,

wherein the nanostructures consist of one-dimensional nanostructures extending substantially parallel with the in-plane directions along a first single direction and the external optical microstructures consist of one-dimensional microstructures extending substantially parallel with the in-plane directions along a second single direction, and the first single direction is different from the second single direction.

2. The light extraction film of claim 1, wherein the one-dimensional microstructures are orthogonal to the one-dimensional nanostructures in the in-plane directions.

3. The light extraction film of claim 2, wherein the one-dimensional nanostructures and the one-dimensional microstructures are each linear structures.

4. The light extraction film of claim 1, wherein the low index nanostructured layer comprises photonic crystal structures or linear gratings.

5. The light extraction film of claim 1, further comprising a protective layer applied over the backfill layer.

6. A method for making a light extraction film having internal nanostructures and external microstructures, comprising:

providing a flexible substantially transparent film having a major surface and in-plane directions parallel with the major surface;

applying a low index nanostructured layer having nanostructures to the flexible substantially transparent film;

applying a high index planarizing backfill layer over the nanostructured layer; and

applying external optical microstructures to the flexible substantially transparent film on a side opposite the nanostructured layer,

wherein the nanostructures consist of one-dimensional nanostructures extending substantially parallel with the in-plane directions along a first single direction and the external optical microstructures consist of one-dimensional microstructures extending substantially parallel with the in-plane directions along a second single direction, and the first single direction is different from the second single direction.

7. The method of claim 6, wherein the one-dimensional microstructures are orthogonal to the one-dimensional nanostructures in the in-plane directions.

8. The method of claim 6, further comprising applying a protective layer over the backfill layer.

9. The method of claim 6, wherein the nanostructured layer and the external optical microstructures are contained within two films laminated together.

10. The method of claim 6, wherein the nanostructured layer and the external optical microstructures are formed using sequential microreplication processes.

11. The method of claim 6, wherein the nanostructured layer and the external optical microstructures are formed in a single microreplication process using two structured and synchronized tools.

12. The method of claim 6, wherein the nanostructured layer and the external optical microstructures are formed using an extrusion process.

13. The method of claim 6, wherein the nanostructured layer and the external optical microstructures are each formed using a laser ablation process.