

CLAIMS

1. A tunable optical device comprising:

a ferroelectric layer comprising a ferroelectric material;

one or more first electrodes on a first side of the ferroelectric layer; and

one or more second electrodes on a second side of the ferroelectric layer opposite the first side;

wherein a refractive index of the ferroelectric material is changeable in response to a potential difference applied between the one or more first electrodes and the one or more second electrodes; and

wherein the one or more first electrodes and the one or more second electrodes are configured to allow visible light or infrared light to pass through.

2. The tunable optical device according to claim 1,

wherein the ferroelectric material is barium strontium titanate (BST), barium titanate (BTO), lead lanthanum zirconate titanate (PLZT), lithium niobate (LiNbO_3), or potassium tantalate niobate (KTN).

3. The tunable optical device according to claim 1 or claim 2,

wherein the one or more first electrodes and the one or more second electrodes comprise a material selected from a group consisting of indium tin oxide (ITO), fluorine doped tin oxide (FTO), aluminum zinc oxide (AZO), barium titanate (BTO),

strontium vanadate (SrVO_3), calcium vanadate (CaV_2O_6), carbon nanotubes, and graphene.

4. The tunable optical device according to any one of claim 1 to claim 3, further comprising:

a distributed Bragg reflector (DBR);

wherein the one or more second electrodes are over the distributed Bragg reflector (DBR).

5. The tunable optical device according to claim 4, further comprising:

a further distributed Bragg reflector (DBR) such that the ferroelectric layer, the one or more first electrodes and the one or more second electrodes are between the distributed Bragg reflector (DBR) and the further distributed Bragg reflector (DBR).

6. The tunable optical device according to any one of claim 1 to claim 3, further comprising:

a substrate;

wherein the one or more second electrodes are over the substrate.

7. The tunable optical device according to claim 6,

wherein the substrate comprises magnesium oxide (MgO), sapphire (Al_2O_3), lanthanum aluminate - strontium aluminum tantalate (LSAT), strontium titanate (STO), magnesium fluoride (MgF_2), silicon, or quartz (SiO_2).

8. The tunable optical device according to any one of claim 1 to claim 3, further comprising:

a broadband metallic mirror;

wherein the one or more second electrodes are over the broadband metallic mirror.

9. The tunable optical device according to any one of claim 1 to claim 8,
wherein the one or more first electrodes comprise a plurality of sub-wavelength structures forming a metasurface.
10. The tunable optical device according to any one of claim 1 to claim 8, further comprising:
a plurality of contacts located at corner regions of a circumscribed polygon.
11. The tunable optical device according to any one of claim 1 to claim 10,
wherein the tunable optical device is any one selected from a group consisting of a modulator, a tunable filter, a beam sweeper, a beam steering device, a tunable lens and a light router.
12. A method of forming a tunable optical device, the method comprising:
forming a ferroelectric layer comprising a ferroelectric material;
forming one or more first electrodes on a first side of the ferroelectric layer; and
forming one or more second electrodes on a second side of the ferroelectric layer opposite the first side;
wherein a refractive index of the ferroelectric material is changeable in response to a potential difference applied between the one or more first electrodes and the one or more second electrodes; and
wherein the one or more first electrodes and the one or more second electrodes are configured to allow visible light or infrared light to pass through.
13. The method according to claim 12,

wherein the ferroelectric material is barium strontium titanate (BST), barium titanate (BTO), lead lanthanum zirconate titanate (PLZT), lithium niobate (LiNbO_3), or potassium tantalate niobate (KTN).

14. The method according to claim 12 or claim 13,

wherein the one or more first electrodes and the one or more second electrodes comprise a material selected from a group consisting of indium tin oxide (ITO), fluorine doped tin oxide (FTO), aluminum zinc oxide (AZO), barium titanate (BTO), strontium vanadate (SrVO_3), calcium vanadate (CaV_2O_6), carbon nanotubes, and graphene.

15. The method according to any one of claim 12 to claim 14, further comprising:

forming a distributed Bragg reflector (DBR);

wherein the one or more second electrodes are over the distributed Bragg reflector (DBR).

16. The method according to claim 15, further comprising:

forming a further distributed Bragg reflector (DBR) such that the ferroelectric layer, the one or more first electrodes and the one or more second electrodes are between the distributed Bragg reflector (DBR) and the further distributed Bragg reflector (DBR).

17. The method according to any one of claim 12 to claim 14,

wherein the one or more second electrodes are formed over the substrate.

18. The method according to claim 17,

wherein the substrate comprises magnesium oxide (MgO), sapphire (Al_2O_3), lanthanum aluminate - strontium aluminum tantalate (LSAT), strontium titanate (STO), magnesium fluoride (MgF_2), silicon, or quartz (SiO_2).

19. The method according to any one of claim 12 to claim 14,
wherein the one or more second electrodes are formed over a broadband metallic mirror.
20. The method according to any one of claim 12 to claim 19,
wherein the one or more first electrodes comprise a plurality of sub-wavelength structures forming a metasurface.
21. The method according to any one of claim 12 to claim 19, further comprising:
forming a plurality of contacts located at corner regions of a circumscribed polygon.
22. The method according to any one of claim 12 to claim 21,
wherein the tunable optical device is any one selected from a group consisting of a modulator, a tunable filter, a beam sweeper, a beam steering device, a tunable lens and a light router.