CLAIMS

1. A method of fabricating an optical lens, the method comprising:

forming a layer of a flat lens structure on a front surface of a substrate;

depositing a protective metal layer on the layer of the flat lens structure and on a back surface of the substrate,

wherein the protective metal layer comprises chromium, gold, titanium, or nickel,

wherein the back surface is located opposite to and away from the front surface having the layer of the flat lens structure;

irradiating the protective metal layer at the front surface with a laser to form a channel (i) through the protective metal layer, (ii) through the layer of the flat lens structure and (iii) in the substrate, wherein the channel has a depth defined by a thickness of the substrate remaining at the channel after irradiating the protective metal layer at the front surface with the laser;

removing the protective metal layer at the front surface and the back surface of the substrate; and

separating the layer of the flat lens structure with underlying substrate from the rest of the substrate to obtain the optical lens.

2. The method of claim 1, further comprises cleaning (i) the protective metal layer, (ii) the layer of the flat lens structure and (iii) the substrate after irradiating the protective metal layer at the front surface with the laser and prior to removing the protective metal layer.

3. The method of claim 2, wherein the cleaning comprises subjecting (i) the protective metal layer, (ii) the layer of the flat lens structure and (iii) the substrate to ultrasonication at a power operable to clean (i) the protective metal layer, (ii) the layer of the flat lens structure and (iii) the substrate.

4. The method of any one of claims 1 to 3, wherein forming the layer of the flat lens structure comprises depositing an optical material on the substrate, wherein the optical material comprises TiO_2, Si_3N_4, GaN, AlN, GaP, GaAlN, GaAlP, Si, or Ge.

5. The method of any one of claims 1 to 4, further comprises patterning the layer of the flat lens structure to form nanostructures from the layer of the flat lens structure, wherein the nanostructures comprise a material having a higher refractive index than the substrate, wherein the material comprises TiO_2, Si_3N_4, GaAlN, GaAlP, GaAlN, GaAlP, Si, or Ge.

6. The method of any one of claims 1 to 5, further comprising:
depositing a layer of photoresist on the back surface of the substrate;
forming one or more channels in the photoresist; and
removing the photoresist after the irradiating.

7. The method of any one of claims 1 to 6, wherein the substrate comprises glass, quartz, sapphire, or magnesium fluoride.

8. The method of any one of claims 1 to 7, wherein depositing the protective metal layer comprises depositing the protective metal layer on the front surface and the back surface by electronic beam evaporation or sputtering.

9. The method of any one of claims 1 to 8, wherein depositing the protective metal layer comprises depositing the protective metal layer to have a thickness ranging from 80 nm to 400 nm.

10. The method of any one of claims 1 to 9, wherein irradiating the protective metal layer at the front surface with the laser comprises irradiating the protective metal layer at the front surface with a single-beam laser.

11. The method of any one of claims 1 to 10, wherein irradiating the protective metal layer at the front surface with the laser comprises aligning the laser to the flat lens structure to derive a diameter of the optical lens.

12. The method of claim 11, wherein the diameter of the optical lens is less than 2 mm.

13. The method of any one of claims 1 to 12, wherein the laser comprises:
a pulsed laser having a pulse duration of 10 picoseconds or less; and/or
a pulse energy ranging from 100 to 200 µJ.

14. The method of any one of claims 1 to 13, wherein irradiating the protective metal layer at the front surface with the laser comprises passing the laser through an apparatus having one or more nozzles configured in a manner which minimizes generation of particles from (i) the protective metal layer, (ii) the layer of the flat lens structure and (iii) the substrate.

15. The method of any one of claims 1 to 14, wherein removing the protective metal layer comprises chemically etching away the protective metal layer.

16. The method of any one of claims 1 to 15, wherein separating the layer of the flat lens structure with underlying substrate from the rest of the substrate comprises subjecting the flat lens structure and the substrate to ultrasonication at a power operable to break through the substrate remaining at the channel for the separating.

17. The method of any one of claims 1 to 16, wherein the thickness of the substrate remaining at the channel ranges from 50 µm to 100 µm.

18. The method of any one of claims 5 to 17, wherein the nanostructures extend away from the front surface, and wherein the nanostructures comprise nanopillars, nanodisks, or nanobars.

19. An optical lens structure comprising an optical lens connected to a substrate at a substrate portion, wherein the optical lens comprises a layer of a flat lens structure formed on the substrate and a plurality of nanostructures that extend away from a surface of the flat lens structure,

wherein the layer of the flat lens structure comprises an optical material,

wherein the optical material comprises TiO_2, Si_3N_4, GaN, AlN, GaP, GaAlN, GaAlP, Si, or Ge, and

wherein the nanostructures comprise a material comprising TiO_2, Si_xN_y, GaAlN, GaAlP, Si, or Ge,

wherein the optical lens is separable from the substrate by using ultrasonic agitation to break through the substrate portion.

20. The optical lens structure of claim 19, wherein the optical lens has a diameter less than 2 mm.