CLAIMS

1. An optical system comprising:

a lens structure configured to generate an outgoing Gaussian beam based on an incoming Gaussian beam; and

a light source configured to provide the incoming Gaussian beam to the lens structure;

wherein the lens structure is a flat lens or a phase plate;

wherein the lens structure comprises a plurality of unit elements;

wherein dimensions and a position of each of the plurality of unit elements are determined based on a phase change required to be provided by each of the plurality of unit elements; and

wherein the phase change required to be provided by each of the plurality of unit elements is determined based on a radius of a curvature of the incoming Gaussian beam (R_{in}), a desired distance between the lens structure and a beam waist of the outgoing Gaussian beam (*f*), a wavelength of the incoming Gaussian beam (λ), a desired beam radius of the incoming Gaussian beam at the lens structure (*w*), and a type of the outgoing Gaussian beam desired.

2. The optical system according to claim 1,

where the lens structure further comprises a substrate such that the plurality of unit elements is in contact with the substrate; and

wherein each of the plurality of unit elements has at least one dimension smaller than a wavelength of the incoming Gaussian beam.

3. The optical system according to claim 1,

wherein each of the plurality of unit elements is any one selected from a group consisting of a pillar, a disk, a bar, a slot on the substrate, and a torus.

4. The optical system according to any one of claims 1 to 3,

wherein each of the plurality of unit elements has a cross-section of any one shape selected from a group consisting of a circle, an ellipse, a triangle, a square, an annular square, an annular ring, and a polygon.

5. The optical system according to any one of claims 1 to 4,

wherein the plurality of unit elements comprises any one material selected from a group consisting of amorphous silicon, titanium dioxide, aluminum oxide, hafnium oxide, niobium oxide, silicon nitride, gallium nitride, aluminum nitride, aluminum gallium nitride, gallium phosphide, aluminum phosphide, aluminum gallium phosphide, crystalline germanium, and crystalline silicon.

6. The optical system according to any one of claims 1 to 5,

wherein the outgoing Gaussian beam is a converging beam.

7. The optical system according to any one of claims 1 to 5,

wherein the outgoing Gaussian beam is a diverging beam.

8. The optical system according to any one of claims 1 to 5,

wherein the outgoing Gaussian beam is a collimated beam.

9. The optical system according to any one of claims 1 to 8,

wherein a ratio of a diameter of the lens structure to a radius of a beam waist of the incoming Gaussian beam at the lens structure is any value equal to or greater than 2.

10. The optical system according to claim 9,

wherein the ratio of the diameter of the lens structure to the radius of the beam waist of the incoming Gaussian beam is equal to 2, 2.5, π, 4.6 or greater.

11. A method of forming an optical system, the method comprising:

forming a lens structure configured to generate an outgoing Gaussian beam based on an incoming Gaussian beam provided by a light source;

wherein the lens structure is a flat lens or a phase plate;

wherein the lens structure comprises a plurality of unit elements;

wherein forming the lens structure includes determining dimensions and a position of each of the plurality of unit elements based on a phase change required to be provided by each of the plurality of unit elements; and

wherein the phase change required to be provided by each of the plurality of unit elements is determined based on a radius of a curvature of the incoming Gaussian beam (R_{in}), a desired distance between the lens structure and a beam waist of the outgoing Gaussian beam (*f*), a wavelength of the incoming Gaussian beam (λ), a desired beam radius of the incoming Gaussian beam at the lens structure (*w*), and a type of the outgoing Gaussian beam desired.

12. The method according to claim 11,

wherein the type of the outgoing Gaussian beam is any one selected from a diverging beam, a converging beam, and a collimated beam.

13. The method according to any one of claims 11 to 12,

wherein forming the lens structure further includes:

depositing a layer of lens material on a substrate;

forming the plurality of unit elements by patterning the layer of lens material.

14. The method according to claim 13,

wherein patterning the layer of lens material comprises:

forming a patterned resist layer on the layer of lens materials; and

etching the layer of lens material based on the patterned resist layer.

15. The method according to claim 13,

wherein patterning the layer of lens material comprises:

depositing a resist layer on a hard mask layer;

patterning the resist layer to form a patterned resist layer;

forming a hard mask based on the hard mask layer using the patterned resist layer; and

etching the layer of lens materials based on the hard mask.

16. The method according to any one of claims 11 to 15,

wherein each of the plurality of unit elements has at least one dimension smaller than a wavelength of the incoming Gaussian beam.

17. The method according to any one of claims 11 to 16,

wherein each of the plurality of unit elements is any one selected from a group consisting of a pillar, a disk, a bar, a slot on the substrate, and a torus.

18. The method according to any one of claims 11 to 17,

wherein each of the plurality of unit elements has a cross-section of any one shape selected from a group consisting of a circle, an ellipse, a triangle, a square, an annular square, an annular ring, and a polygon.

19. The method according to any one of claims 11 to 18,

wherein the plurality of unit elements comprises any one material selected from a group consisting of amorphous silicon, titanium dioxide, aluminum oxide, hafnium oxide, niobium oxide, silicon nitride, gallium nitride, aluminum nitride, aluminum gallium nitride, gallium phosphide, aluminum phosphide, aluminum gallium phosphide, crystalline germanium, and crystalline silicon.

20. The method according to any one of claims 11 to 19,

wherein a ratio of a diameter of the lens structure to a radius of a beam waist of the incoming Gaussian beam is any value equal to or greater than 2.

21. The method according to claim 20,

wherein the ratio of the diameter of the lens structure to the radius of the beam waist of the incoming Gaussian beam is equal to 2, 2.5, π, 4.6, or greater.