CLAIMS

1. A meta-lens having a phase profile, comprising:

a substrate; and

a plurality of nanostructures disposed on the substrate, wherein each individual nanostructure of the nanostructures imparts a light phase shift that varies depending on a location of the individual nanostructure on the substrate, and the light phase shifts of the nanostructures define the phase profile of the meta-lens,

wherein each individual nanostructure of the nanostructures is located at an (x, y) coordinate in an x-y plane of the substrate, and wherein the phase profile of each individual nanostructure of the nanostructures is

$$\phi(x,y) = \frac{2\pi}{\lambda_d}\left(f - \sqrt{x^2 + y^2 + f^2}\right), \text{ and}$$

wherein an angle $\theta_{nf}(x, y)$ of the individual nanostructure is determined by

$$\theta_{nf}(x,y) = \frac{\pi}{\lambda_d}\left(f - \sqrt{x^2 + y^2 + f^2}\right)$$

where λ_d is a design wavelength of the meta-lens and f is a design focal length of the meta-lens.

2. The meta-lens of claim 1, wherein the light phase shift of each individual nanostructure of the nanostructures depends on the location of the individual nanostructure on the substrate and a size or an orientation of the individual nanostructure.

3. The meta-lens of claim 1, wherein the nanostructures have an aspect ratio of at least about 2:1.

4. The meta-lens of claim 1, wherein the nanostructures include nanofins, and the light phase shift of each individual nanofin of the nanofins depends on the location of the individual nanofin on the substrate and an orientation of the individual nanofin.

5. The meta-lens of claim 4, wherein an individual nanofin is located at an (x, y) coordinate in an x-y plane of the substrate, the individual nanofin is rotated by an angle with

respect to an axis in the x-y plane.

6. The meta-lens of claim 5, wherein the phase profile of the meta-lens is an infinity-corrected lens phase profile.

7. The meta-lens of claim 4, wherein each nanofin has a rectangular cross-section, with an aspect ratio of at least about 2:1.

8. The meta-lens of claim 4, wherein each nanofin is formed of a high index dielectric, the index being greater than approximately 2.

9. The meta-lens of claim 8, wherein the dielectric is titanium dioxide.

10. The meta-lens of claim 4, wherein a numerical aperture of the meta-lens is less than or equal to 0.8.

11. The meta-lens of claim 4, wherein the meta-lens has a focusing efficiency of greater than about 50% for visible spectrum wavelengths.

12. The meta-lens of claim 4, wherein the meta-lens is configured to resolve features with sub-wavelength gaps of about $\left(\frac{\lambda}{2\times NA}\right)$, where λ is a design wavelength of the meta-lens and *NA* is a numeral aperture of the meta-lens.

13. The meta-lens of claim 1, wherein the nanostructures include nanopillars, and the light phase shift of each individual nanopillar of the nanopillars depends on the location of the individual nanopillar on the substrate and a size of the individual nanopillar.

14. The meta-lens of claim 13, wherein the light phase shift of each individual nanopillar of the nanopillars is

$$\varphi_t(x,y) = 2\pi - \frac{2\pi}{\lambda_d}\left(\sqrt{x^2+y^2+f^2} - f\right),$$

where λ_d is a design wavelength of the meta-lens and *f* is a design focal length of the meta-lens.

15. The meta-lens of claim 13, wherein the light phase shift of the individual nanopillar is realized by adjusting a diameter of the individual nanopillar.

16. The meta-lens of claim 13, wherein a height of the individual nanopillar is greater than a design wavelength of the meta-lens.

17. The meta-lens of claim 13, wherein a unit cell size *U* of the nanopillar on the substrate meets a criterion of ($U < \frac{\lambda}{2NA}$), where λ is a design wavelength of the meta-lens and *NA* is a design numerical aperture of the meta-lens.

18. A meta-lens, comprising:

a substrate; and

a plurality of nanostructures disposed on the substrate, wherein each individual nanostructure of the nanostructures imparts a phase profile that varies depending on a location of the individual nanostructure on the substrate and at least one property of the individual nanostructure,

wherein the nanostructures include nanofins, each individual nanofin of the nanofins imparts a phase profile that varies depending on a location of the individual nanofin on the substrate and an orientation of the individual nanofin, and the phase profiles of the nanofins define a polarization sensitive phase profile of the meta-lens.

19. The meta-lens of claim 18, wherein the phase profiles of the nanostructures that vary are realized by varying orientations of the nanostructures, sizes of the nanostructures, aspect ratios of the nanostructures, materials of the nanostructures, spatial arrangement of the nanostructures, shapes of the nanostructures, or a combination of two or more thereof.

20. The meta-lens of claim 18, wherein the meta-lens has a phase profile of a spherical

lens, a infinity-corrected lens, a point-to-point lens, or a bi-convex lens.

21. The meta-lens of claim 18, wherein the nanostructures include nanopillars, each individual nanopillar of the nanopillars imparts a phase profile that varies depending on a location of the individual nanopillar on the substrate and a diameter of the individual nanopillar, and the phase profiles of the nanopillars define a polarization insensitive phase profile of the meta-lens.

22. An optical system, comprising:

an optical component; and

a first planar meta-lens optically coupled to the optical component, the first planar meta-lens including:

a first substrate, and

a plurality of first nanostructures disposed on the substrate, wherein each individual first nanostructure of the first nanostructures imparts a phase profile that varies depending on a location of the individual first nanostructure on the first substrate and at least one property of the individual first nanostructure,

wherein each individual first nanostructure of the first nanostructures is located at an (x, y) coordinate in an x-y plane of the first substrate, and wherein the phase profile of each individual first nanostructure of the first nanostructures is

$$\phi(x,y) = \frac{2\pi}{\lambda_d}\left(f - \sqrt{x^2 + y^2 + f^2}\right), \text{ and}$$

wherein an angle $\theta_{nf}(x, y)$ of the individual nanostructure is determined by

$$\theta_{nf}(x,y) = \frac{\pi}{\lambda_d}\left(f - \sqrt{x^2 + y^2 + f^2}\right)$$

where λ_d is a design wavelength of the first meta-lens and f is a design focal length of the first meta-lens.

23. The optical system of claim 22, wherein the optical component is a second planar

meta-lens, the second planar meta-lens including:

a second substrate, and

a plurality of second nanostructures disposed on the second substrate, wherein each individual second nanostructure of the second nanostructures imparts a phase profile that varies depending on a location of the individual second nanostructure on the second substrate and at least one property of the individual second nanostructure.

24. The optical system of claim 23, wherein the second substrate with the second nanostructures is stacked on the first substrate with the first nanostructures, and a phase profile of the first planar meta-lens is different from a phase profile of the second planar meta-lens.

25. The optical system of claim 23, wherein the second planar meta-lens is configured to correct for an aberration of the first planar meta-lens.