CLAIMS

What is claims is:

1. An intraocular lens, comprising:

a lens having an anterior surface and a posterior surface; and

a diffractive profile disposed on at least one of the anterior surface and the posterior surface, the diffractive profile

comprising one or more annular zones about the optical axis of the lens where each annular zone having four annular subzones where each annular subzone comprises a diffractive step the annular subzones radiating from the optical axis of the lens to some radius R_D on the lens; and

the diffractive profile configured to produce constructive interference in at least five consecutive diffractive orders within a range of vision, the five consecutive diffractive orders including a lowest diffractive order, an extended intermediate diffractive order, an intermediate diffractive order, an extended near diffractive order, and a highest diffractive order, wherein: the highest diffractive order corresponds to a near focus for near vision, a lowest diffractive order corresponds to a distance focus for distance vision, the extended intermediate diffractive order corresponds to an extended intermediate focal point, the intermediate diffractive order corresponds to an intermediate focal point, and the extended near diffractive order corresponds to an extended near focal point;

wherein the diffractive profile having diffractive steps described with the following formula:

$$OPD(\mathrm{X}) = \begin{cases} \Phi_{11} + \dfrac{(\mathrm{X} - \mathrm{X}_0)(\Phi_{12} + \mathrm{n} - \Phi_{11})}{\Delta \mathrm{X}} & \mathrm{X}_0 \le \mathrm{X} < \mathrm{X}_1 \\ \Phi_{21} + \dfrac{(\mathrm{X} - \mathrm{X}_1)(\Phi_{22} + \mathrm{n} - \Phi_{21})}{\Delta \mathrm{X}} & \mathrm{X}_1 \le \mathrm{X} < \mathrm{X}_2 \\ \Phi_{31} + \dfrac{(\mathrm{X} - \mathrm{X}_2)(\Phi_{32} + \mathrm{n} - \Phi_{31})}{\Delta \mathrm{X}} & \mathrm{X}_2 \le \mathrm{X} < \mathrm{X}_3 \\ \Phi_{41} + \dfrac{(\mathrm{X} - \mathrm{X}_3)(\Phi_{42} + \mathrm{n} - \Phi_{41})}{\Delta \mathrm{X}} & \mathrm{X}_3 \le \mathrm{X} < \mathrm{X}_4 \end{cases}$$

where

$$\Delta \mathrm{X} = \frac{2\lambda}{ADD}$$

$$\mathrm{X}_0 = 4\,\Delta \mathrm{X}\, Int\left(\frac{X}{4\,\Delta \mathrm{X}}\right)$$

$$\mathrm{X}_1 = \mathrm{X}_0 + \Delta \mathrm{X}$$

$$\mathrm{X}_2 = \mathrm{X}_0 + 2\,\Delta \mathrm{X}$$

$$\mathrm{X}_3 = \mathrm{X}_0 + 3\,\Delta \mathrm{X}$$

λ is the design wavelength, Φ is the optical path difference phase value, ADD is the desired addition power at the highest diffractive order and n is an integer.

2. The intraocular lens of claim 1, wherein

the near, extended near, intermediate, and the extended intermediate focal points each correspond to a different add power relative to a base power of the distance focal point;

an add power corresponding to the extended intermediate focal point is less than one half of an add power corresponding to the near focal point;

an add power corresponding to the intermediate focal point is one half of an add power corresponding to the near focal point; and

an add power corresponding to the extended near focal point is greater than one half of an

add power corresponding to the near focal point.

3. The intraocular lens of claim 1, wherein the five consecutive diffractive orders are 0, +1, +2, +3, and +4.

4. The intraocular lens of claim 1, wherein the five consecutive diffractive orders are -2, -1, 0, +1, and +2.

5. The intraocular lens of claim 1, wherein the diffractive profile is apodised by the top hat function:

$$A = \begin{cases} 1 & r \leq R_D \\ 0 & r > R_D \end{cases}$$

Where r is the radius of the lens and R_D is the radius of the top hat function.

6. The intraocular lens of claim 1, wherein the diffractive profile has a diffractive efficiency of at least 98%.

7. The intraocular lens of claim 1, wherein the diffractive steps in each annular subzone of the diffractive profile are configured such that:

a diffraction efficiency of the lowest diffractive order is at least 39%;

a diffraction efficiency of the highest diffractive order is at least 20%, and

a diffraction efficiency of each of the extended near, intermediate, and extended intermediate diffractive order is in the range of 5 - 21%.

8. The intraocular lens of claim 1, wherein the OPD is further modified with the following formula:

$$OPD(\mathrm{X}) = \alpha + \beta X + \gamma X^2 + \delta X^3 \quad R_D^2 \leq \mathrm{X} \leq R^2$$

Where α, β, γ, and δ coefficients of the polynomials to be optimized for optimal performance of the lens.

9. The intraocular lens of claim 1, wherein n = 1 resulting in five consecutive diffractive orders being +4, +5, +6, +7, and +8 and the lens being achromatized.

10. An intraocular lens, comprising: a lens having an anterior surface and a posterior surface; and a diffractive profile disposed on at least one of the anterior surface and the posterior surface, the diffractive profile comprising one or more annular zones about the optical axis of the lens where each annular zone having four annular subzones where each annular subzone comprises a diffractive step the annular subzones radiating from the optical axis of the lens to some radius *RD* on the lens; and

the diffractive profile configured to produce constructive interference in at least five consecutive diffractive orders within a range of vision, the five consecutive diffractive orders including a lowest diffractive order, an extended intermediate diffractive order, an intermediate diffractive order, an extended near diffractive order, and a highest diffractive order, wherein: the highest diffractive order corresponds to a near focus for near vision, a lowest diffractive order corresponds to a distance focus for distance vision, the extended intermediate diffractive order corresponds to an extended intermediate focal point, the intermediate diffractive order corresponds to an intermediate focal point, and the extended near diffractive

order corresponds to an extended near focal point;

wherein the diffractive profile existing in $X \leq R_D^2$ is subjected to a plurality of sinusoidal Fourier harmonics and the refractive profile existing in $R_D^2 < X \leq R^2$ is subjected to the polynomial described with the following formula:

$$OPD(\mathrm{X}) = \begin{cases} \sum_{1}^{N} A_i \cos(i\Omega X + \Psi_i) & \mathrm{X} \leq R_D^2 \\ \alpha + \beta X + \gamma X^2 + \delta X^3 & R_D^2 < \mathrm{X} \leq R^2 \end{cases}$$

Where

$$\Omega = \frac{\pi ADD}{4\lambda}$$

the values of N, A_i, Ψ_i, α, β, γ, and δ are all known in art, λ is the design wavelength, and ADD is the addition power for the near focus.

11. The intraocular lens of claim 10, wherein the number of sinusoidal Fourier harmonics is at least twelve.