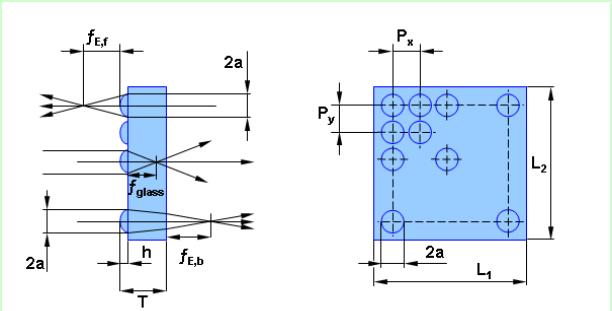
PHYSICAL AND OPTICAL PROPERTIES OF PLANO-CONVEX REFRACTIVE MICROLENSES

Definitions

Lens width	$2a_1$, $2a_2$
Lens pitch	P_x, P_y
Lens sag	h
Radius of curvature	R_C
Effective front focal length	$f_{E,f}$
Effective back focal length	$f_{E,b}$
Focal length in glass	f_{glass}
Refractive index glass	n
Wavelength	λ
Conic constant	K



Radius of Curvature

$$R_C = \frac{h(K+1)}{2} + \frac{a^2}{2h}$$

Lens sag

$$h = R_C - \sqrt{R_C^2 - a^2}$$

$$= f_{E,f}(n-1) - \sqrt{f_{E,f}^2 (n-1)^2 - r^2}$$

Effective front focal length

$$f_{E,f} = \frac{R_c}{n-1}; \quad f_{E,f} = \frac{\left(h + \frac{a^2}{h}\right)}{2(n-1)} \approx \frac{a^2}{h}$$

Effective back focal length

$$f_{E,b} = \frac{R_c}{n-1} - \frac{T}{n}$$

Focal length in glass

$$f_{glass} = \frac{R_c}{n-1} \cdot n$$

Numerical Aperture

$$NA = \sin u$$

$$NA \approx \frac{h}{a}; \quad NA \approx \tan u = \frac{a}{f_{E,f}}$$

F-Number

$$F = \frac{f_{E,f}}{2a} \approx \frac{1}{2NA}$$

Fresnel-Number

$$FN = \frac{a^2}{\lambda f_{E,b}}$$

Airy Disk Diameter (1.Min)

$$\varnothing_{dl} = 2.44 \cdot \lambda F \approx 1.22 \cdot \frac{\lambda}{NA}$$

Imaging Equations

$$\frac{1}{s'} - \frac{1}{s} = \frac{1}{f'_{E,f}}; \quad \beta = \frac{s'}{s}$$

$$\bar{z} \cdot z' = -\bar{f}^2; \beta = \frac{\bar{f}}{z} = \frac{z'}{\bar{f}}$$

Hexagonal Packed

$$P_y = \frac{P_x}{2}\sqrt{3}$$

Grating Equation

$$\sin\alpha - \sin\beta = \frac{m\lambda}{\Lambda}$$

Depth of Focus (Rayleigh) = λ/4 Wave Aberrations

$$\delta z = \frac{\lambda}{n \sin^2 u} = \frac{\lambda}{NA^2} = 4\lambda F^2$$

Abbe Resolution Criteria

$$\delta x = \frac{\lambda}{2n \sin u} = \frac{\lambda}{2NA}$$

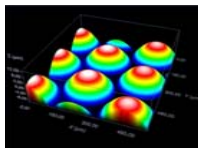
Lateral - Longitudinal Resolution

$$\delta z = \frac{4n}{\lambda} \cdot \delta x$$

Maréchal

$$Strehl > 0.8$$

$$\delta_W < \lambda/14$$



Aspherical Lens Profiles

$$h = \frac{1}{R_C} \cdot \frac{a^2}{1 + \sqrt{1 - (K+1)\frac{a^2}{R_C^2}}} + c_1 a^4 + c_2 a^6 + \ldots$$

Concic Constant K

K>0	ellipsoid
K=0	sphere
-1<K<0	ellipsoid
K=-1	paraboloid
K<-1	hyperboloid

Plane Plate - Optical Path Difference

$$\Delta z = \frac{n-1}{n} T$$

Talbot-Distance

$$z_T = \frac{2d^2}{\lambda} \cdot \cos^3(\alpha)$$

1 rad ≡ 57.296°
1 mrad ≡ 0.057°
17.45 mrad ≡ 1°
1mW ≈ 10^{16} photons
dB = 10 log (P_1/P_2)