XXXI. Light Diffraction: Atomic Mask Diffraction Patterns: Math

The leading edge of semiconductors involve using hundresof unique layers of lithography and accompanying steps. Extreme Ultraviolet, EUV, processing shrinks the laser wavelength size down to 13.5 nanometers. In order to create a single EUV mask, you have to first create the mask . At its very top is the mirror layer - a multi-layer Bragg reflector with 40-50 alternating layer pairs of molybdenum and silicon. The mask consists of transmission diffraction gratings. The diffracted coherent beams form an interference pattern which is recorded in the photoresist. The final pattern is formed from multiple interference patterns. Shown is the mask pattern result with just 5 atomic scatterers.

Establish mask geometry:

Number of Atoms: A $\quad A := 5$

$$R := 2 \qquad m := 1..A \qquad \Theta_m := \frac{2\cdot\pi\cdot m}{A} \qquad x_m := R\cdot\sin(\Theta_m) \qquad y_m := R\cdot\cos(\Theta_m) \qquad d := .5$$

Calculate coordinate-space wave function:

$$\Psi(xx,yy) := \frac{1}{\sqrt{A}}\cdot\sum_{m=1}^{A} \mathrm{if}\left[\left[xx \ge \left(x_m - \frac{d}{2}\right)\right]\cdot\left[xx \le \left(x_m + \frac{d}{2}\right)\right]\cdot\left[yy \ge \left(y_m - \frac{d}{2}\right)\right]\cdot\left[yy \le \left(y_m + \frac{d}{2}\right)\right], 1, 0\right]$$

Fourier transform of position wave function into the momentum representation:

$$\Phi(p_x, p_y) := \frac{1}{2\cdot\pi\cdot\sqrt{A}}\cdot\sum_{m=1}^{A}\left(\exp(-i\cdot p_x\cdot x_m)\cdot\exp(-i\cdot p_y\cdot y_m)\right)$$

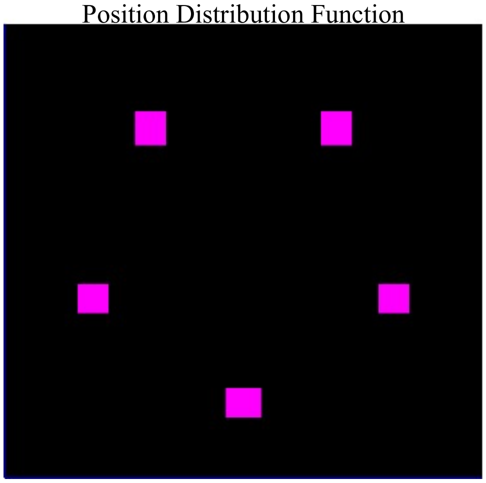
$$N := 100 \qquad \Delta p := 10 \qquad \Delta x := -3 \qquad j := 0..N \qquad xx_j := -\Delta x + \frac{2\cdot\Delta x\cdot j}{N} \qquad p_{x_j} := -\Delta p + \frac{2\cdot\Delta p\cdot j}{N}$$

$$\Delta y := -3 \qquad k := 0..N \qquad yy_k := -\Delta y + \frac{2\cdot\Delta y\cdot k}{N} \qquad p_{y_k} := -\Delta p + \frac{2\cdot\Delta p\cdot k}{N}$$

Display slit pattern and diffraction pattern:

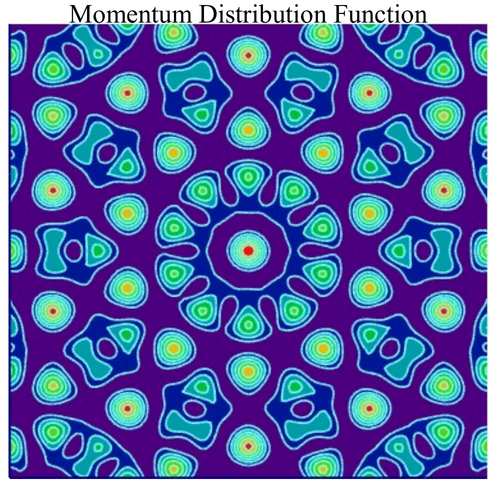
$$MaskPattern_{j,k} := \left(\left|\Psi(xx_j, yy_k)\right|\right)^2 \qquad DiffractionPattern_{j,k} := \left(\left|\Phi(p_{x_j}, p_{y_k})\right|\right)^2$$

Position Distribution Function



MaskPattern

Momentum Distribution Function



DiffractionPattern