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Calculation and simulation of a multichannel DOE with increased diffraction efficiency

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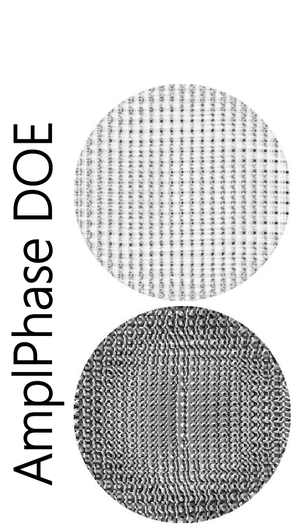
Abstract

The development of efficient methods for forming a complex transmission function of a phase DOE with a given multichannel intensity distribution has been carried out. The methods of diffractive optics based on spatial frequency control are used to form a multichannel DOE matched with a set of wave aberrations of various types and values. Iterative calculation methods are used to calculate the phase multichannel DOE.

Method

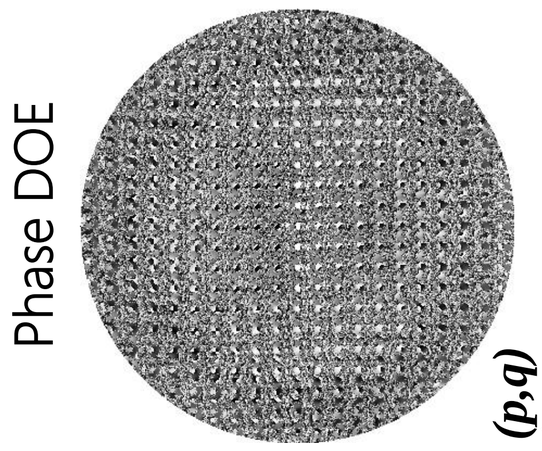
$$g(x,y)=\sum_{p=0}^{P}\sum_{q=0}^{Q}\sum_{k=1}^{K}\exp\left[-i\kappa C_k Z_{pq}(x,y)\right]\exp\left[i\left(a_{kpq}x+b_{kpq}y\right)\right],$$

Z_{pq} is Zernike polynomials

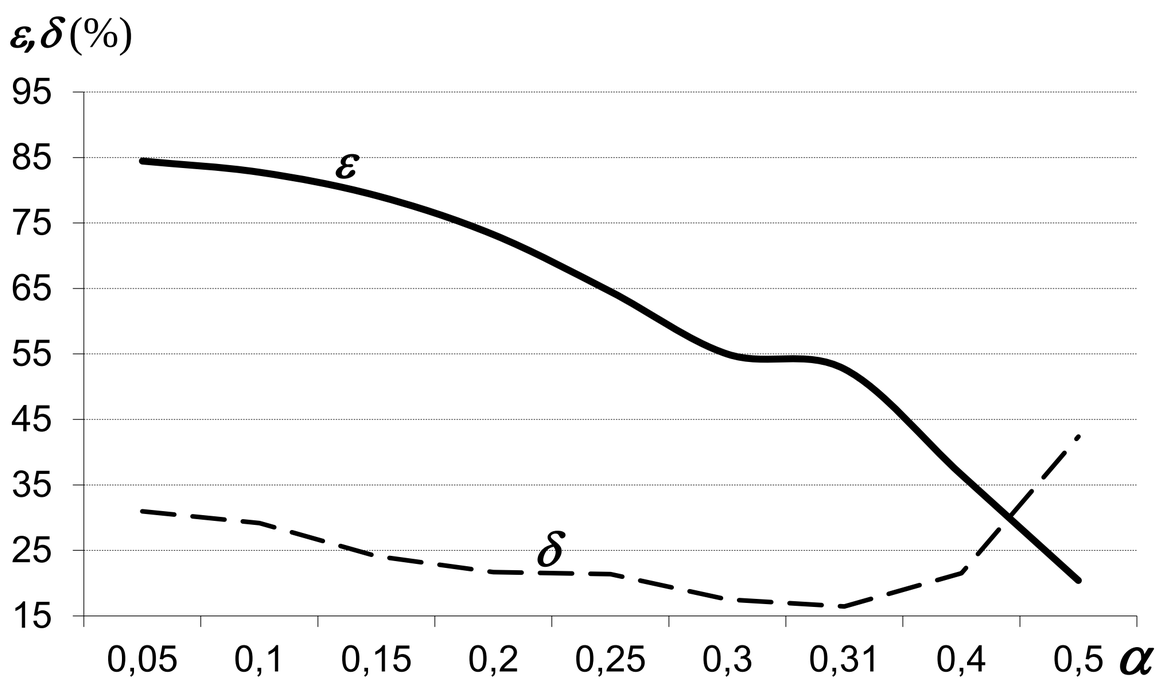


$$\tilde{g}(x,y)=\begin{cases}\exp\{i\arg[g(x,y)]\}, & |g(x,y)|\geq\alpha,\\ \exp\{i\arg[g(x,y)]+i\mu\}, & |g(x,y)|<\alpha,\end{cases}$$

$$\mu=\begin{cases}\pi, & \operatorname{sgn}(S_{ij})>0,\\ 0, & \operatorname{sgn}(S_{ij})<0,\end{cases}\qquad S_{ij}\in[-0.5,\,0.5]$$



$$g(x,y)\xrightarrow[\text{Phase DOE calculation}]{}g(x,y)\xrightarrow[\text{Fourier Transform}]{}|F(u,v)|^2$$



diffraction efficiency

$$\varepsilon=\left(\iint_{\Omega}|F(u,v)|^2\,\mathrm{d}u\,\mathrm{d}v\right)\cdot\left(\iint_{\Omega}|F_0(u,v)|^2\,\mathrm{d}u\,\mathrm{d}v\right)^{-1}$$

accuracy formations

$$\delta=\left(\iint_{\Omega}\left(|F(u,v)|^2-|F_0(u,v)|^2\right)^2\mathrm{d}u\,\mathrm{d}v\right)^{1/2}\left(\iint_{\Omega}|F_0(u,v)|^4\,\mathrm{d}u\,\mathrm{d}v\right)^{-1/2}$$

The smallest error δ =15% is achieved at α=0.31 with an efficiency of ε =52%.

At α=0 the maximum efficiency of ε =85% is achieved, but the error increases to δ =30%.

Conclusion

The scientific novelty lies in calculating an adaptive multichannel DOE that is optimal for use in optical circuits based on liquid-crystal spatial light modulators and digital micromirror devices. In addition, the optimal phase profile for increasing the diffraction efficiency of the element. To increase the diffraction efficiency of the DOE, composition methods are considered. They are a more general case and cover not only the class of focusing DOEs, but also all formers of mode beams, spatial filters for decomposition of light, and various composite DOEs.

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