The DOE and CGH calculator

Purpose:
A tool to help design different Diffractive Optical Elements and Computer Generated Holograms to be written in photo-resist. It is found in the drop down menu under accessories in the main OPTISCAN project window.

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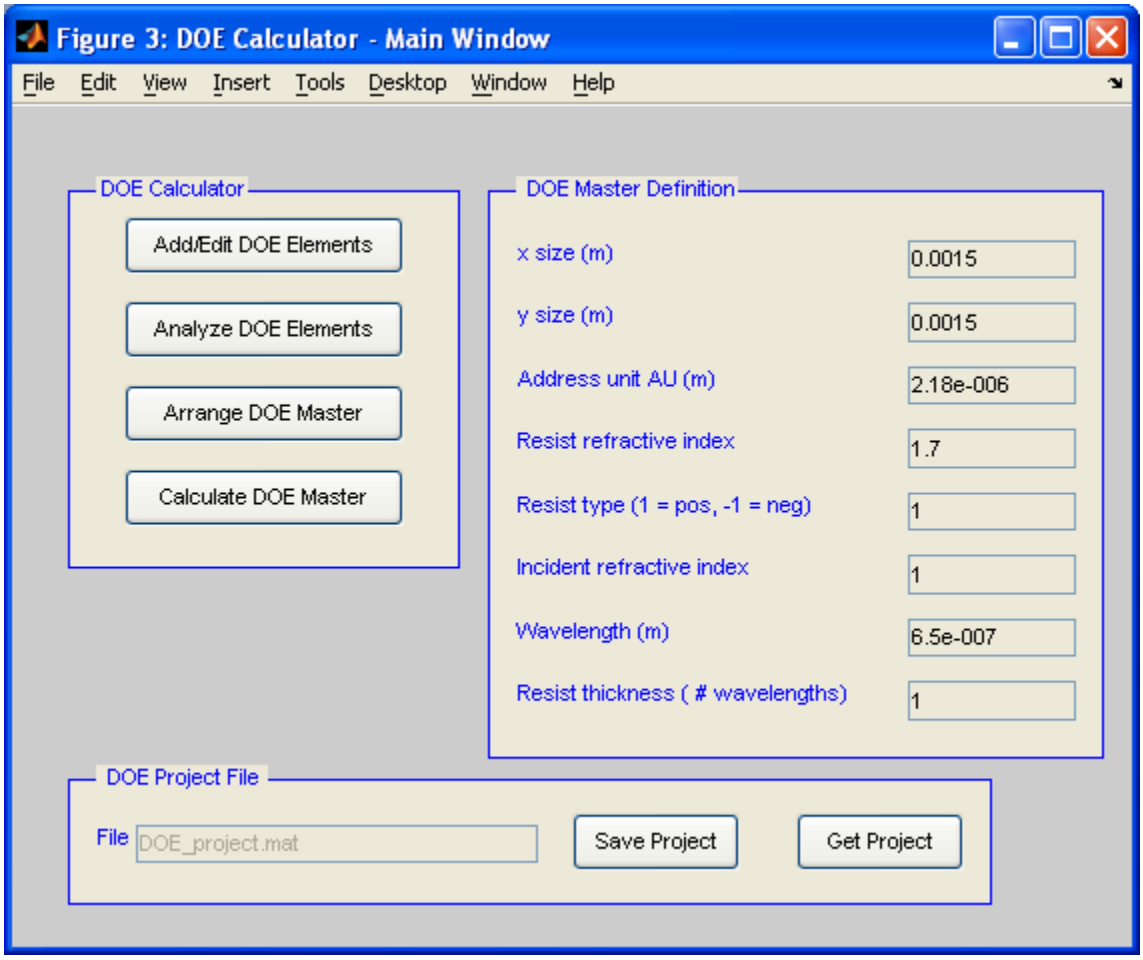
Main Window



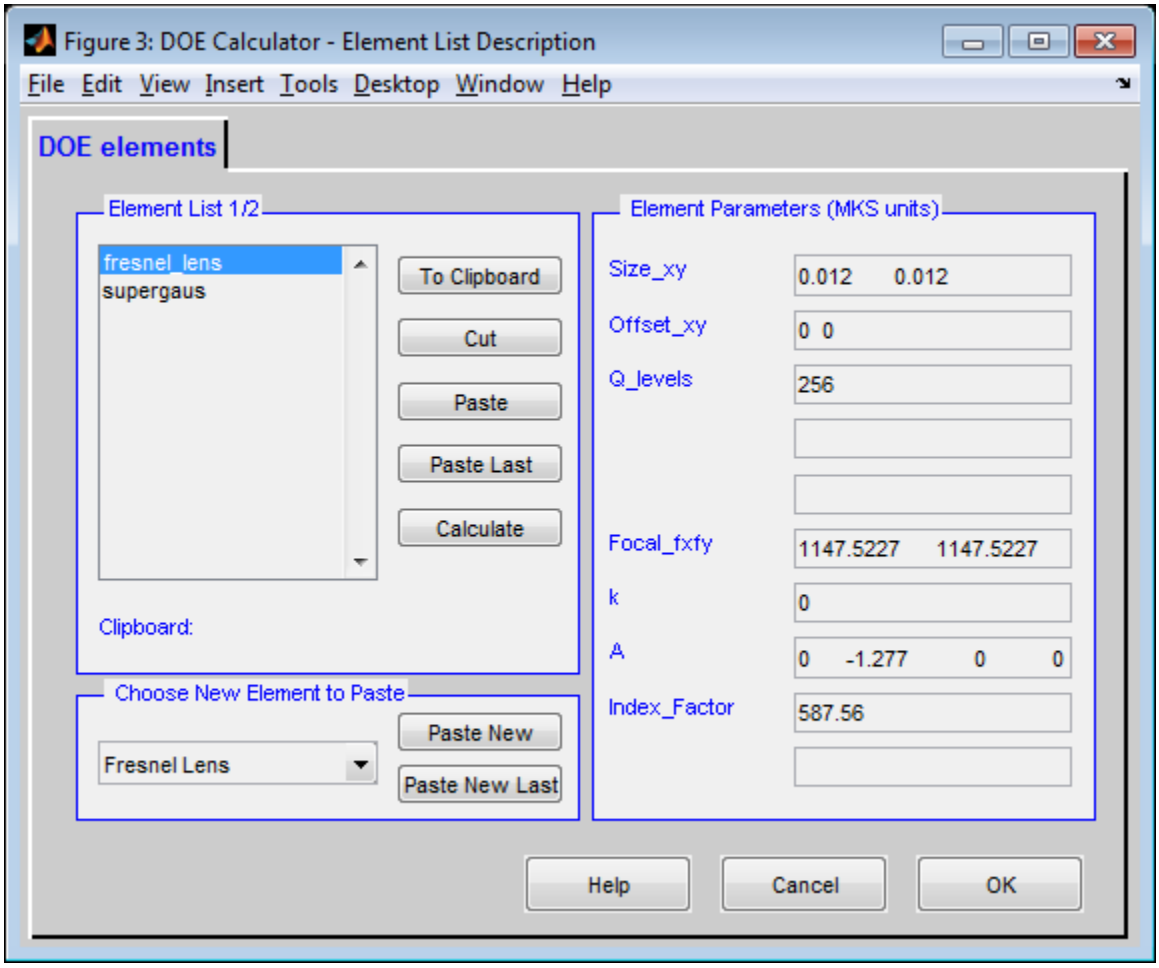
DOE Calculator – Main Window – Master Definition	
FUNCTION	**DESCRIPTION**
x size, y size	The size of the Master CGH being written. The Master contains CGH Elements, which are edited in a separate menu (See "Add/Edit DOE Elements" below). The size of the Master CGH should be large enough to incorporate all Elements. (units = meters)
Address unit AU	The size of one pixel in the Master CGH. Pixel size of all Elements in the Master will be the size of AU. (units = meters)
Resist refractive index	The refractive index of the photoresist (n_g) into which the CGH will be written
Resist type	1 = positive , -1 = negative
Incident refractive index	The refractive index of the medium (n_i) in which the CGH will used (air = 1, water = 1.33)
Wavelength	The design vacuum wavelength of the CGH. (units = meters)

Resist Thickness	The OPD in wavelengths corresponding to the photoresist thickness at Wavelength. That is, OPD in wavelength units = $(n_q - n_t)t/\lambda$, where t is the physical thickness of the resist.

DOE Calculator - Main Window – Buttons	
FUNCTION	**DESCRIPTION**
Add/Edit DOE Elements	Used to change the element list containing separate DOE Elements, like Fresnel lenses and gratings, which are part of the Master DOE.
Analyze DOE Elements	This function is under construction at the present time (4/9/07).
Arrange DOE Master	Used to arrange the separate Elements in the Element List as to their positions and tiling in the Master DOE. Also, the way (replace, add and subtract) in which the Elements are added into the master can be specified.
Calculate DOE Master	Opens panel that specifies type of linearization, border and function for generating the Master DOE. (This button controls the last step in the Master DOE calculation.)

DOE Calculator - Main Window – Project File	
FUNCTION	**DESCRIPTION**
File	Specifies the file name to which the Project File will be saved. The Project File contains specifications for the Master DOE, the Element List and the Arrange DOE Master panel. Saving the project will allow the user to go back and edit any of these parameters for future work. The Project File doe not contain the actual BMP file of the Master DOE.
Save Project	Opens a Browse Window in which the user specifies the filename of the project.
Get Project	Opens a Browse window in which the user specifies a previously saved project to edit or re-create.

Element List Description



General	
MENU NAME	**DESCRIPTION**
Element List	The elements to be written on the master CGH (note: the order in which they appear on the list is the order in which they will be written tiled on the master.)
Element Parameters	The parameters that may be chosen to calculate the CGH selected in the Element List
Choose New Element to Paste	Where to select the elements to add to the Element List
Help, Cancel, OK Buttons	Help – Opens OptiScan Help window Cancel – Resets values according to previous edit OK – Accept changes and return to Main Window.

Fresnel Lens

Fresnel Lens - Element Parameters	
Parameter	**Description**
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Offset_xy	The horizontal and vertical offset of the center of the element. Note: this is an offset inside the Element Size_xy window, and does not specify the offset in the Master DOE. (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Focal_fxfy	Focal length in the horizontal and vertical dimensions. (units = meters)
Index_Factor	When converting from a sweat surface profile to a Fresnel lens using photoresist, the Index_Factor describes the additional surface height necessary to compensate for the large refractive index of the Sweatt model. The value entered is the value of the Sweatt refractive index used in the design program. (ex. Use 587.56 is use used a Sweat refractive index of wavelength in nm for the design wavelength of 587.56nm. See the "How To" file entitled "Example conversion from Zemax Sweatt to OptiScan Fresnel Surface" for more details.) The default value of this parameter is n_{resist}.
k	Conic constant used to determine surface shape according to the formula. When k and all A constants are zero: $z_{\text{Surface}} = x^2 / 2 f_x + y^2 / 2 f_y$, and when k or any A constants are nonzero: $z_{\text{Surface}} = \frac{\text{Index\_Factor - } n_{\text{incident}}}{n_{\text{resist}} - n_{\text{incident}}} \left\{ \frac{\left(x^2 + y^2\right) / f_x}{1 + \sqrt{1 - (1+k)\frac{\left(x^2 + y^2\right)}{f_x^{\,2}}}} + \sum_{i=1}^{5} A_i \left(x^2 + y^2\right)^i \right\}$ Note: When a base surface radius is desired, rather than a focal length, the following formula may be used to determine the focal-length input for the DOE Calculator: $f = \frac{R}{n_{\text{resist}} - n_{\text{incident}}}$ The default value of Index_Factor = n_{resist} , so unless Index_Factor is changed, the net effect on the surface sag before quantizing is zero.

A	Aspheric coefficients A1 … A5 used to determine surface shape according to the formula above. (Five-element vector [A1 … A5], units = inverse of corresponding spatial variable power)

Grating

Grating – Element Parameters	
Parameters	**Description**
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels) (only important for blaze grating)
Rotation_deg	The angle which the element is rotated about the center. (units = degrees)
Period	Period of the grating. (units = meters)
Type_Duty	Type (0 = blaze grating, 1 = binary grating) For Blaze Grating: the full Period is used to ramp the linear exposure increase, according to Q_Levels. Duty is the duty cycle of the grating
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, a blaze grating with OPD_ptg = 100 will ramp the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the ramp will only be 50% of the maximum thickness. For a binary grating, the OPD_ptg specifies the difference between the maximum and minimum thicknesses in the profile.

Supergaussian

Supergaus – Element Parameters	
Parameters	**Description**
Supergaus equation	Implements the two-dimensional super-Gaussian function $f(x,y) = \exp\left\{-\left[\frac{(x-x_o)^2 + (y-y_o)^2}{r^2}\right]^N\right\}$
Size_xy	Horizontal and vertical dimensions of the element. (units = meters)
Offset_xy	The horizontal and vertical offset of the center of the element. Note: this is an offset inside the Element Size_xy window, and does not specify the offset in the Master DOE. (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Radius	Radius of the super-Gaussian r (units = meters)
Exponent	The super-Gaussian exponent N
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, OPD_ptg = 100 will set the element thickness to the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the element thickness will only be 50% of the maximum thickness.

Zernike

Zernike – Element Parameters	
Parameters	**Description**
Zernike description	Implements a Zernike-coefficient expansion of the OPD. Expansion coefficients are in the order specified in Malacara, Optical Shop Testing. See OptiScan help description under aberration panel in the lens object for more detail on the Zernike description.
Size_xy	Horizontal and vertical dimensions of the element. (units = meters)
Offset_xy	The horizontal and vertical offset of the center of the element. Note: this is an offset inside the Element Size_xy window, and does not specify the offset in the Master DOE. (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Radius	Radius over which the Zernike coefficients are defined. (units = meters)
Coef_Vector	More coefficients are inputted than can be shown. Use the arrows and scroll keys (home and end) to see all of the coefficients. See OptiScan help description under aberration panel in the lens object for more detail on the Zernike description. These values can be changed manually, or when the "Calculate" button is used, the query box asks for the name of a file in which the coefficients are stored. Usually, the file input is more convenient if the number of coefficients is large. See OptiScan help description under aberration panel in the lens object for more detail on the Zernike file description.
FringeScaleFactor	Factor used to multiply the Zernike coefficient vector during calculation of the CGH. This factor is convenient for viewing the CGH with fewer fringes (FringeScaleFactor <1) to review pattern shape in optical testing applications.

User BMP File

User_bmp_file – Element Parameters	
Parameters	**Description**
User bmp description	Writes a user defined bmp file to the photo-resist. (ex. A signature logo.)
Size_xy	Horizontal and vertical dimensions of the element. (units = meters)
Offset_xy	The horizontal and vertical offset of the center of the element. Note: this is an offset inside the Element Size_xy window, and does not specify the offset in the Master DOE. (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
File_Name	The name of the file to be written. Using "Calculate" allows the user to change the input filename and directory.
Input-Type	1 = exposure input 2 = thickness input
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, OPD_ptg = 100 will set the element thickness to the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the element thickness will only be 50% of the maximum thickness.
BMP_sampling	The pixel size of the input BMP file. The output pixel size is specified by AU on the Main Window.
Snap_flag	= 0 when using interpolation to tile in Arrange Panel = 1 when using nearest-position w/o interpolation in Arrange Panel

Ramp

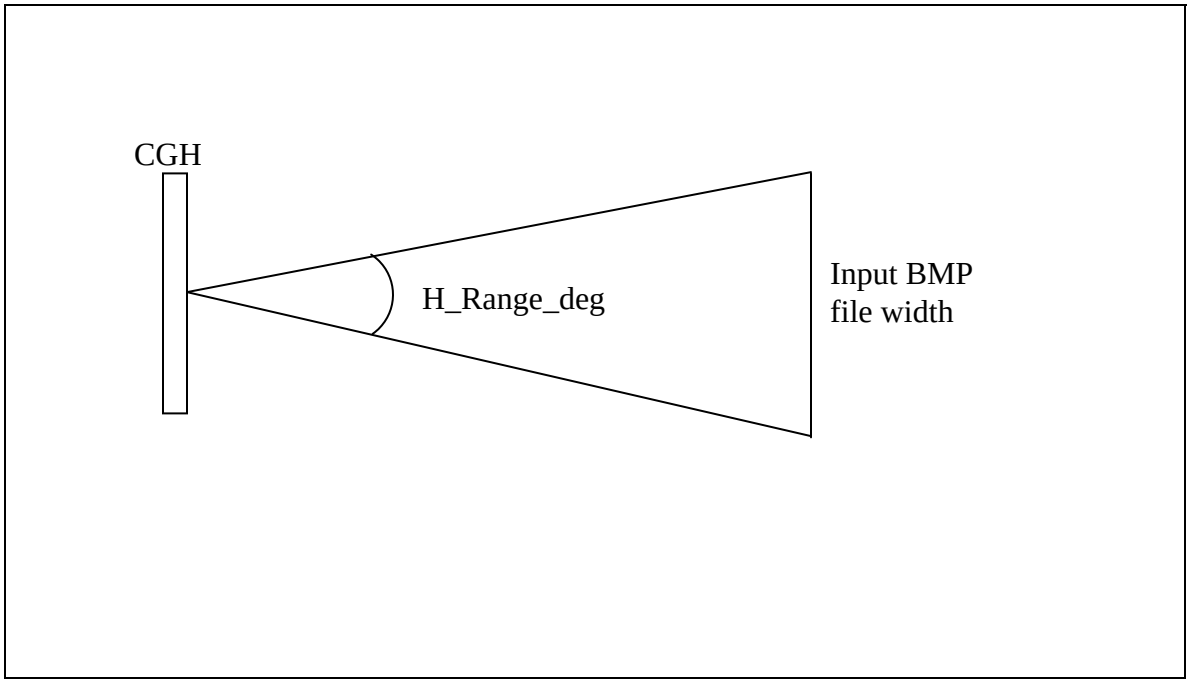
Ramp – Element Parameters	
Parameters	**Description**
Ramp description	Writes a simple linear ramp.
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Rotation_deg	The angle which the element is rotated about the center. (units = degrees)
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, OPD_ptg = 100 will set the element thickness to the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the element thickness will only be 50% of the maximum thickness.

Filled Rectangle

Filled_rectangle – Element Parameters	
Parameters	**Description**
Filled rectangle description	Writes a simple rectangle with the interior filled in.
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Rotation_deg	The angle which the element is rotated about the center. (units = degrees)
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, OPD_ptg = 100 will set the element thickness to the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the element thickness will only be 50% of the maximum thickness.

GS Beam Shaper

GS_beam_shaper – Element Parameters	
Parameters	**Description**
GE beam shaper description	Takes a bmp image file and creates a Fourier hologram for it using the Gerchberg-Saxton algorithm.
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Target_far_field	Displays the name of the BMP image file to be used in the calculation. Using the "Calculate" button will reset the filename and the directory for the input file.
N_Loops_N_FFT	A two-element vector. The first element is the number of loops used in the Gerchberg-Saxton algorithm. The second element is the size of one side of the square in pixels to be used for the Fast Fourier Transform (FFT).
H_range_deg	The full angular range corresponding to the input Target_far_field BMP file. See figure below. (units = degrees)
Disp_Flag	1 = display signal to noise ratio and estimated image. An image estimate will be displayed for every ten loops of the GS algorithm. The size of the image estimate depends on several the Wavelength and AU (from the Main Window). The full angular width of the image estimate display is Wavelength/AU in radians; 0 = don't display this information.



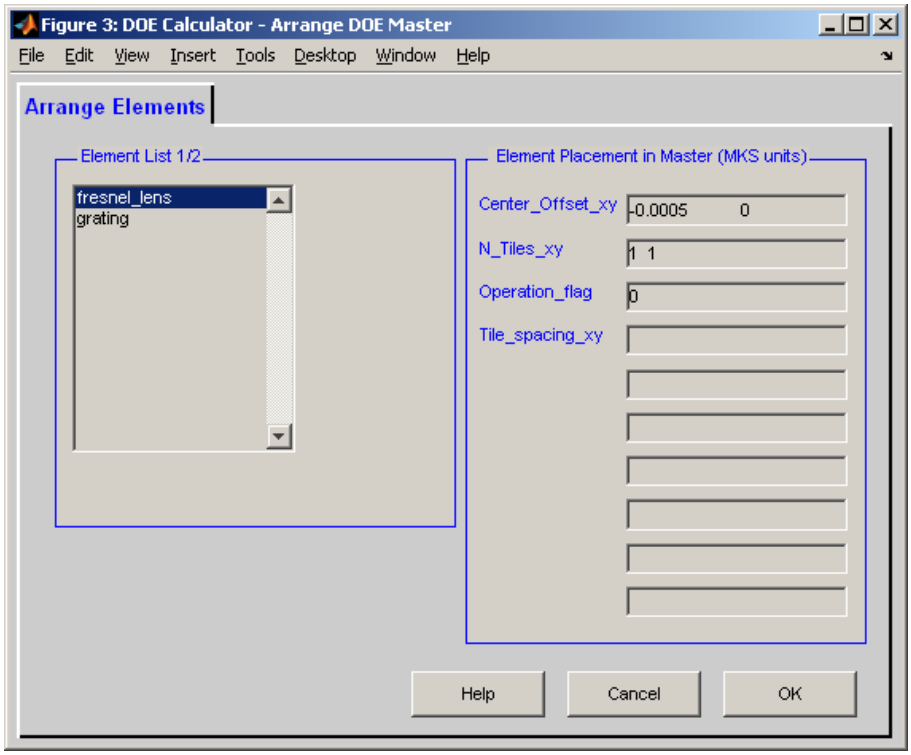
Box

Box – Element Parameters	
Parameters	**Description**
Box description	Writes a simple box.
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Rotation_deg	The angle which the element is rotated about the center. (units = degrees)
Border	The width of the border. (units = meters)
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, OPD_ptg = 100 will set the element thickness to the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the element thickness will only be 50% of the maximum thickness.

Text

Text – Element Parameters	
Parameters	**Description**
Text description	Writes text.
Size_xy	Horizontal and vertical dimensions of the element (units = meters)
Q_Levels	Number of quantization levels in exposure. (ex. 2 = binary resist, 256 = 256 grey levels)
Text_string	The text to be written.
Font_size	The size of the text to be written in pixels.
OPD_ptg	The percentage of the total OPD for the total thickness of the element. For example, OPD_ptg = 100 will set the element thickness to the maximum thickness according to Resist Thickness on the Main Window. If OPD_ptg = 50, the element thickness will only be 50% of the maximum thickness.
Font_Type	The font to be used to write the text.

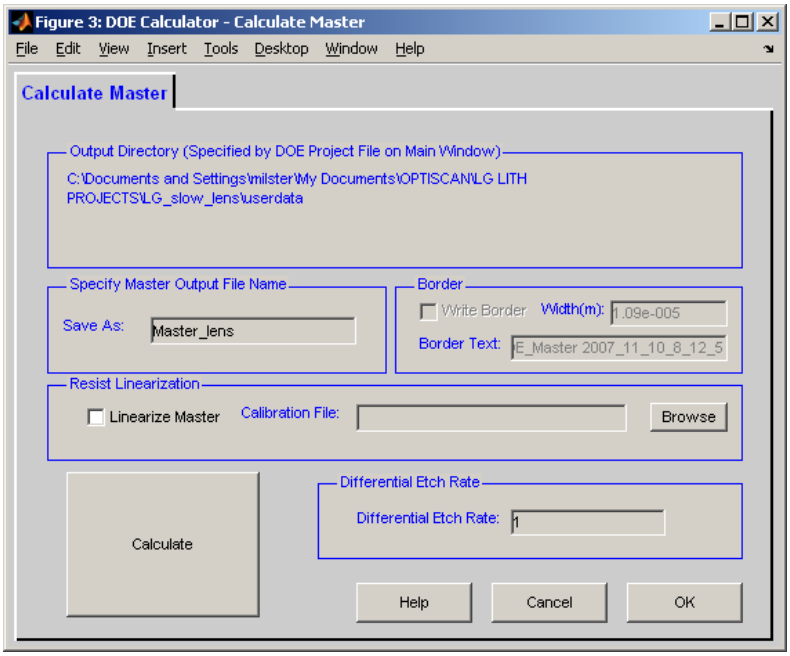
Arrange Button



Arrange DOE Master		
MENU NAME	**DESCRIPTION**	
Element List	The elements to be written on the master CGH (note: the order in which they appear on the list is the order in which they will be written tiled on the master.) This list is modified under the "Add/Edit DOE Elements" window. Selecting an Element will change the corresponding display for the Placement.	
Element Placement in Master	Center_Offset_xy	Offset of the element from the center of the Master DOE. This is a two-element vector (x and y). (units = meters)
	N_Tiles_xy	Number of tiles in the x and y dimensions for the Element. This is a two-element positive integer vector (x and y) that is centered at Center_Offset_xy.

	Operation_flag	0 = simple pixel-by-pixel replacement 1 = add BMP values modulo 256 2 = add BMP values, divide by 2 and take modulo 256 3 = mask (BMP values=0 in Element are set to zero in Master DOE) 4 = mask (BMP values>0 in Element are set to zero in Master DOE) 5 = subtract, then take modulo 256. 6 = subtract from 255 and replace 7 = add 255 at locations of zeros 8 = add 255 at locations of > zero values 9 = 255 at locations where > zero values of Element or background
	Tile_spacing_xy	Two-element vector (like Center_Offset_xy) that defines the spacing between elements in the tile. If blank or [0 0], the elements are placed directly next o each other.
Help, Cancel, OK Buttons	Help – Opens OptiScan Help window Cancel – Resets values according to previous edit OK – Accept changes and return to Main Window.	

Calculate Button



Calculate Master	
MENU NAME	**DESCRIPTION**
Output Directory	Specified by the Project Name in the Main Window.
Master Output File name	Name of final output BMP file for the writer.
Border	Under construction. Not operational at this time (4/09/07).
Resist Linearization	If linearization is required, use the checkbox. A linearization characterization file is required that is entered through the BROWSE button. The user will be directed to select the file and the offset for linearization.
Calculate	Select this button to start the calculation.
Differential Etch Rate	The ratio of the PR etch rate to the glass etch rate. (Under construction 11/10/07).
Help, Cancel, OK Buttons	Help – Opens OptiScan Help window Cancel – Resets values according to previous edit OK – Accept changes and return to Main Window.