Instructions for making a CGH pattern from startup with OptiScan V7.6. I used Windows Vista business for this example.

DATE: 09/30/08

1.) Open Matlab.
2.) Select the directory that contains the OptiScan *startup.m* file. See Figure 1 below that was produced for my PC in the "Current Directory" menu item. You can browse for the directory with the ⌷ button. (It looks like I need to renew my license!)
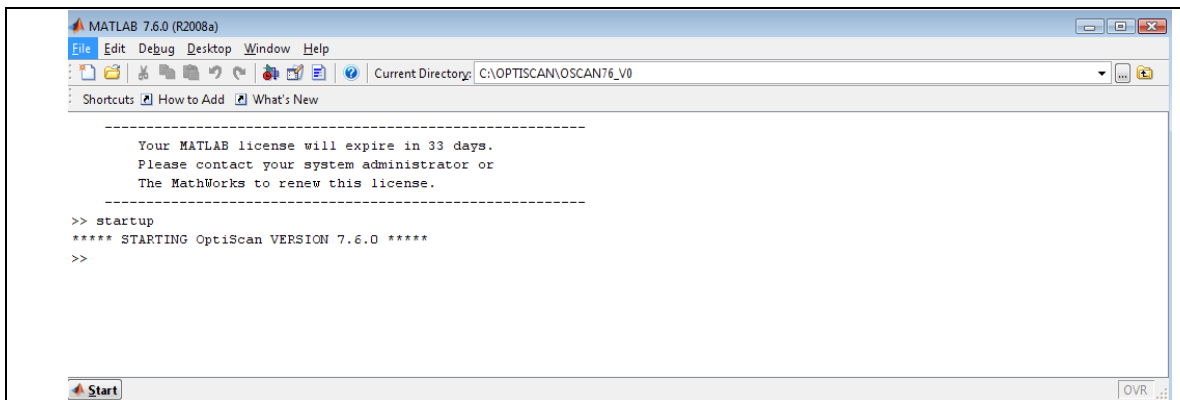

Figure 1. Starting OptiScan in Matlab.

3.) Enter "startup" as shown in Figure 1.
4.) The interface window shown in Figure 2 should appear. If not, check your directories again for the startup.m file.
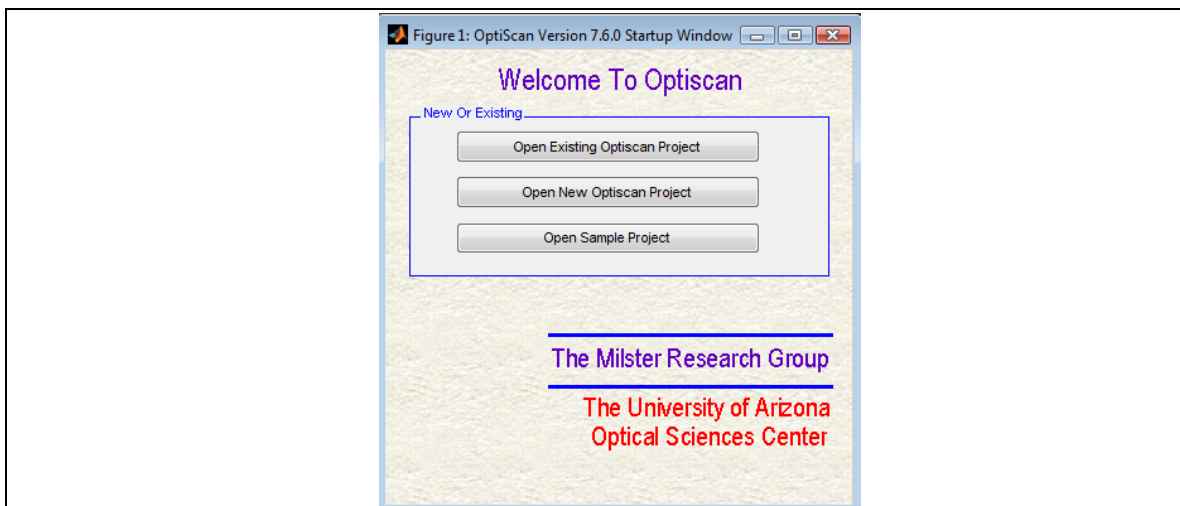

Figure 2. Initial interface window for OptiScan.

5.) If you already have an OptiScan project defined for this task, skip to Step 9.

6.) If you do not have an OptiScan project defined for this task, select the "Open New OptiScan Project" button.

7.) A browser window similar to the one shown in Figure 3A should appear. Select a directory for the project with the browse, like "PROJ7" shown in the figure. Then create a new folder for your project with the "Create New Folder" button. Enter the name of the new folder, like CGH TEST as shown in Figure 3B. Now, enter the name of the project, which will be the name of a command file in Matlab format that contains all of the setup information for the calculation. As shown in Figure 3C, the new name for this test is OptiScan_Project_CGH_TEST_093008. It is a good idea to identify the project file with a leading indicator, like "OptiScan_Project_", because it clearly separates this file from other Matlab files that may be created in the same folder.
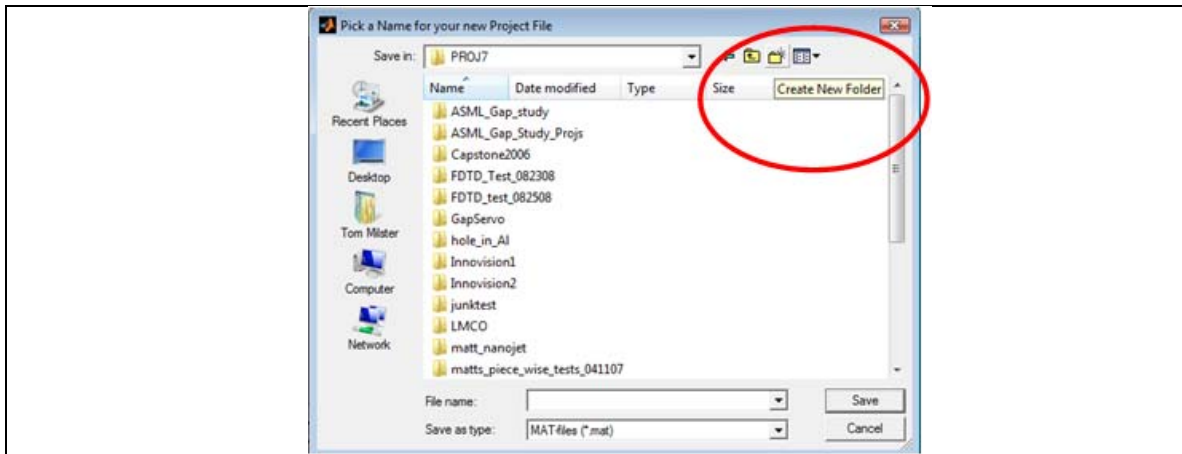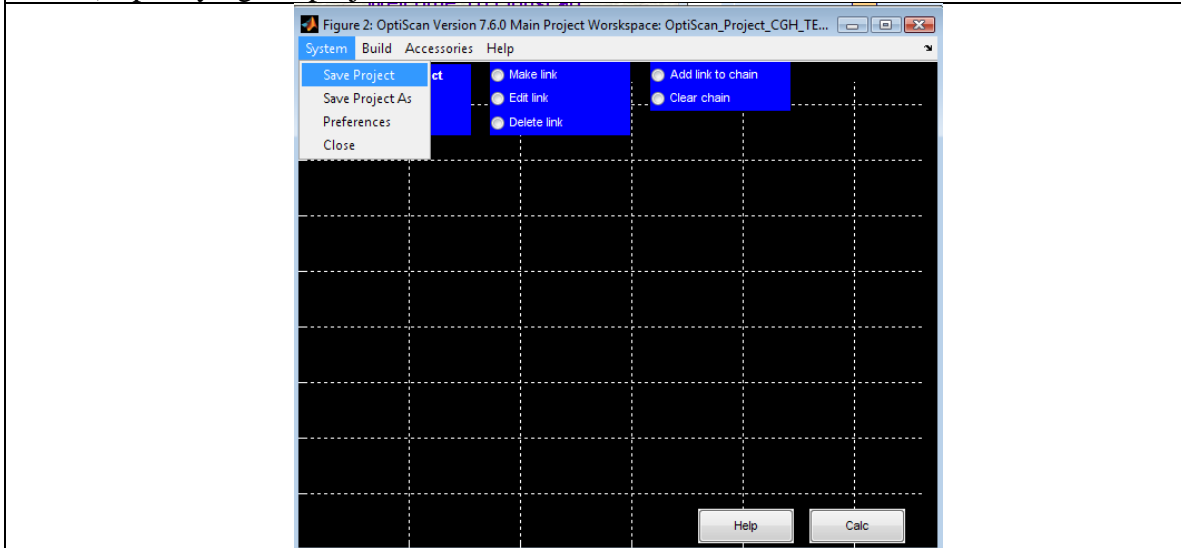

A) Creating a new directory for your project
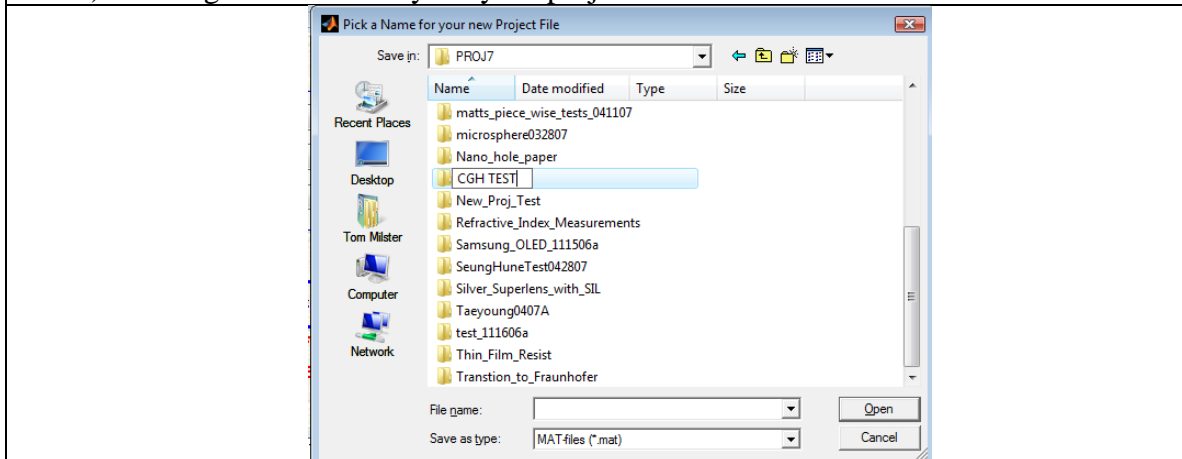
B.) Entering the folder name
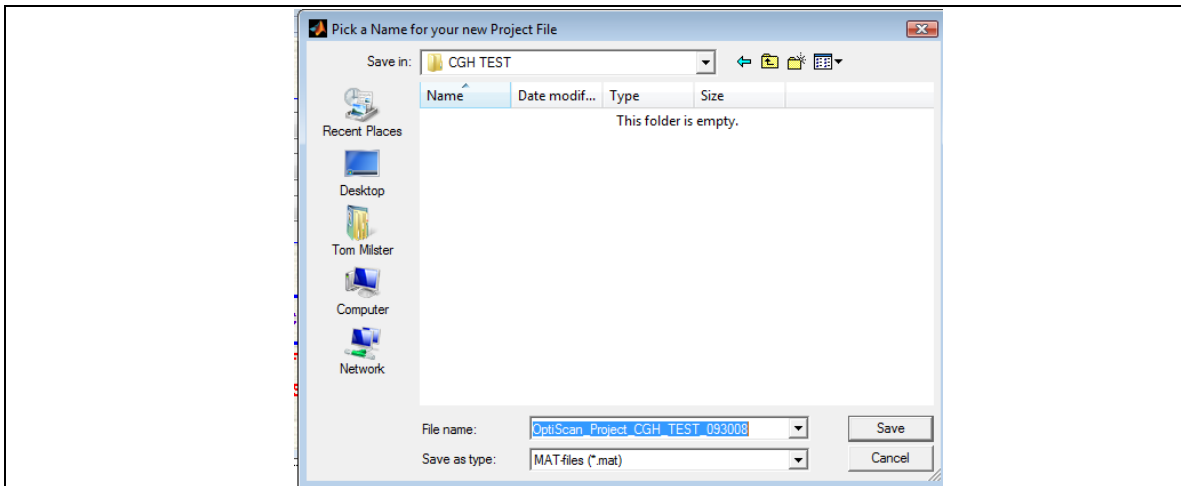
C.) Specifying the project name

D.) The blank OptiScan Main Window of the new project

Figure 3. Steps for creating a new project.

8.)   After you select the "save" button, the new blank OptiScan Main Window appears on your screen, as shown in Figure 3D. Notice that the project name is displayed as the figure title. It is a good idea to immediately save the project by selecting the "Save Project" option under the "System" menu item. Now skip to Step 11.

9.)   If you already have an OptiScan Project saved, you can reopen it by selecting the "Open Existing OptiScan Project" button, as displayed in Figure 2.

10.)   When prompted to do so, browse to the desired project folder and select the OptiScan project file, as shown in Figure 4. After selecting the "Open" button, the project window should appear, as shown in Figure 3D.
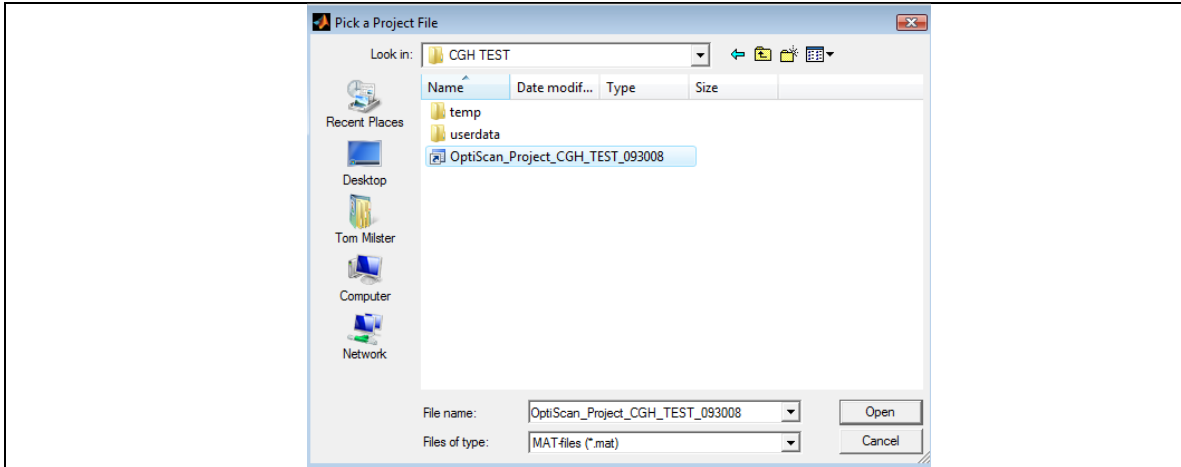
Figure 4. Opening a previously saved OptiScan project.

11.) At this point, we are ready to open the DOE and CGH Calculator. We will assume that this is the first time the calculator has been used with this project, so there are no previously saved DOE Projects. If there are previously saved DOE Projects, you can simply modify them with the calculator and resave them under a different name.

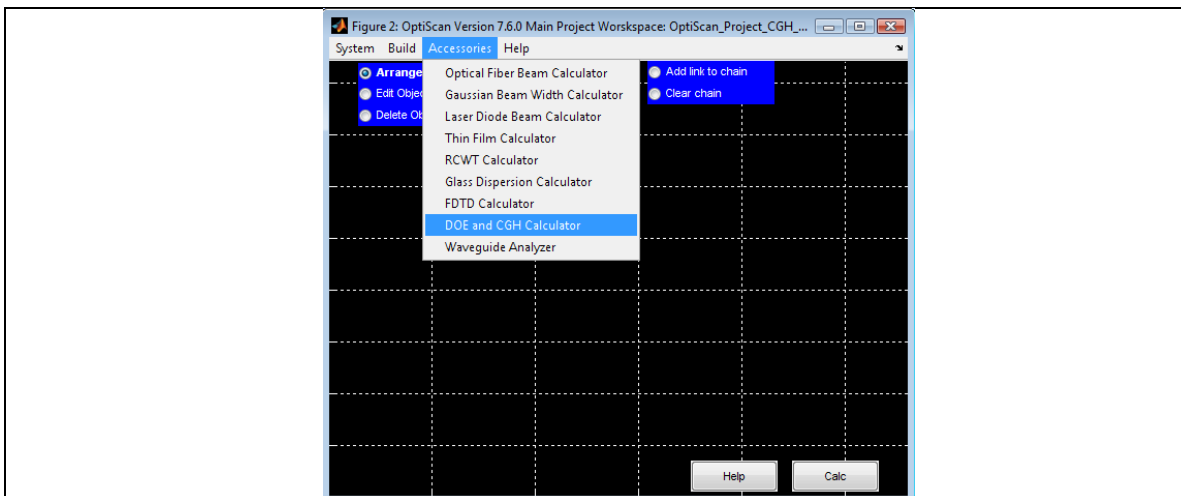12.) Open "DOE and CGH Calculator" under the "Accessories" menu item, as shown in Figure 5.

Figure 5. Opening the DOE and CGH Calculator.

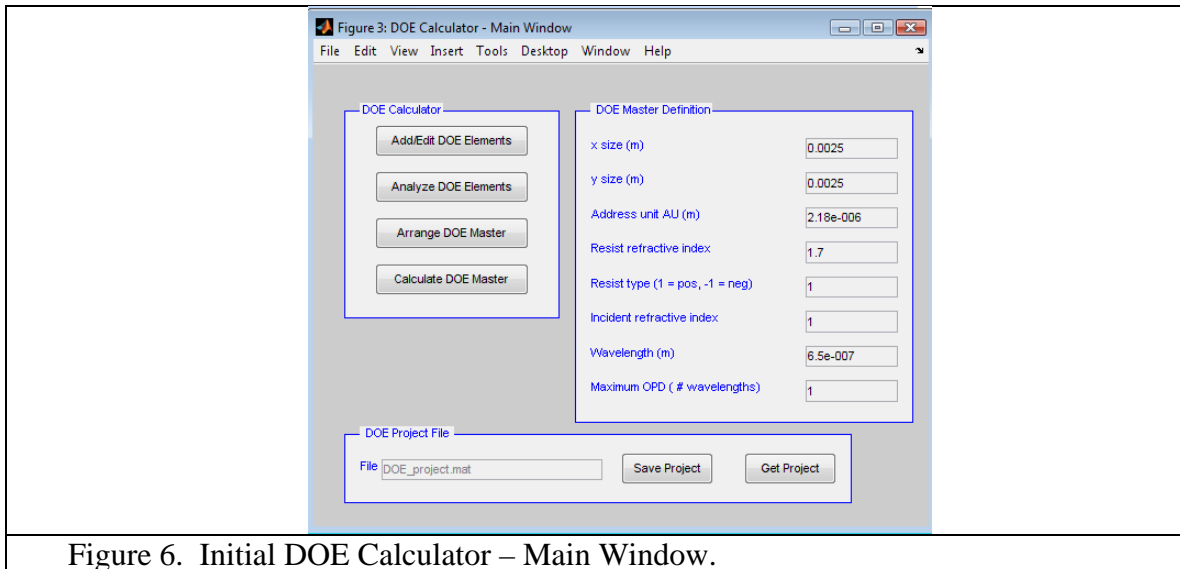13.) The Main Window for the DOE Calculator appears, as shown in Figure 6.

Figure 6. Initial DOE Calculator – Main Window.

14.) Details of the setup parameters are described in the "DOE and CGH Calculator Help" file. We will only go through a specific example in this document.

15.) Let's change the Master Definition to the following:
   a. Xsize = 0.005 m
   b. Ysize = 0.005 m
   c. Address unit = 2.1e-6 m
   d. Resist refractive index = 1.59e-6
   e. Resist Type = 1
   f. Incident refractive index = 1
   g. Wavelength = 632.8e-9
   h. Resist thickness = 1 wave

16.) After these changes are made, save the DOE project by selecting the "Save Project" button and enter the filename "DOE_project_CGH_TEST_093008" for the name of the DOE project. The default directory is the "userdata" directory of the OptiScan Project. It is always a good idea to name the DOE project file so that it can be differentiated from other Matlab files in the same folder, which we can accomplish by using the identifier "DOE_project" as a leader to the filename. You should also save your project after any changes are made to the setup. Your window should appear as shown in Figure 7.
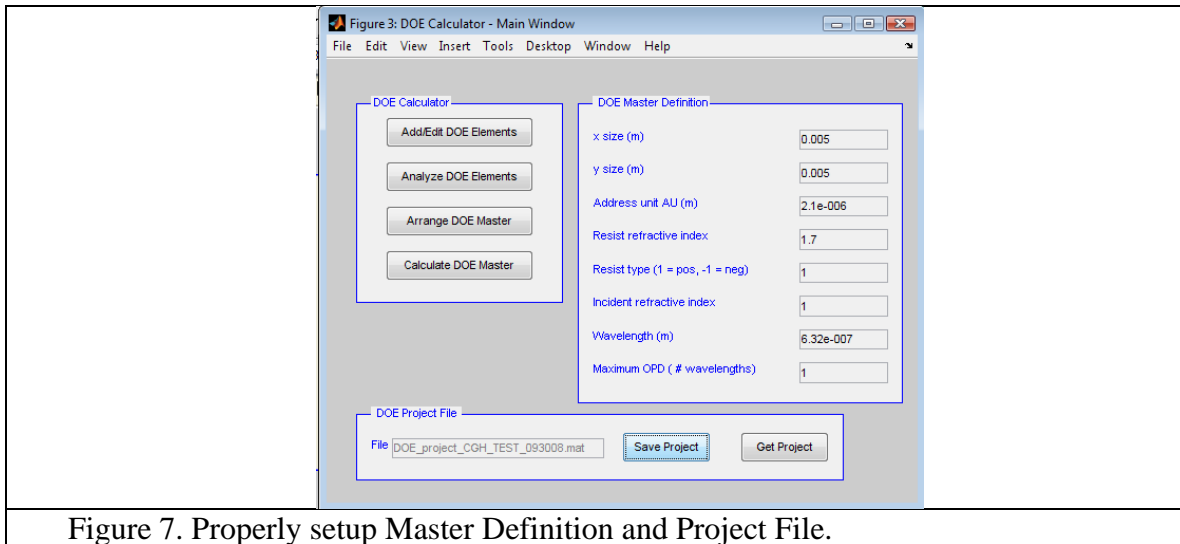
Figure 7. Properly setup Master Definition and Project File.

17.) Now, let's edit the elements contained in the Master DOE. Select the "Add/Edit DOE Elements" button, and the "Element List Description" window will appear. Default elements are a Fresnel lens and a grating. Let's cut those elements from the Element List. To cut the elements, select each element and the "Cut" button. To add the new element, select "GS Beam Shaper" from the dropdown menu under "Choose New Element to Paste". Then, Select the "Paste New" button. The "GS_beam_shaper" element should appear in the Element List.

18.) A minor bug in the program is that the Element Parameters may not change to those associated with the new element. To make the element parameters appear properly, select any gray area of the Element List box outside the GS_beam_shaper line and then reselect the GS_beam_shaper. This action should correct the Element Parameters window.

19.) Default parameters for the CGH are a 512x512 array of grayscale pixels on an approximately 1mm by 1mm area. The GS algorithm is used for the basic construction with 10 iteration loops. The full horizontal range of the target file is 3 degrees.

20.) Let's exit the DOE elements window for a few steps and save the resulting DOE Project that we have made. Select "OK" on the bottom-right-hand corner of the DOE elements window to return to the DOE Calculator – Main Window, as shown in Figure 7. Select the "Save Project" button and save your project file under the same name as we specified in Step 16. The program will ask you if you want to replace the project file, and you will select "Yes".

21.) We will now specify a target file that will be the desired pattern displayed in the far field of the CGH. First, let's go back to the Matlab command line interface window and construct a target file. For the next few steps, we will be operating outside of the OptiScan interface windows.

22.) It is probably a good idea to change the "Current Directory" of the Matlab command line interface window to the "userdata" folder of the current OptiScan project.

23.) Entering the following commands in the Matlab Command Line Window will produce a bright square in and otherwise black background, as shown in Figure 8. The array size is 1024x1024, and the variable type is "uint8", which is unsigned 8-bit integer. Width of the square is one half of the matrix width. After creation, the array is written out to a bmp (8-bit bitmap) file for further processing. Of course, other patterns may be used, but the bmp file format and uint8 variable type must be used. Also, gray-scale uint8 values between 0 and 255 may be used in the matrix.

    a. >> X = repmat(uint8(0),1024,1024);
    b. >> indx = 257:767;
    c. >> X(indx,indx)=repmat(uint8(255),length(indx),length(indx));
    d. >> figure;imagesc(X);colormap(gray);axis image
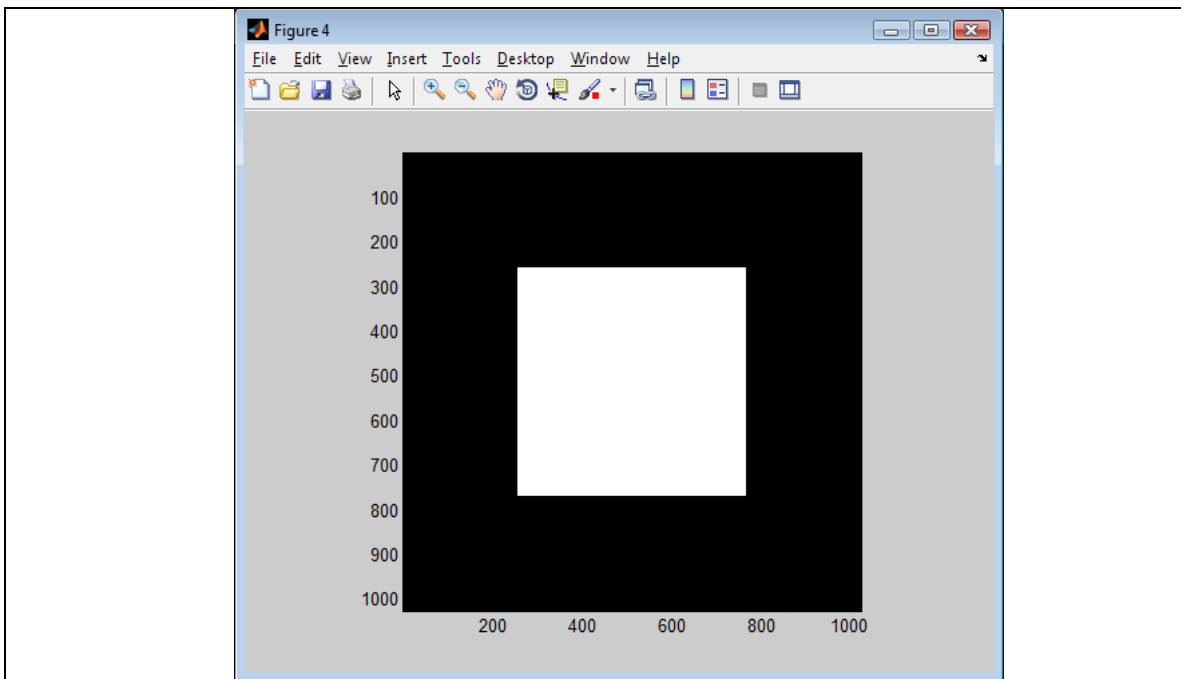   e. >> imwrite(X,'white_square.bmp','bmp');

Figure 8. White square in black background for the target file.

24.) Figure 8 shows the ideal result of the CGH being illuminated by a laser beam. In the far field, it should produce a white square. Let's now enter that information into the DOE and CGH Calculator. We now return to the DOE Calculator – Main Window, as shown in Figure 7. Select the "Add/Edit DOE Elements" button to return to the DOE elements window, which should look like Figure 9.
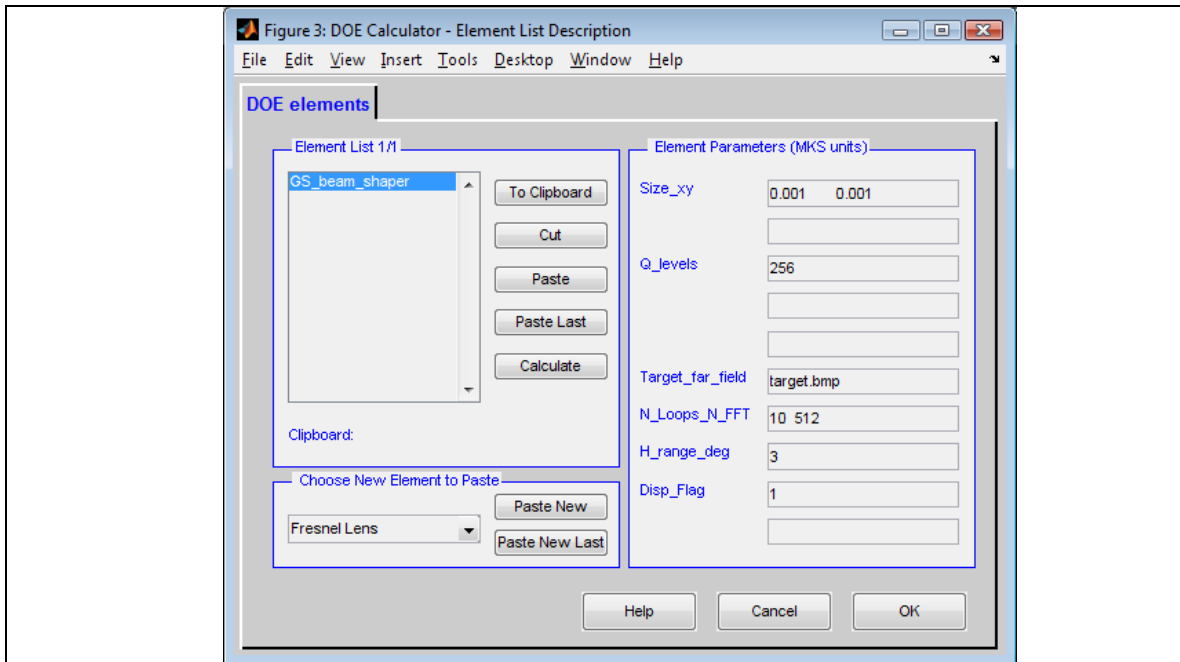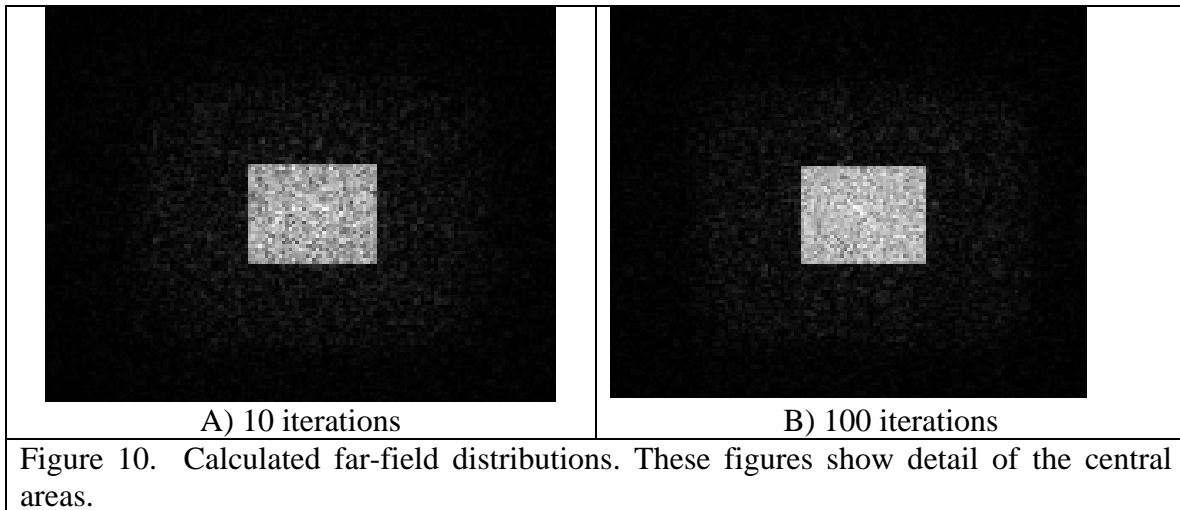
Figure 9. DOE elements window before specifying Target_far_field file.

25.) To enter the new target file, select the "Calculate" button. An input window should appear asking you to Specify a BMP file for Input. The "white_square.bmp" file should appear in the userdata folder. Select this file.

26.) The calculator will start immediately. After only 10 iterations, the program will stop and display several new windows, which are described below.

    a. Figure 100: DOE GENERATOR: GS Algorithm – This window plots the signal-to-noise ratio (SNR) as a function of iteration number. As the quality of the far-field construction improves, the SNR increases. For this example, the maximum SNR reached after 10 iterations is about 10.85. Since the slope of the SNR curve remains high at the last iteration, more iterations will probably increase quality of the reconstruction.

    b. Figure 101: Image Distribution – This widow shows the calculated reconstruction irradiance. It should look like that shown in Figure 10A.

    c. Figures 103 through 106 – These figures show Exposure (laser light power) and resulting thickness profiles across the CGH.

    d. Figure 107: Linear DOE Element Exposure Map – This image is a map of the exposure profile that can be used to generate your CGH.

| A) 10 iterations | B) 100 iterations |

Figure 10.   Calculated far-field distributions. These figures show detail of the central areas.

27.)   The program asks if you want to save your bmp file. Select "No" at this time.

28.)   Notice that the square reconstruction is only a small portion of the Image Distribution shown in Figure window 101. The maximum boundaries of the Image Distribution correspond to the minimum pixel period and wavelength. We specified 2.1 μm pixel size (Address Unit) and 632.8 nm wavelength, so the full angular range of the Image Distribution is 0.6328/2.1*180/pi = 17.2 degrees. Our specification was for a full angle of 3 degrees (H_range_deg) on the target file, so the white square full range is 1.5 degrees, which is only 8.7% of the displayed Image Distribution width.

29.)   Since the SNR plot displayed in Figure window 100 indicated possible improvement with more iterations, let's go back to the DOE elements widow and select 100 iterations in the N_Loops_N_FFT parameter line.   The parameter line after the change should look like this: N_Loops_N_FFT 100 512.

30.)   Select the Calculate button again, specify "white_square.bmp" and wait for the program to finish.

31.)   You will see the SNR climb to almost 12.15. The calculated reconstructed image is shown in Figure 10B. The reconstructed pattern is smoother, and there is less noise in the surrounding area of the pattern.

32.)   At this point, you can save the Exposure Map as a bmp file in order to print directly, or you can skip the save operation in favor of including the CGH in a larger matrix. To save the bmp Exposure Map, select "Yes" to the request box that asks "Do you want to save the DOE exposure data as a bmp file?". When prompted to do so, enter a filename, like "exposure_map_for_white_square".   The file will be saved with a bmp extension in the userdata directory.