Mask and Method to Pattern Chromeless Phase Lithography Contact Hole

Background of Invention

1) Field of the Invention

This invention relates, in general, to masks used in making semiconductor devices and, more particularly, to making phase shift masks and using phase shift mask and more particularly to chromeless phase shift mask used to form contact hole patterns.

2) Description of the Prior Art

In the manufacturing of semiconductor devices small features or small geometric patterns are created by using conventional optical photolithography. Typically,

optical photolithography is achieved by projecting or by transmitting light through a pattern made of optically opaque areas and optically clear areas on a mask. The optically opaque areas of the pattern block the light, thereby casting shadows and creating dark areas, while the optically clear areas allow the light to pass, thereby creating light areas. Once the light areas and dark areas are formed, they are projected onto and through a lens and subsequently onto a photosensitive layer on a semiconductor substrate. However, it should be understood that dimensions can be scaled for use with other reduction tools. Projecting light areas and dark areas on the photosensitive layer results in portions of the photosensitive layer being exposed, while other portions of the photosensitive layer will be unexposed.

However, because of increased semiconductor device complexity, which results in increased pattern complexity, increased resolution demands, and increased pattern packing density on the mask, distance between any two opaque areas has decreased. By decreasing the distances between the opaque areas, small apertures are formed which diffract the light that passes through the apertures. The diffracted light results in effects that tend to spread or to bend the light as it passes so that the space between the two opaque areas is not resolved, therefore making diffraction a severe limiting factor for conventional optical photolithography.

A method for dealing with diffraction effects in conventional optical

photolithography is achieved by using a chromeless phase shift mask, which replaces the previously discussed mask. Generally, with light being thought of as a wave, phase shifting with a chromeless phase shift mask is achieved by effecting a change in timing or by effecting a shift in waveform of a regular sinusoidal pattern of light waves that propagate through a transparent material. Typically, phase shifting is achieved by passing light through areas of a transparent material of either differing thicknesses or through materials with different refractive indexes, thereby changing the phase or the period pattern of the light wave.

Chromeless phase shift masks reduce diffraction effects by combining both phase shifted light and nonphase shifted light so that constructive and destructive interference takes place. Generally, a summation of constructive and destructive interference of phase shift masks results in improved resolution and in improved depth of focus of a projected image of an optical system.

Relevant patents include the following:

US 6,376,130 - Stanton - Chromeless alternating reticle for producing semiconductor device features - An alternating phase shift reticle for a capacitor layout scheme for a memory device and a method for its fabrication is disclosed. The alternating phase shift mask has regions of 0 and 180 degree phase shifts arranged in a way such that

all sides of each region corresponding to a given phase shift value are bounded by areas corresponding to an opposite phase shift value.

US 6,623,895 - Chen , et al. - shows a Hybrid phase shift mask- The method includes the steps of forming at least one non-critical feature on the mask utilizing one of a low-transmission phase shift mask (pattern) and a non-phase shifting mask (pattern), and forming at least one critical feature on the mask utilizing a high-transmission phase shift mask (pattern).

US 5,863,712 Von Bunau , et al. - Pattern forming method, projection exposure system, and semiconductor device fabrication method.

US 5,786,115 - Kawabata, et al. - Mask producing method.

Summary of the Invention

Embodiments of the present invention provide structure and a method of fabrication a chromeless phase shift mask which is characterized as follows.

An example embodiment is a phase shift mask comprised of : a mask comprised of a first phase shift region and a second phase shift region; the first phase shift region and the second phase shift region are about 180 degrees out of phase;

the first phase shift region is comprised of at least a unit cell; the unit cell is comprised of (a) a center section and (b) at least three rectangular sections extending outwards from the center section; the center section has a rectangular shape;

the second phase shift region is adjacent to the first region;

the unit cell has a shape that when light passes through the mask, the destructive interference between the first phase shift region and a second phase shift region creates a contact hole pattern.

An example embodiment is a chromeless phase shift mask comprised of: a mask comprised of a first phase shift region and a second phase shift region; the first phase shift region and the second phase shift region are about 180 degrees out of phase;

the first phase shift region is comprised of unit cells, each unit cell comprised of (1) an center section and (2) four rectangular sections extending outwards

from the center section; the center section has a rectangular shape; the unit cells are connected by adjacent rectangular sections to form a plurality of rows and columns;

the second phase shift region is adjacent to the first region;

whereby when light passes through the mask, the destructive interference between the first phase shift region and a second phase shift region creates a contact hole pattern.

An example embodiment is a method for projecting patterns onto a semiconductor substrate comprising: providing an illumination source;

providing a phase shift mask that has a first phase shift region and a second phase shift region; the first phase shift region and the second phase shift region are about 180 degree out of phase;

the first region comprised of a unit cell; the unit cell comprised of (a) a center section and (b) at least three rectangular sections extending outwards from the center section; the center section has a rectangular shape; the unit cell has a shape that when light passes through the mask, the destructive interference between the first phase shift region and a second phase shift region creates a contact hole pattern;

projecting light from the illumination source thru the phase shift mask onto a semiconductor substrate.

The above and below advantages and features are of representative embodiments only, and are not exhaustive and/or exclusive. They are presented only to assist in understanding the invention. It should be understood that they are not representative of all the inventions defined by the claims, to be considered limitations on the invention as defined by the claims, or limitations on equivalents to the claims. For instance, some of these advantages may be mutually contradictory, in that they cannot be simultaneously present in a single embodiment. Similarly, some advantages are applicable to one aspect of the invention, and inapplicable to others. Furthermore, certain aspects of the claimed invention have not been discussed herein. However, no inference should be drawn regarding those discussed herein relative to those not discussed herein other than for purposes of space and reducing repetition. Thus, this summary of features and advantages should not be considered dispositive in determining equivalence. Additional features and advantages of the invention will become apparent in the following description, from the drawings, and from the claims.

Brief Description of the Drawings

The features and advantages of a mask according to the embodiments of the present invention and further details of a process of fabricating such a mask and devices with the mask in accordance with the embodiments of the present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which like reference numerals designate similar or corresponding elements, regions and portions and in which:

Figure 1 shows a representation of an embodiment of the mask having a first (e.g., 180 degree) phase shift region 104 (cross-junction feature) that has a cross shape.

Figure 2A shows a top down view of a PSM of an embodiment of the invention.

Figure 2B shows a cross sectional view thru a first region 12 in figure 2A.

Figures 3A and 3B show top plan representation of embodiments of the unit cell with the different length and width rectangular sections.

Figure 4 shows a simulation of the contact hole projection of increasing lengths of rectangular sections of an example embodiment of the invention.

Figure 4A shows top plan view of a dense array (rows and columns) contact pattern according to an example embodiment of the invention.

Figure 4B is a top down view of the resulting contact hole pattern from the mask in figure 4A that is projected onto photoresist according to example embodiment of the invention.

Fig. 4C shows a top down image view of a chromes less PSM with a Dense array contact similar to that shown in figure 4A.

Figures 5A and 5B show a top down views of an embodiment of a chromeless PSM with a dense (simulated) contact hole array 516.

Fig. 6 shows a graph of the Intensity across section (white line) in Fig. 5B according to example embodiment of the invention.

Fig. 7A is an top down view of a chromeless mask that shows a column 715 of misaligned contact holes 716A according to example embodiment of the invention.

Fig. 8A shows top down view of a mask with first phase shift regions comprised of unit cells in a random contact pattern with "regulator phase feature" 801 added to regulate the intensity according to example embodiment of the invention.

FIG. 9 pictorially illustrates an optical system 150 that uses a chromeless phase shift mask of an embodiment of the present invention.

Detailed Description of the Preferred Embodiments

The present invention will be described in detail with reference to the accompanying drawings. The embodiments of the present invention provides a structure and a method of forming a chromeless mask pattern used to define contact holes. Other embodiments provide a method of using the mask.

Figure 1 shows a representation of an embodiment of the mask having a first (e.g., 180 degree) phase shift region 104 (cross-junction feature) that has a cross shape. The mask is preferably the chromeless type. The quasar illumination fields 102 are superimposed over the mask areas for illustration purposes.

We illuminate the embodiment's chromeless mask with a cross-junction feature using quasar illumination, to form a (contact) hole feature in the photoresist at the center of the cross-junction of two phase lines. This is because unlike other area, there are no neighboring phase edges to create the destructive interference. This structure can be used in the chromeless phase lithography to define contact holes.

Figure 1 shows the quasar illumination 102, and the first (e.g., 180 degree) phase shift region 104 of a phase shift mask (PSM). No edges at axis K-K' and axis L-L' interference at a certain first dimension result in a hole formation.

The "certain first dimension" can be determined by computer simulation. Illuminating parameters, such as wavelength, partial coherency, illuminating

sector angle and type of off-axis illuminations, will affect the required edges separation dimension for formation of the contact hole. For example, with a 248 nm wavelength, numerical aperture setting 0.80 quasar illumination, outer partial coherency factor of 0.55 and inner partial coherency factor of 0.30 at 30 deg illuminating sector, the required dimension for a hole formation is about and more than (70x4) nm on mask as with used on a projection system magnification of 4 times.

A. example embodiment of a phase shifting mask

Figure 2A shows a top down view of a PSM of an embodiment of the invention. Figure 2B shows a cross sectional view thru a first region 12 in figure 2A.

The chromeless PSM mask (e.g., mask substrate) 10 preferably comprises a first phase shift region 12 and a second phase shift region 14. The first and second phase shift regions are preferably about 180 degrees out of phase. For example, the first region 12 of 180 degree phase shift and a second region 14 has a 0 degree phase shift, or viscera .

The first phase shift region is preferably comprised of a unit cell. As shown in figure 2A, the unit cell 13 (24 20 32 28 36) preferably has an orthogonal cross shape with a rectangular center section 20 (see dashed center rectangle) and preferably four (legs) rectangular sections 24 28 32 36 preferably connected to and outwards extending

from the rectangular center (middle) section 20. In an option shown figure 3C, the unit cell can be comprised of 3 rectangular sections. Unit cells can also be joined together as shown in figure 4A.

The center section 20 can also be a rectangle or other shape and is not restricted to a square. As the roundness of the (circular contact hole light) shape and displacement are affected by proximity structures, hence optical proximity correction process may change the original square shape to rectangle depending on the effect of neighboring structures. If the proximity lights that influence the resultant intensity at the center location are all equal, then the center section (20) is a square. In other embodiments, the center section could take the shape of a rectangle to correct the influence from the proximate lights.

The second region 14 is adjacent to the first region 12.

The sidewall of the trench that where region 12 and region 14 transit should be ideally or as close to 90 deg as possible. The depth of the trench depends on the wavelength, such that it generate an optical path difference of 180 deg. The minimum width dimension that can be manufactured to-date is about 200nm, but not restricted to that dimension with the technology advancement. As mentioned in previous section answer, the dimension is limited by the illumination parameters.

Figure 2B shows an example cross sectional view thru the horizontal leg 32 20 24 of the first region 12 in figure 2A in the mask or substrate 10. The mask can be a conventional phase shift substrate comprised of, for example, quartz, silica glass or

borosilicate glass. The mask can have trenches or raised areas to define the first and second phase shift regions.

Contact hole 16 (to be imaged on the resist layer) is located assigned as a (180 degrees) phase shift layer 12. All the orthogonal rectangular sections (legs) 24 28 32 36 are extended such that the resulting intensity will produce a hole 16 in the center of the line (in the resist) as shown in Fig. 2A. For sub-wavelength size contact hole projections, the dimension width of the line/legs should be less than half the illuminating wavelength and low inner and outer sigma factor should be used. Fine tuning can be achieve with the edge movement as shown in Fig. 4.

For illustration, a quasar 30 deg illumination angle, Wavelength = 0.248um, NA =0.80, sigma inner of 0.30 and sigma outer of 0.55.

In general, for initial parameter assignment (before proximity correction), L_1 is approximately equal to W_1. D_1 should also preferably be equal to W_1 for ease of designing the layout.

B. embodiments of the unit cell with the different length and width rectangular sections

Figures 3A and 3B show embodiments of the unit cell with the different length and width rectangular sections (legs). Figure 3A shows the length L2x L2y of the rectangular sections and W2 widths of the rectangular sections. As the rectangular section

length (L) increases, the diameter of the projected contact hole (D_2) increase. However, the relationship is non-linear. The size of D_x will saturate at even thought L_x increases.

Figure 3A shows a cross with the legs about twice as long as in Figure 2A.

Using the above-mention illuminating parameters for illustration, L is length of rectangular section, W is width of rectangular section, D is diameter of projected hole, the length of a side of the center section is also, W.

1. $L_1 = W_1 = 0.100um$, $D_1 = 0.125um$.
2. $L_2 = 0.150um$, $W_2 = 0.100um$, $D_2 = 0.137um$.
3. $L_3 = 0.200um$, $W_3 = 0.100um$, $D_3 = 0.144um$.
4. $L_4 = 0.300um$, $W_4 = 0.100um$, $D_4 = 0.146um$.
5. $L_5 = 0.050um$, $W_5 = 0.100um$, $D_5 = 0.00um$.
6. $L_6 = 0.130um$, $W_6 = 0.100um$, $D_6 = 0.135um$.

Figure 3B

As shown in figure 3B, if the legs L_3 get shorter than the leg's "critical dimension" of 0.07um when W is 0.100um, hence no contact hole is formed for any smaller dimension. However, if L_3 is decreases, the general trend is a decrease in D_3. From the illustration,

1. $L_3 = 0.4W_3 = 0.040um$, $W_3 = 0.100um$, $D_3 = 0.00um$.
2. $L_4 = 0.7W_4 = 0.070um$, $W_4 = 0.100um$, $D_4 = 0.034um$.
3. $L_5 = 0.8W_5 = 0.080um$, $W_5 = 0.100um$, $D_5 = 0.088um$.

C. *simulation of the contact hole projection*

Figure 4 shows a simulation of the contact hole projection of increasing lengths of rectangular sections. Figure 4 shows that as the legs get longer, the hole gets bigger till it saturates at a dimension dependent on the illumination.

Referring to figure 4, the lines around the outside shows the computer simulated resist boundary at an intensity threshold of 0.30. The region outside the boundary indicates the resist is exposed and will be develop and rinse away during the developing cycle.

D. *dense array contact pattern*

Figures 4A and 4B, show a dense array (rows and columns) contact pattern. Figure 4A is a top down view of the mask and first phase shift region 412 (e.g., 180 degree phase shift region) comprised of unit cells and second phase shift region 414 (e.g., unshifted regions). Figure 4B is a top down view of the resulting contact hole pattern that is projected onto photoresist. If Wx is equal to Wy, then 2*Ly should be greater than Wx. 2*Ly should then be approximately greater by at least 1.4 times of Wx. This is because at close proximity, such that 2*Ly is less than 1.4 times of Wx, all the edges will interfere and no contact hole can be formed.

Figure 4B shows the resulting contact hole pattern in the photo resist. D is the diameter of the contact hole pattern 420.

Fig. 4C shows a top down image view of a chromes less PSM with a Dense array contact similar to that shown in figure 4A.

E. example embodiment of chromes less PSM

Figures 5A and 5B show a top down views of an embodiment of a chromeless PSM with a dense (simulated) contact hole array 516 can be patterned using the unit cells 512 (e.g., 180 degree shift regions) with novel phase regulator features 501 added to regulate the intensity. The non-patterned regions 514 preferably have about 180 a phase shift compared to the unit cells 512 and phase regulator feature 501. Figure 5A shows at least two columns 512 comprised of unit cells; the two columns are spaced apart; a regulator feature 501 between the two columns.

Figure 5A is a schematic top down view. Figure 5B is a photographic top down views of an embodiment of a chromeless PSM with a dense array contact can be pattern with novel phase regulator features 501 added to regulate the intensity.

Phase regulator feature 501 is to create destructive interference at the background region where there is no contact hole feature present. The edge of the (unit cell(s) 512) cross legs will interfere with the nearest edge of the phase feature 501. The width of the phase regulator feature is between 1 to 2 times the width of the cross feature (unit cell) used. It is placed with a spacing of at least 0.5 times the width of the (unit cell)

cross feature used and more preferably about 0.5 time the width of the center section of the unit cell. Strips of phase feature 501 can be used at spacing of the cross feature width for large background region. Else a chrome feature could be used to cover the background region.

Fig. 6 shows the Intensity across section (white line) in Fig. 5B. Using the illustrated illumination condition, sub-wavelength contact hole with dimension of about 0.107 μm can be patterned using 248 nm-wavelength source photolithography with this embodiment.

F. example chromeless mask with a column of misaligned contact holes

Fig. 7A is an top down view of a chromeless mask that shows a column 715 of misaligned contact holes 716A. Figure 7A shows aligned contact holes columns 717 of aligned (simulated) contact holes 716. Fig. 7B is an image of a chromeless mask that shows a misaligned contact hole. In normal circuit layout, not all holes are neatly arranged in array. In some instance, misalignment/skewing of a block of array of hole can occur. This embodiment can also handle such cases using the same cross shape approach. Figures 7A and 7B show the embodiments "regulator phase features" 701 and 702 added to achieve the correct contact hole pattern.

Figure 7A shows at least two columns comprised of unit cells; the two columns are spaced apart and mis-aligned in an x or y direction; at least a regulator feature between the two columns.

G. contact pattern with "regulator phase feature"

Fig. 8A shows top down view of a mask with first phase shift regions comprised of unit cells 801 in a random contact pattern with "regulator phase feature" 801 added to regulate the intensity. Figure 8B is a top down image of a mask with first phase shift regions comprised of unit cells in a random (simulated) Contact hole 816 pattern with "regulator phase feature" 801 added to regulate the intensity. The **BLACK** background is 180 deg phase shifted quartz, all the Grey blocks are 0 deg phase shifted quartz "phase features". The **WHITE** features are the simulated contact hole opening. They appeared displaced from the contact location and vary in sizes, as no proximity correction is done with this illustration.

Figure 8A shows the first region comprised of a double cell 822 comprised of at least two unit cells are joined and at least a first separate unit cell 812. The double cell 822 and the first unit cell 812 are separated by at least a regulator feature (814 or 801)

H. method to use the mask to expose a wafer

FIG. 9 pictorially illustrates an optical system 150 that uses a chromeless phase shift mask of an embodiment of the present invention. Generally, illumination source 155 is a lamp which emits commonly used frequencies, such as i -line (365 nanometers). However, other sources of illumination can be used, such as excimer laser with wavelength of 248nm, 193nm and 157nm . Arrows 151 illustrate illumination that is directed from illumination source 155 towards a chromeless phase shift mask 152 which can be mask 10. The illumination, that is depicted by arrows 151, then passes through chromeless phase shift mask 152, where the illumination wave form changes. Arrows 153 illustrate the effective illumination after passing through chromeless phase shift mask 152. Illumination depicted by arrows 153 falls on a lens 154. Numerical aperture of lens 154, generally, ranges between values of 0.5 to 0.85. However, it should be understood that numerical aperture is a physical attribute of the lens optics, and numerical aperture will improve or approach a theoretical limit as lens optics improves, e.g., numerical aperture will approach 1.0. With immersion lithography the numerical aperture can be up to 1.44, depending on the refractive index of the medium. Typically, lens 154 is a reduction lens which reduces an image that is made by phase shift mask 152. This reduced image is projected onto a surface of a semiconductor substrate 158. Arrows 157 represent the projection of the reduced image from lens 154 to semiconductor substrate 158.

I. non-limiting embodiments

In the above description numerous specific details are set forth such as flow rates, pressure settings, thicknesses, etc., in order to provide a more thorough understanding of the present invention. It will be obvious, however, to one skilled in the art that the present invention may be practiced without these details. In other instances, well known process have not been described in detail in order to not unnecessarily obscure the present invention.

Although this invention has been described relative to specific insulating materials, conductive materials and apparatuses for depositing and etching these materials, it is not limited to the specific materials or apparatuses but only to their specific characteristics, such as conformal and nonconformal, and capabilities, such as depositing and etching, and other materials and apparatus can be substituted as is well understood by those skilled in the microelectronics arts after appreciating the present invention

Unless explicitly stated otherwise, each numerical value and range should be interpreted as being approximate as if the word about or approximately preceded the value of the value or range.

Given the variety of embodiments of the present invention just described, the above description and illustrations show not be taken as limiting the scope of the present invention defined by the claims.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the invention. It is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

1. A phase shift mask comprising:

a mask comprised of a first phase shift region and a second phase shift region; said first phase shift region and said second phase shift region are about 180 degrees out of phase;

said first phase shift region is comprised of at least a unit cell; said unit cell is comprised of (a) a center section and (b) at least three rectangular sections extending outwards from said center section; said center section has a rectangular shape;

said second phase shift region is adjacent to said first region;

the unit cell has a shape that when light passes through said mask, the destructive interference between said first phase shift region and a second phase shift region creates a contact hole pattern.

2. The phase shift mask of claim 1 wherein the center section is centered in the area where a via hole pattern is desired to be formed.

3. The phase shift mask of claim 1 wherein said first phase shift region has an orthogonal cross shape with said center section and four rectangular sections outwards extending from the center section.

4. The phase shift mask of claim 1 wherein said unit cell has an orthogonal cross shape with a square shaped center section and four rectangular sections outwardly orthogonally extending from the square center section.

5. The phase shift mask of claim 1 wherein said unit cell has an orthogonal cross shape with a square shaped center section and four square shaped rectangular sections outwards extending from the square center section; the center section and the rectangular sections have the same length sides.

6. The phase shift mask of claim 1 wherein said phase shift mask is a chromeless phase shift mask.

7. The phase shift mask of claim 1 wherein said rectangular sections have a minimum length between 70 and 200 % of the width of the center section.

8. The phase shift mask of claim 1 which further comprises a plurality of first regions arranged in a row and column formation whereby contact hole are formed in rows or column under the center sections.

9. The phase shift mask of claim 1 which further comprises a plurality of first regions arranged in a row and column formation whereby contact hole are formed in rows or column under the center sections.

10. The phase shift mask of claim 1 wherein said first phase shift region has a 180 degree shift and a second phase shift region has a zero degree shift.

11. The phase shift mask of claim 1 wherein said first phase shift region has a 0 degree shift and a second phase shift region has a 180 degree shift.

12. The phase shift mask of claim 1 wherein mask is thinner in said first phase shift region than in said second phase shift region.

13. The phase shift mask of claim 1 wherein said mask is comprised of a first area for defining contact holes and a second area for defining lines; said first phase shift regions and said second phase shift regions are in said first area; said second area does contain said unit cells.

14. The phase shift mask of claim 1 wherein over 90% of the area of the mask is comprised of said first phase shift regions and said second phase shift regions for forming contact hole patterns.

15. The phase shift mask of claim 1 which further includes a regulator feature having the same phase shift as the first region; said regulator features positioned to create destructive interference in the background region.

16. The phase shift mask of claim 1 which further includes a regulator feature having about the same phase shift as the first phase shift region; the regulator feature is positioned so that the edge of first phase shift region will interfere with the nearest edge of the regulator feature; the regulator feature has a width between 1 to 2 times the width of the said center section; the regulator feature is positioned with a spacing of at least 0.5 times the width of the center section.

17. The phase shift mask of claim 1 wherein shows at least two columns comprised of unit cells; the two columns are spaced apart; at least a regulator feature between the two columns.

18. The phase shift mask of claim 1 wherein at least two columns comprised of unit cells; the two columns are spaced apart and mis-aligned in an x or y direction; at least a regulator feature between the two columns.

19. The phase shift mask of claim 1 which includes said first region comprised of a double cell comprised of at least two unit cells are joined and at least a first separate unit cell; the double cell and the first unit cell are separated by at least a regulator feature.

20. A chromeless phase shift mask comprising:

a mask comprised of a first phase shift region and a second phase shift region; said first phase shift region and said second phase shift region are about 180 degrees out of phase;

said first phase shift region is comprised of at least a unit cell; said unit cell is comprised of (1) an center section and (2) at least three rectangular sections extending outwards from said center section; said center section and said rectangular sections have a square shape;

said second phase shift region is adjacent to said first phase shift region;

whereby when light passes through said mask, the destructive

interference between said first phase shift region and a second phase shift region creates a contact hole pattern.

21. The chromeless phase shift mask of claim 20 wherein the center section is centered in the area where a via hole pattern is desired to be formed.

22. The chromeless phase shift mask of claim 20 wherein said unit cell has an orthogonal cross shape with a square shaped center section and four square shaped rectangular sections outwards extending from the square center section; the center section and the rectangular sections have about the same length sides.

23. The chromeless phase shift mask of claim 20 which further comprises a plurality of unit cells arranged in a row and column formation whereby contact holes are formed in rows or column under the center sections.

24. A chromeless phase shift mask comprising:

a mask comprised of a first phase shift region and a second phase shift region; said first phase shift region and said second phase shift region are about 180 degrees out of phase;

said first phase shift region is comprised of unit cells, each unit cell comprised of (1) an center section and (2) four rectangular sections extending outwards from said center section; said center section has a rectangular shape; said unit cells are connected by adjacent rectangular sections to form a plurality of rows and columns;

said second phase shift region is adjacent to said first region;

whereby when light passes through said mask, the destructive interference between said first phase shift region and a second phase shift region creates a contact hole pattern.

25. The chromeless phase shift mask of claim 24 wherein said unit cell has an orthogonal cross shape with a square shaped center section and four square shaped rectangular sections outwards extending from the square center section; the center section and the rectangular sections have the same length sides.

26. The chromeless phase shift mask of claim 24 wherein over 90% of the area of the mask is comprised of said first phase shift regions and said second phase shift regions for forming contact hole patterns.

27. The chromeless phase shift mask of claim 24 which further includes a regulator feature having the same phase shift as the first region; said regulator features positioned to create destructive interference in the background region.

28. The chromeless phase shift mask of claim 24 which further includes a regulator feature having about the same phase shift as the first phase shift region; the regulator feature is positioned so that the edge of first phase shift region will interfere with the nearest edge of the regulator feature; the regulator feature has a width between 1 to 2

times the width of the said center section; the regulator feature is positioned with a spacing of at least 0.5 times the width of the center section.

29. A method for projecting patterns onto a semiconductor substrate comprising:

providing an illumination source;

providing a phase shift mask that has a first phase shift region and a second phase shift region; said first phase shift region and said second phase shift region are about 180 degree out of phase;

said first region comprised of a unit cell; said unit cell comprised of (a) a center section and (b) at least three rectangular sections extending outwards from said center section; said center section has a rectangular shape; the unit cell has a shape that when light passes through said mask, the destructive interference between said first phase shift region and a second phase shift region creates a contact hole pattern;

projecting light from said illumination source thru said phase shift mask onto a semiconductor substrate.

30. The method of claim 29 wherein the dimension width of the rectangular sections are less than half the illuminating wavelength and low inner and outer sigma factors are used.

31. A method for projecting patterns onto a semiconductor substrate comprising:

providing an illumination source;

providing a phase shift mask that has a first phase shift region and a second phase shift region; said first phase shift region and said second phase shift region are about 180 degree out of phase;

said first region comprised of a unit cell; said unit cell comprised of (a) a center section and (b) at least three rectangular sections extending outwards from said center section; said center section has a rectangular shape; the unit cell has a shape that when light passes through said mask, the destructive interference between said first phase shift region and a second phase shift region creates a contact hole pattern;

providing a lens system that receives the pattern that is projected from the phase shift mask;

reducing the pattern in the lens system; and

projecting the reduced pattern onto a semiconductor substrate.

32. The method of claim 31 wherein said illumination source is an off-axis type illumination source.

33. The method of claim 31 wherein said illumination source is a quasar type illumination source.

34. The method of claim 31 wherein the reduced pattern is projected onto a photosensitive layer over a semiconductor substrate.

35. The method of claim 31 wherein said semiconductor substrate comprises a photoresist layer and said reduced pattern forms a contact hole pattern on said photoresist layer.

36. The method of claim 31 wherein said semiconductor substrate comprises a photoresist layer and said reduced pattern forms a row or a column of contact hole patterns on said photoresist layer.

37. The method of claim 31 wherein said first phase shift region has a 180 degree shift and a second phase shift region has a zero degree shift.

38. The method of claim 31 wherein said first phase shift region has a 0 degree shift and a second phase shift region has a 180 degree shift.

39. The method of claim 31 wherein said first phase shift region has an orthogonal cross shape with said center section and four rectangular sections outwards extending from the center section.

40. The method of claim 31 wherein said unit cell has an orthogonal cross shape with a center section and four rectangular sections outwards extending from the rectangular center section.

41. The method of claim 31 wherein said unit cell has an orthogonal cross shape with a square shaped center section and four square shaped rectangular sections outwards

extending from the square center section; the center section and the rectangular sections have the same length sides.

42. The method of claim 31 wherein said phase shift mask is a chromeless phase shift mask.

43. The method of claim 31 wherein said rectangular sections have a minimum length between 70 and 200 % of the width of the center section.

44. The method of claim 31 wherein said first region comprises a plurality of unit cells arranged in a row and column formation whereby contact holes are formed in rows or column under the center sections.

45. The method of claim 31 wherein further comprises a plurality of first regions arranged in a row and column formation whereby contact holes are formed in rows and column under the center sections.

46. A method for forming a phase shift mask for use in semiconductor device fabrication; comprising:

providing a mask;

forming masking layer over said mask; said masking layer has a pattern which can be used to etch said mask to form at least a first phase shift region and a second

phase shift region which provides a phase shift for light passing there through; said first phase shift region having a cross shape;

etch said mask through said masking layer to form said first phase shift region and said second phase shift region; said first phase shift region is comprised of at least a unit cell; said unit cell is comprised of (a) a center section and (b) at least three rectangular sections extending outwards from said center section; said center section has a rectangular shape;

the unit cell has a shape that when light passes through said mask, the destructive interference between said first phase shift region and a second phase shift region creates a contact hole pattern.

47. The method of claim 46 wherein said first region is a 0 degree phase shift region and said second region is a 180 degree phase shift region.

48. The method of claim 46 wherein said first phase shift region is a 180 degree phase shift region and said second region is a 0 degree phase shift region.

49. The method of claim 46 wherein the etch forms a trench in said first phase shift region; said first phase shift region is a 180 degree phase shift region and said second region is a 0 degree phase shift region.

50. The method of claim 46 wherein the etch forms a trench in said second phase shift region; said first region is a 0 degree phase shift region and said second region is a 180 degree phase shift region.

51. The method of claim 46 wherein said masking layer is comprised of two or more layers; said masking layer is comprised of a chrome layer and an overlying resist layer.

52. The method of claim 46 wherein said mask is comprised of quartz, silica glass and borosilicate glass.

53. The method of claim 46 wherein said mask which further includes a regulator feature having about the same phase shift as the first phase shift region; the regulator feature is positioned so that the edge of first phase shift region will interfere with the nearest edge of the regulator feature; the regulator feature has a width between 1 to 2 times the width of the said center section; the regulator feature is positioned with a spacing of at least 0.5 times the width of the center section.

54. The method of claim 46 wherein said mask has at least two columns comprised of unit cells; the two columns are spaced apart; at least a regulator feature between the two columns.

55. The method of claim 46 wherein said mask has at least two columns comprised of unit cells; the two columns are spaced apart and mis-aligned in an x or y direction; at least a regulator feature between the two columns.

56. The method of claim 46 wherein said first region comprised of a double cell comprised of at least two unit cells are joined and at least a first separate unit cell; the double cell and the first unit cell are separated by at least a regulator feature.