ABSTRACT

The embodiments of the invention relate to a method and apparatus for measuring the etch depth between etching for an alternate phase shift photomask in a semiconductor photomask processing system. The apparatus for measuring the etch depth of a substrate in an etch processing system comprises a measurement cell coupled to a mainframe of the etch processing system, and an etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell allows light beams to pass between the etch depth measurement tool and the substrate. The embodiments of the invention also relate to the method of preparing an alternate phase shift mask by partially etching the quartz substrate to an initial etch depth, followed by measuring the etch depth with an integrated measurement tool. The substrate is then etched and measured repeatedly until the targeted etch depth has been reached.
INTEGRATED METROLOGY CHAMBER FOR TRANSparent SUBSTRATES

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to the fabrication of photomasks useful in the manufacture of integrated circuits.

[0003] 2. Background of the Related Art

[0004] Photolithography techniques use light patterns and photore sist materials deposited on a substrate surface to develop precise patterns on the substrate surface prior to the etching process. In conventional photolithographic processes, a photore sist is applied on the layer to be etched, and the features to be etched in the layer, such as contacts, vias, or interconnects, are defined by exposing the photore sist to a pattern of light through a photolithographic photomask which corresponds to the desired configuration of features. A light source emitting ultraviolet (UV) light, for example, may be used to expose the photore sist to alter the composition of the photore sist. Generally, the exposed photore sist material is removed by a chemical process to expose the underlying substrate material. The exposed underlying substrate material is then etched to form the features in the substrate surface while the retained photore sist material remains as a protective coating for the unexposed underlying substrate material. Since photomasks are used repeatedly to create device patterns, quality control of photomask manufacturing is very important.

[0005] Photolithographic photomasks, or reticles, include binary (or conventional) photomasks and phase shift masks (PSM), which could be used in sub 0.13 μm technology. Binary (or conventional) masks typically include a substrate made of an optically transparent silicon based material, such as quartz (i.e., silicon dioxide, SiO2), having an opaque light-shielding layer of metal, such as chromium, on the surface of the substrate. Phase shift masks improve the resolution of the aerial image by phase shifting. The principle of phase shift mask is described in P. 230-234 of Plummer, Deal and Griffin, “Silicon VLSI Technology Fundamentals, Practice and Modeling”, 2000 by Prentice Hall, Inc. Phase shift masks could be either attenuated phase shift or alternate phase shift mask. An attenuated phase shift mask typically includes a substrate made of an optically transparent silicon based material, such as quartz, having a translucent layer of material, such as molybdenum silicide (MoSi) or molybdenum silicon oxyride (MoSiON), on top. When the photolithographic light, e.g. at 248 nm wavelength, shines through the patterned mask surface covered by the translucent layer, the transmission (e.g. 6% at 248 nm wavelength) and the thickness of the translucent layer create a phase shift, e.g., 180°, compared to the photolithographic light that shines through the patterned mask surface not covered by the translucent layer. An alternate phase shift mask typically includes a substrate made of an optically transparent silicon based material, such as quartz, which is etched to a certain depth to create a phase shift with the un-etched transparent substrate when the photolithographic light shines through the patterned mask. It also has a chrome layer with the same pattern as the quartz. There is another type of phase shift mask, the Chromeless Phase Lithography (CPL) Mask, which has the chrome layer removed.

[0006] Photomasks allow light to pass therethrough in a precise pattern onto the substrate surface. The metal layer on the photomask substrate is patterned to correspond to the features to be transferred to the substrate. The patterns on the photomask could be 1x, 2x or 4x the size of that which will be patterned on the wafer substrate. Typically, a photolithographic stepper reduces the image of the photomask by 4x and prints the pattern on the photore sist covering the wafer substrate. Conventional photomasks are fabricated by first depositing one to two thin layers of metal, which could either be opaque or translucent depending on the types of masks being formed, on a substrate comprising an optically transparent silicon based material, such as quartz, and depositing a photoresist layer on substrate. The photomask is then patterned using conventional laser or electron beam patterning equipment to define the critical dimensions in the photore sist. The top metal layer, typically opaque, is then etched to remove the metal material not protected by the patterned photoresist, thereby exposing the underlying silicon based material. For a binary mask, the photomask is formed after the metal etching step. While for attenuate and alternate phase shift masks, additional photoresist patterning and etching of transparent substrate or translucent metal layer are needed to form the photomask.

[0007] Since photomasks are used repeatedly to create device patterns, the accuracy and tight distribution of the critical dimensions, and the phase shift angle and its uniformity across the substrate are key requirements for binary and phase shift photomasks. For alternate phase shift mask, the phase angle is affected by the depth of the transparent material, such as quartz. Since precise control of the phase shift is very important, the etching of the transparent material, such as quartz, is often accomplished after multiple etching processes and multiple etch depth measurements to ensure phase shift of the mask is within control limit. If the etch depth measurement is performed in a system not integrated with the etching system, process cycle time could be very long and the approach could increase the total defect counts.

[0008] Therefore, there remains a need in the art for an integrated metrology tool to measure etch depth (or phase shift angle) of photomask in a semiconductor photomask processing system.

SUMMARY OF THE INVENTION

[0009] The embodiments of the invention relates to a method and apparatus for measuring the etch depth between etching for an alternate phase shift photomask in a semiconductor photomask processing system. In one embodiment, an apparatus for measuring the etch depth of a substrate in an etch processing system comprises a measurement cell coupled to a mainframe of the etch processing system, and an etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell allows light beams to pass between the etch depth measurement tool and the substrate.

[0010] In another embodiment, an apparatus for measuring the etch depth of a substrate in an etch processing system comprises a measurement cell coupled to a mainframe of the etch processing system, an etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell allows light
beams to pass between the etch depth measurement tool and the substrate, and a substrate transfer robot placed in the mainframe to transfer substrate to the measurement cell, wherein the substrate transfer robot having a robot blade to hold a substrate and the robot blade having an opening to allow light beam to be shined on the substrate backside.

[0011] In another embodiment, a method of preparing an alternate phase shift mask comprises a) placing a substrate in an etch processing chamber, wherein the substrate is made of an optically transparent material and has a first patterned opaque layer and a second patterned photoresist layer on the optically transparent material, b) etching the quartz to a first etch depth, c) transferring the substrate to a measurement cell coupled to a substrate transfer chamber, d) measuring the etch depth from the substrate backside by a etch depth measurement tool coupled to the bottom of the measurement cell to determine the etch time of the etch depth, e) placing the substrate back to the etch processing chamber, f) etching for the etch time determined by the etch depth measurement, g) transferring the substrate to the measurement cell, h) measuring the etch depth from the substrate backside by a etch depth measurement tool coupled to the bottom of the measurement cell to determine the etch time of the etch depth and i) repeating “e” to “i” until a targeted etch depth has been reached.

[0012] In another embodiment, an apparatus for measuring the etch depth of a substrate in an etch processing system comprises a measurement cell coupled to a mainframe of the etch processing system, a etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell that allows light beams to pass between the etch depth measurement tool and the substrate, a CD measurement tool coupled to the top of the measurement cell, wherein an opening at the top of the measurement cell allows light beams to pass between the CD measurement tool and the substrate, and a substrate transfer robot placed in the mainframe to transfer the substrate to the measurement cell, wherein the substrate transfer robot having a robot blade to hold the substrate and the robot blade having an opening to allow light beam to be shined on the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] So that the manner in which the above recited aspects of the invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

[0014] It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0015] FIGS. 1A-1F are cross-sectional views showing an etching sequence for processing an alternate phase shift photomask.

[0016] FIG. 2 is a block diagram of key components of an integrated etch system.

[0017] FIG. 3 is a diagram of one embodiment of an integrated etch system.

[0018] FIG. 4 is a schematic diagram showing a substrate, a measurement tool, and the impeding and reflected light beams between the substrate and the measurement tool.

[0019] FIG. 5A shows a schematic drawing of the end of the robot arm with a robot blade.

[0020] FIG. 5B shows a schematic drawing of a measurement cell and an etch depth metrology tool.

[0021] FIG. 5C shows a schematic drawing of a measurement cell with an etch depth measurement tool and a CD measurement tool.

DETAILED DESCRIPTION

[0022] For convenience, the present invention is described herein primarily with reference to the etching of alternate phase shift masks. The concept of the invention can be used for etching other types of photomasks.

[0023] FIGS. 1A-1F illustrate an exemplary process flow of creating an alternate phase shift mask. A substrate 100 is introduced into a processing chamber. The substrate 100 (or reticle) comprises a base material of an optically transparent material 110, for example, optical quality quartz, calcium fluoride, alumina, sapphire, or combinations thereof, typically made of optical quality quartz material. An opaque (or light-shielding) metal layer 120, such as chromium, is deposited on the optically transparent material 110 as shown in FIG. 1A. The light-shielding metal layer, such as chromium layer, may be deposited by conventional methods known in the art, such as by physical vapor deposition (PVD) or chemical vapor deposition (CVD) techniques. The light-shielding (or opaque) metal layer 120 is typically deposited to a thickness between about 50 and about 150 nanometers (nm) thick, however, the depth of the layer may change based upon the requirements of the manufacturer and the composition of the materials of the substrate or metal layer.

[0024] Referring to FIG. 1B, the substrate 100 is then transferred to another processing chamber where a layer of resist material 130, such as “RISTON” resist, manufactured by Du Pont de Nemours Chemical Company, is deposited upon the opaque metal layer 120 to a thickness between about 200 and 600 nm thick. The resist material 130 is then pattern-etched using conventional laser or electron beam patterning equipment to form a first opening 125 which is used to define the dimensions of the second opening 135 to be formed in the opaque metal layer 120.

[0025] The substrate 100 is then transferred to an etch system, such as the Tetra I™ photomask etch chamber in the Tetra I™ photomask etch system described in FIG. 3 (described below), manufactured by Applied Materials, Inc., of Santa Clara, Calif. Aspects of the invention will be described below in reference to an inductively coupled plasma etch chamber that includes the Tetra I™ photomask etch chamber. However, other process chambers may be used to perform the processes of the invention, including, for example, capacitively coupled parallel plate chambers and magnetically enhanced ion etch chambers as well as inductively coupled plasma etch chambers of different designs.

[0026] The light-shielding metal layer 120 is etched using metal etching techniques known in the art or by new metal etching techniques that may be developed to form the
second opening 135 which expose the underlying transparent material 110 as shown in FIG. 1C.

[0027] Referring to FIGS. 1A-1C, after etching of the light-shielding metal layer 120 is completed, the substrate 100 is transferred to a processing chamber, where the remaining resist material 130 is usually removed from the substrate 100. The resist removal could be accomplished by an oxygen plasma process, or other resist removal technique known in the art.

[0028] Referring to FIGS. 1D-1F, the substrate 100 may be further processed by etching the transparent material 110. In etching the transparent material 110, the resist material 130 is removed and a second photoresist 140 is applied and patterned to expose the underlying transparent material 110 within the second opening 135. The resist material is deposited to a depth between about 200 nm and 600 nm thick, but may be of any thickness and may also be of the same thickness as the depth of the features to be etched in the transparent material 110 to form the photomask. The photoresist 140 is then etched to form a third opening 145 in the resist layer 140 and the metal layer 120. The patterned substrate 100 is then transferred to an etch chamber, such as the Tetra I™ photomask etch system described in FIG. 3 (described below), for plasma etching the transparent mate-

[0029] Since the etch depth 175 in the transparent material 110 determines the phase shift angle, the precise control of the etch depth 175 is very critical. For example, in order to achieve a phase shift angle of 180° for alternate phase shift mask for KrF excimer laser lithography, the quartz etch depth is about 2400 Å. To avoid over-etch, the initial etching only etches partially, such as 50%-75%, of the targeted etch depth. The etch depth 175 (or phase shift angle) of the etched substrate 100 is measured at an integrated metrology tool. The substrate 100 subsequently undergoes additional etch and etch depth measurement until the targeted etch depth 175 is reached. Performing etch depth measurement in an integrated metrology tool has the advantage of avoiding the need of transferring the substrate to an area not under the same vacuum environment. Transferring substrates to an area not under the same vacuum environment repeatedly is time consuming, due to breaking vacuum, and could result in particle generation, which is very undesirable for photomask making.

[0030] After the targeted etch depth 175 is reached, the second resist material 140 is then removed to form a patterned substrate surface 155. An alternate phase shift mask with a patterned substrate surface 165 is formed after the metal layer 120 is removed. Occasionally, dry etching in an etch chamber only etches to reach a percentage of the final etch depth and the final step is a wet etch step, since wet etch could reduce the surface roughness and could reduce the micro-trenching on the photomask substrate.

[0031] Alternate phase shift photomask etching processes for light-shielding layers such as chromium, and optically transparent materials, such as quartz, include dry etching processes. Plasmas of etching gases, such as chlorine-containing gases (e.g., Cl₂) or fluorine-containing gases (e.g., SF₆ or CF₃), oxidizing gases, such as oxygen, and inert gases, such as helium, could be used to etch the metal layers formed on the substrate or the substrate itself. Details of etching chemistries that are used to etch light-shielding layer for this application have been disclosed in commonly assigned U.S. patent application Ser. No. 10/418,795, titled “Process For Etching Photomasks”, and filed on Apr. 18, 2003 and U.S. patent application Ser. No. 10/235,223, titled “Methods And Apparatus For Etching Metal Layers on Substrates”, and filed on Sep. 4, 2002. Etching of the silicon based material of the substrate is described in commonly assigned U.S. Pat. No. 6,534,417, titled “Method and Apparatus For Etching Photomasks”, issued Mar. 18, 2003 and U.S. Pat. No. 6,391,790, also titled “Method and Apparatus For Etching Photomasks”, issued May 21, 2002. The disclosures of all of these applications are incorporated herein by reference to the extent not inconsistent with aspects of the invention.

[0032] Etch depth metrology techniques as employed by the present invention are advanced process control (APC) enablers. It detects the reflection of a substrate over a broad wavelength range. The detected wavelength spectra are fitted to a theoretical model to enable the characterization of the film. The metrology can be used to measure transparency, etch depth, film thickness and phase shift angle at multiple locations on the substrate. An example of the etch depth (or phase shift angle) measuring tool is the n&k Analyzer 1512RT available from n&k Technology, Inc. of Santa Clara, Calif.

[0033] An exemplary embodiment of the present invention is implemented using a etch depth measuring tool in a processing system 200, as shown in FIG. 2, comprising a measuring tool 210, e.g., a etch depth (or phase shift angle) measurement tool. Processing system 200 further comprises a processor 220, which performs the analysis disclosed herein electronically, and a monitor 230 for displaying results of the analyses of processor 220. Processor 220 can be in communication with a memory device 240, such as a semiconductor memory, and a computer software-implement-

[0034] An example of an etch system that is integrated with an ex-situ metrology tool with the capability of measuring etch depth (or phase shift angle) is shown in FIG. 3. The system, Tetra I™, comprises a chamber or “mainframe” 301, such as the Centura™ processing system available from Applied Materials, Inc. of Santa Clara, Calif., for mounting a plurality of processing chambers, e.g., Tetra I™ photomask reactors (or chambers) 302, and one or more transfer chambers 303, also called “load locks”. In one embodiment of the present invention, three etch reactors 302 and one metrology tool 306 are mounted to the mainframe 301. The metrology tool 306 can be placed under the same vacuum as the mainframe 301, since there is an opening (not shown) between the mainframe 301 and the metrology tool 306 to make them in fluid communication. In one exemplary embodiment, three etchers 302 are used for etching. A robot 304 is provided within the mainframe 301 for transferring wafers between the processing reactors 302, the transfer chambers 303, and an integrated metrology tool 306. The integrated metrology tool 306 can measure the etch depth (or phase shift angle). The transfer chambers 303 are connected to a factory interface 305, also known as a “mini environment”, which maintains a controlled environment. In one embodiment of the invention, the metrology (or measure-
ment) tool 306, mounted to the mainframe 301, has high-speed data collection and analysis capabilities. Cassette holders 308 are connected to the other end of the factory interface 305. A robot 307 is placed inside 305 to transfer substrate between cassette holders (308), and “load locks” (303).

[0035] The etch depth measurement tool 306 is mounted to the mainframe 301 to allow the etched substrate from the etch chamber 302 to be measured and be sent back to etch chamber 302 to be etched again. The etch and measurement process sequence could repeat several times until the targeted etch depth (or phase shift angle) is reached. Due to the nature of repeated etch and measurement to target etch depth of transparent material 110, it’s desirable to have the etch depth measurement tool (or phase shift angle measurement tool) mounted to the mainframe 301. Both mainframe 301 and the metrology tool 306 are under integrated vacuum environment and can avoid the need of transferring the substrate to an area not under vacuum, which could be time consuming due to additional substrate transport and breaking the vacuum. Repeated transferring substrate between processing areas that are under vacuum and not under vacuum is not only time consuming, but also particle generating.

[0036] In another embodiment of the invention, the metrology tool 306 is placed at the location of one of the transfer chambers 303. Placing the metrology tool 306 at the location of one of the transfer chambers 303 also has the advantage of avoiding the need of transferring the substrate to an area not under vacuum.

[0037] Since the substrate is transparent, the phase shift angle (or etch depth) can be measured by analyzing reflected light from the backside of the substrate, which does not require the removal of the opaque film 320 and the photosist film 340. Conventional phase shift angle measurement is performed from the substrate front side and requires the removal of the opaque film 320 and the photosist film 340 prior to phase shift angle measurement. The additional processing steps of removing films can cause particles or other processing defects, which are highly undesirable for photomask preparation. Besides, if the phase shift angle (or etch depth) is found to have not reached the target, the opaque film 320 and photosist film 340 would need to be re-deposited and re-patterned again to allow further etching of the transparent material 310, which could worsen the particles and other processing defects problems.

[0038] FIG. 4 shows a schematic drawing of the etch depth measurement tool (or phase shift angle measurement tool) 460, placed below the backside of a substrate 400. The substrate 400 has an etch depth 450 and also has an opaque film 410 and a photosist film 420 on the front side. On the back side of the substrate 400, there are incident light beams 430, 430' and 432', and reflected light beams 430', 431' and 432'. The light source of incident light beams could be from the measurement tool 460. The light source is preferably a broadband light source. Part of incident light beam 430, reflected light beam 430', is reflected from the interface between the substrate 400 and the environment 470. Reflected light beam 431' is reflected from the interface between the substrate etch interface 451 with the environment 470. Reflected light beam 432' is reflected from the interface between the opaque layer 410 and the substrate 400. The etch depth measurement tool collects reflected light beams over a range of substrate backside surface. By calculating the phase shift between the light beams such as 431' and 432', the etch depth 450 and the phase shift of the transparent substrate can be determined without removing the films on the front side, such as opaque film 410 and photosist film 420, of the substrate 400.

[0039] In one embodiment of the invention a robot arm 500, which is part of robot 304 of the mainframe 301 of FIG. 3, is designed to include a substrate holder 501. The substrate holder 501 has an opening that allows the incident light beams and reflected light beams on the substrate backside to pass through, as shown in FIG. 5A. FIG. 5A shows a schematic drawing of the end of the robot arm 500 that contains a robot blade 510, which has a substrate holder 501. The substrate holder 501 has an aperture 502 that is proportional to the size of the substrate. In one embodiment, the aperture 502 is about 4 inches by 4 inches for a 6 inches by 6 inches substrate. The size of the aperture 502 is smaller than the size of the substrate to allow the edge of the substrate to be supported by the substrate holder. In one embodiment, the thickness of the robot blade 510 is about ½ inch (1.02 cm). The size of the aperture 502 should be as large as possible to allow measurement data to be collected across large area on the substrate.

[0040] FIG. 5B shows the substrate 520 is placed inside the metrology tool 306 of FIG. 3. The metrology tool 306 comprises a measurement cell 550 and an etch depth measurement tool 460. The substrate is moved by the robot arm 500 to be over the measurement point. Underneath the measurement point 560 is a etch depth measurement tool 460. The etch depth measurement tool 460 comprises a broadband light source (not shown), which emits light to the backside of the substrate 520. The robot blade 510 is attached to the robot arm 500 and it has roll and tilt function to allow the surface of substrate 520 to be perpendicular to the measurement light beam emitted from the measurement tool 460. The etch depth measurement tool 460 collects the reflected light from the substrate backside. The data generated from the reflected light are analyzed to calculate the etch depth by the measurement tool 460. In one embodiment of the invention, there is a calibration pad 580, which contains an etch depth measurement calibration device, such as a piece of bare silicon, on the robot blade 510. In one embodiment, the size of the calibration pad is about ½ inch (1.27 cm) in diameter. Periodically, the calibration pad 580 can be moved to be above the measurement point 560 to calibrate the measurement tool 460. A native oxide layer is typically present on the bare silicon surface. The presence of the native oxide layer is important for calibration of some measurement tools. In one embodiment, the measurement point 560 is a circular opening with a diameter, such as about 1 inch (2.54 cm).

[0041] The advantage of backside etch depth measurement is that the measurement does not require the removal of the front side films. Therefore the substrate can be partially etched first, then be measured to target the next etch amount. The substrate can then be re-etched and re-measured multiple times with out the need of moving the substrate to another system to perform photosist layer stripping. For alternate phase shift mask making, the precise control of the phase shift angle (or etch depth) is very critical. Since the substrate is transparent and the phase shift
angle can be measured from the backside, the processing time can be greatly reduced, since the fine tuning of the substrate etch does not require removal of the substrate from the etching module.

[0042] In addition to the mounted etch depth measurement tool 460 on the bottom of the measurement cell 306, in one embodiment of the invention, a CD measurement tool 590 is mounted on top of the measurement cell 306 to collect critical dimension (CD) measurement data through an opening 595 (as shown in FIG. 5C). The collected CD measurement data can be fed forward and backward to the etcher to adjust the substrate etch recipe. Since CD measurement has more stringent measurement location requirement than etch depth measurement, the robot arm 500, which is part of robot 304 in the mainframe 301, might not have sufficient precision control as required. The CD measurement tool 590 could include a moving device (not shown), to allow a measuring device (not shown) in the CD measurement tool to be moved over to a particular measurement location above the substrate 520. The movement of the moving device is controlled by a controller to control its precise movement. FIG. 5C shows a schematic drawing of metrology cell 306 with a top CD measurement tool 590 and a bottom etch depth measurement tool 460.

[0043] The CD measurement tool 590 can employ OCD (optical critical dimension) metrology techniques. OCD metrology techniques are advanced process control (APC) enablers. For example, normal incidence spectrscopic OCD metrology systems provide detailed line profiles not possible with in-line non-destructive SEMs. For photomasks, the OCD metrology can operate under reflective mode (utilizing reflected light) or transmission mode (utilizing transmitted light). The compact size and speed of OCD technology enables the measurement system of the present invention to be fully integrated into a process tool, such as Applied Materials’ Tetra II™ or DPS® II etch system. When combined with APC software, this provides a complete, feed-forward solution for wafer-to-wafer closed loop control. An example of the optical CD measuring tool is the Nano OCD 9000 available from Nanometrics of Milpitas, Calif., or an optical imager as disclosed in U.S. Pat. No. 5,963,329. The optical CD measuring tool can utilize scatterometry, reflectometry or transmission ellipsometry techniques.

[0044] While the foregoing is directed to the preferred aspects of the invention, other and further aspects of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. An apparatus for measuring the etch depth of a substrate in an etch processing system, comprising:
   a measurement cell coupled to a mainframe of the etch processing system; and
   an etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell allows light beams to pass between the etch depth measurement tool and the substrate.

2. The apparatus of claim 1, further comprising:
   a substrate transfer robot placed in the mainframe to transfer the substrate to the measurement cell, wherein the substrate transfer robot having a robot blade to hold a substrate and the robot blade having an opening to allow light beam to be shined on the substrate backside.

3. The apparatus of claim 1, wherein the opening at the bottom of the measurement cell is circular.

4. The apparatus of claim 2, wherein the opening of the robot blade is a square.

5. The apparatus of claim 2, wherein the robot blade comprises a calibration pad used to calibrate the etch depth measurement tool.

6. The apparatus of claim 2, wherein the robot blade has roll and tilt function to position the surface of the substrate to be perpendicular to the light beam emitted from the etch depth measurement tool.

7. The apparatus of claim 1, wherein the measurement cell can be under vacuum.

8. The apparatus of claim 2, wherein the depth measurement tool is configured to test a substrate having an optically transparent layer.

9. An apparatus for measuring the etch depth of a substrate in an etch processing system, comprising:
   a measurement cell coupled to a mainframe of the etch processing system;
   an etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell allows light beams to pass between the etch depth measurement tool and the substrate; and
   a substrate transfer robot placed in the mainframe to transfer substrate to the measurement cell, wherein the substrate transfer robot having a robot blade to hold a substrate and the robot blade having an opening to allow light beam to be shined on the substrate backside.

10. The apparatus of claim 9, wherein the opening at the bottom of the measurement cell is circular.

11. The apparatus of claim 9, wherein the opening of the robot blade is a square.

12. The apparatus of claim 9, wherein the robot blade comprises a calibration pad used to calibrate the etch depth measurement tool.

13. The apparatus of claim 12, wherein the calibration pad comprises a bare silicon.

14. The apparatus of claim 9, wherein the robot blade has roll and tilt function to position the surface of the substrate to be perpendicular to the light beam emitted from the etch depth measurement tool.

15. The apparatus of claim 9, wherein the measurement cell can be under vacuum.

16. The apparatus of claim 9, wherein the depth measurement tool is configured to test a substrate having an optically transparent layer.

17. A method of preparing an alternate phase shift mask, comprising:
   a) placing a substrate in an etch processing chamber, wherein the substrate is made of an optically transparent material and has a first patterned opaque layer and a second patterned photore sist layer on the optically transparent material;
   b) etching the quartz to a first etch depth;
   c) transferring the substrate to a measurement cell coupled to a substrate transfer chamber;
d) measuring the etch depth from the substrate backside by a etch depth measurement tool coupled to the bottom of the measurement cell to determine the etch time of next etch;

e) placing the substrate back to the etch processing chamber;

f) etching for the etch time determined by the etch depth measurement;

g) transferring the substrate to the measurement cell;

h) measuring the etch depth from the substrate backside by an etch depth measurement tool coupled to the bottom of the measurement cell to determine the etch time of next etch; and

i) repeating “e” to “h” until a targeted etch depth has been reached.

18. The method of claim 17, wherein the etch depth measurement is performed by collecting reflected light beams from the backside of the substrate.

19. An apparatus for measuring the etch depth of a substrate in an etch processing system, comprising:

a measurement cell coupled to a mainframe of the etch processing system;

an etch depth measurement tool coupled to the bottom of the measurement cell, wherein an opening at the bottom of the measurement cell that allows light beams to pass between the etch depth measurement tool and the substrate;

a CD measurement tool coupled to the top of the measurement cell, wherein an opening at the top of the measurement cell allows light beams to pass between the CD measurement tool and the substrate; and

a substrate transfer robot placed in the mainframe to transfer the substrate to the measurement cell, wherein the substrate transfer robot having a robot blade to hold the substrate and the robot blade having an opening to allow light beam to be shined on the substrate.