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(54) **DEVICE FOR MEASURING THE PROFILE OF A METAL FILM SPUTTER DEPOSITION TARGET, AND SYSTEM AND METHOD EMPLOYING SAME**

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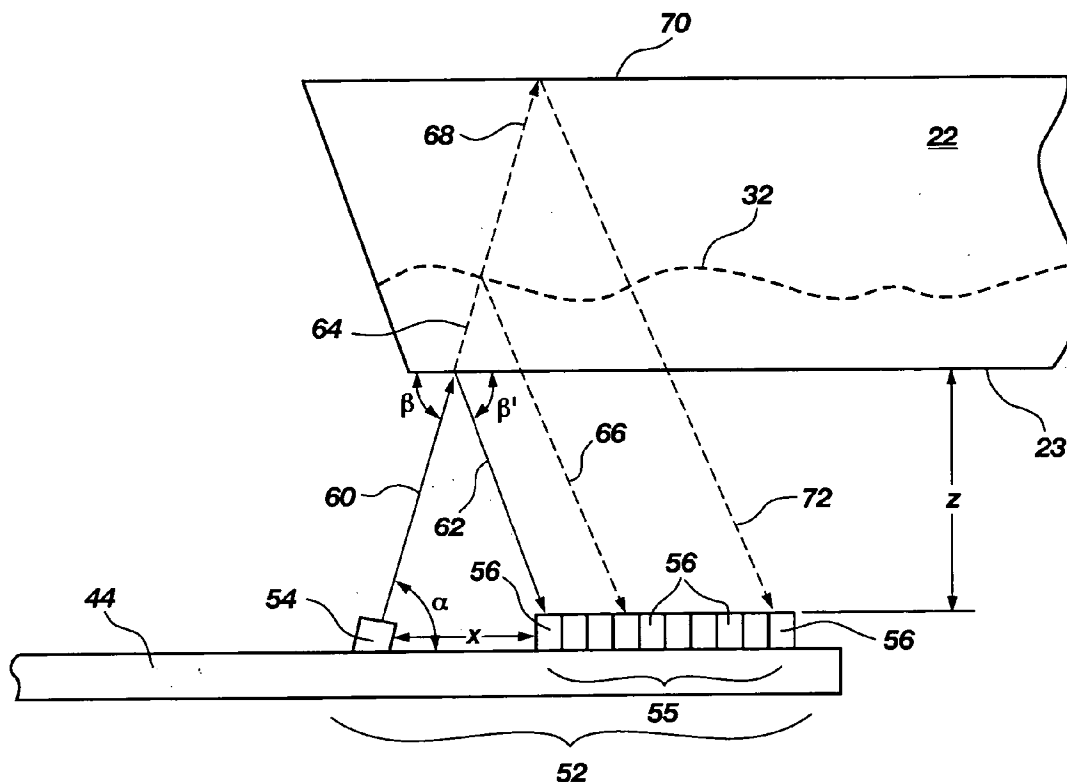
(57) **ABSTRACT**

An apparatus and method for measuring the erosion profile of a metallic target in a sputtering device are provided by inserting a thin sensor into a gap between the target and a substrate pedestal. The sensor is configured to emit an energy beam toward the surface of the target and to detect a reflection of the energy beam. The sensor may comprise a source element configured to emit a collimated light beam and a plurality of detectors arranged in a linear array. The sensor may also comprise optical fibers configured to reduce the size of the sensor. The detectors are positioned relative to the source element so that one of the detectors in the array will be illuminated by a reflection of the collimated light beam. The distance from the sensor to the target may be derived from the position of the detector illuminated by the reflected beam.



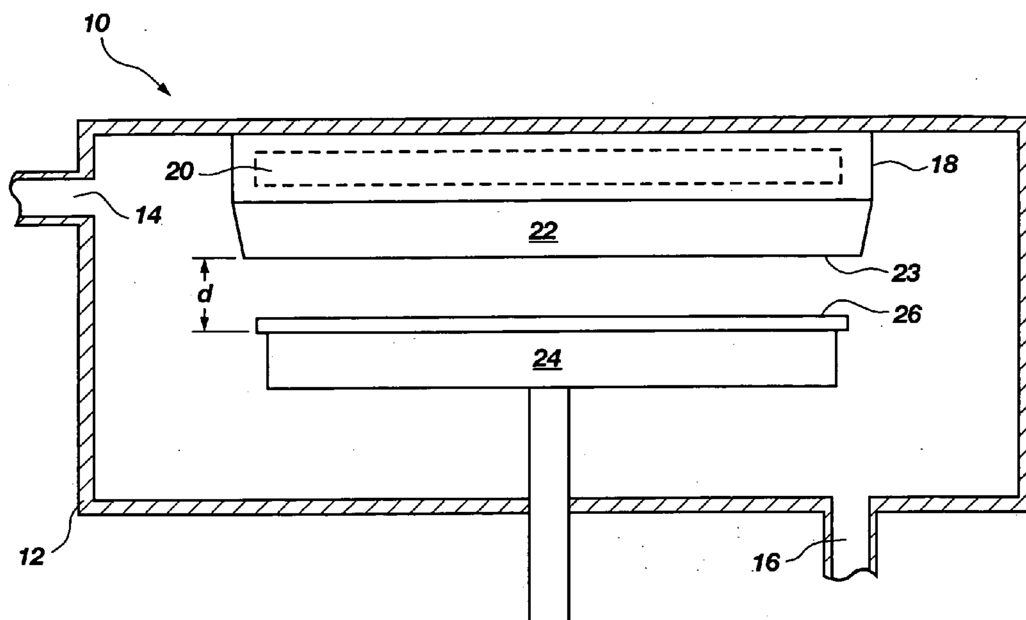


FIG. 1
(PRIOR ART)

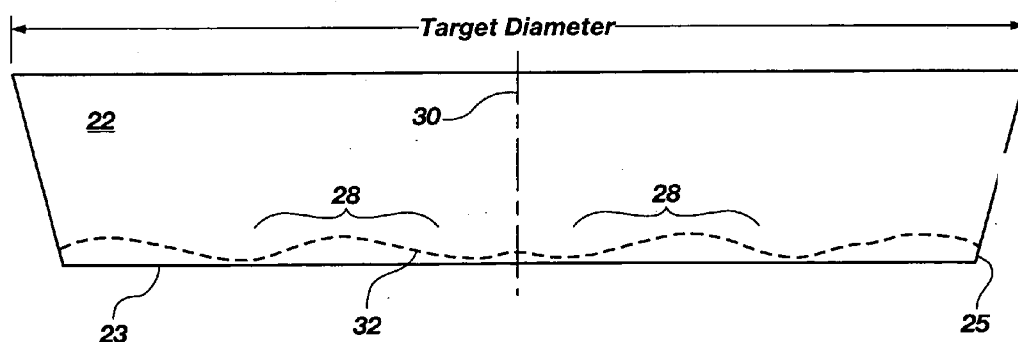


FIG. 2
(PRIOR ART)

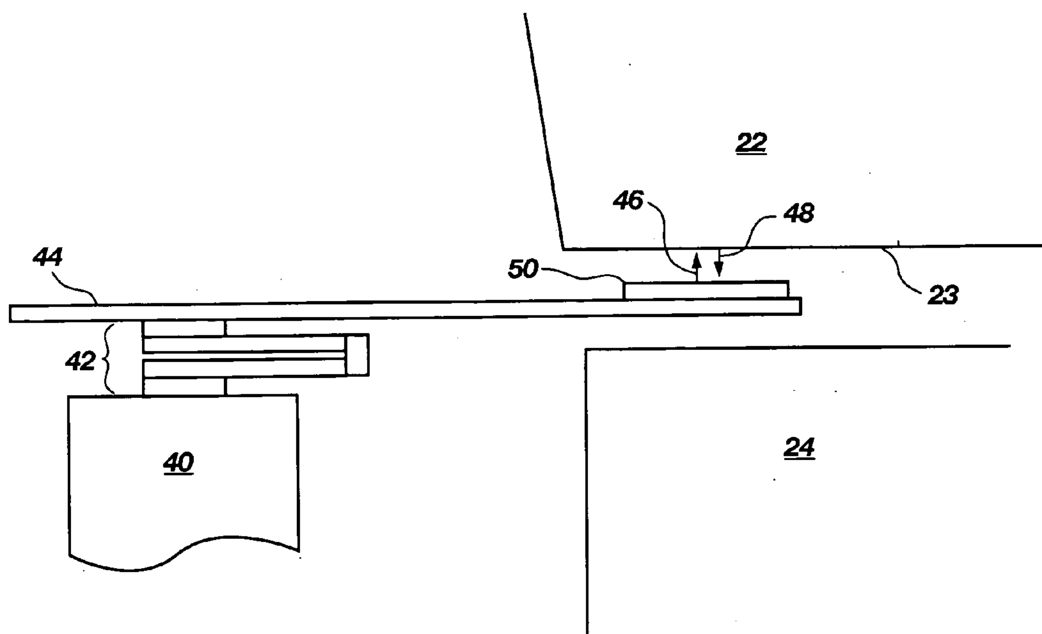


FIG. 3

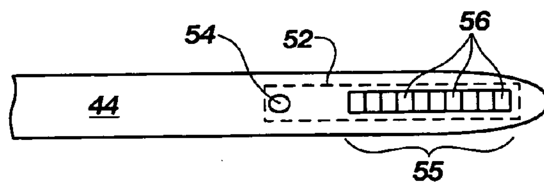


FIG. 4

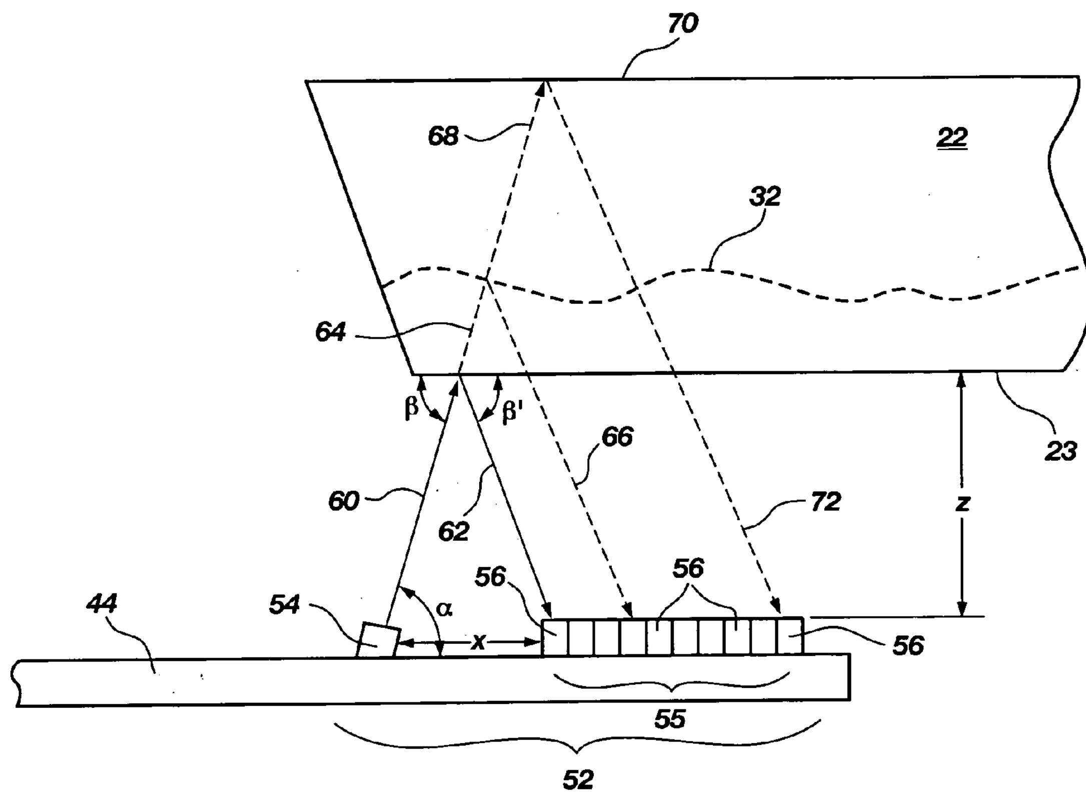


FIG. 5

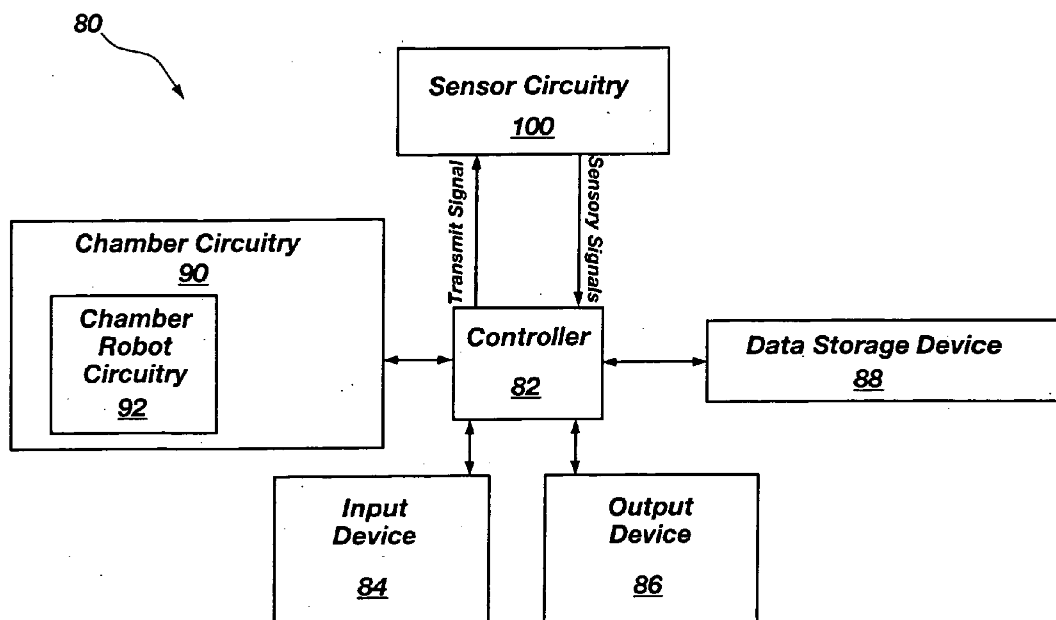


FIG. 6

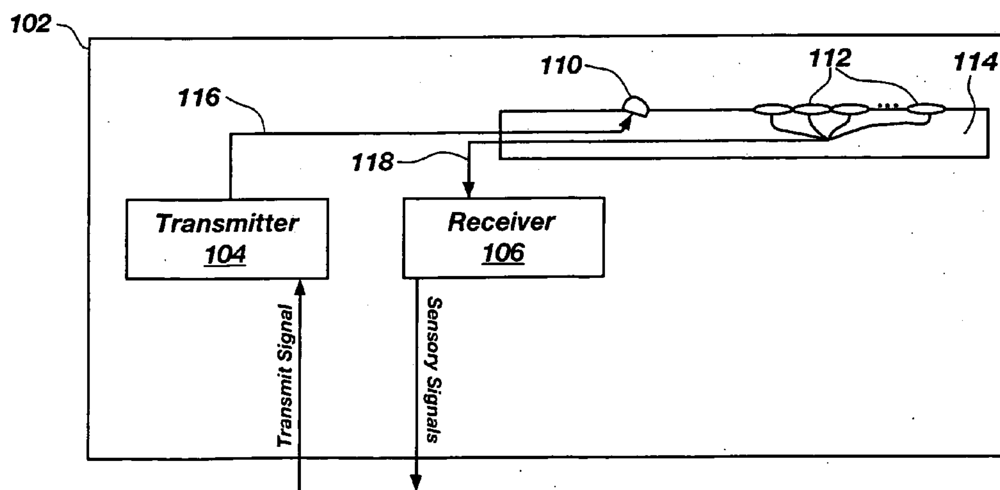


FIG. 7

DEVICE FOR MEASURING THE PROFILE OF A METAL FILM SPUTTER DEPOSITION TARGET, AND SYSTEM AND METHOD EMPLOYING SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of application Ser. No. 10/352,699, filed Jan. 27, 2003, pending.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to sputter deposition on substrate surfaces. More specifically, the present invention relates to methods and apparatus for measuring the profile of a sputtering target.

[0004] 2. State of the Art

[0005] A thin film of metallic material may be deposited on a substrate using a sputter deposition process wherein a metallic target is attacked with ions causing atoms or small particles of the target to be ejected from the target and deposited on the substrate surface. **FIG. 1** illustrates a cross-sectional schematic of a typical sputtering apparatus **10** comprising a vacuum chamber **12** having a gas inlet **14** and a gas outlet **16**. The sputtering apparatus **10** further comprises a substrate support pedestal **24** and a metallic target **22** attached to a sputtering cathode assembly **18**, each located within the vacuum chamber **12**. The pedestal **24** may be configured to secure a substrate **26** thereto with a biasable electrostatic chuck, a vacuum chuck, a clamping structure, or a combination of methods. The substrate **26** may be transported to and from the pedestal **24** manually or with a robotic arm or blade (not shown).

[0006] During the sputtering process, the vacuum chamber **12** is filled with an inert gas, such as argon, through the gas inlet **14** and then reduced to a near vacuum through the gas outlet **16**. The target **22** is negatively charged to cause electrons to be emitted from an exposed surface **23** of the target **22** and move toward an anode (not shown). A portion of the moving electrons strike atoms of the inert gas, causing the atoms to become positively ionized and move towards the negatively charged target **22**. The electrons, inert gas atoms, and ions form a plasma which is typically intensified and confined over the target surface **23** by a magnetic field generated by a magnet assembly **20** located proximate the target **22**. The magnet assembly **20** may comprise one or more permanent magnets or electromagnets located behind and/or to the side of the target **22**. A portion of the ions discharging from the plasma strike the target surface **23** at a high velocity, causing atoms or small particles of the target **22** material to be ejected from the target surface **23**. The ejected atoms or small particles then travel through the vacuum chamber **12** until they strike a surface, such as the surface of the substrate **26**, forming a thin metallic film thereon.

[0007] The magnetic field formed over the target surface **23** by the magnet assembly **20** confines the electrons emitted from the target **22** to an area near the target surface **23**. This greatly increases the electron density and the likelihood of collisions between the electrons and the atoms of the inert gas in the space near the target surface **23**. Therefore, there is a higher rate of ion production in plasma regions near the target surface **23** where the magnetic field intensity is stronger. Varying rates of ion production in different plasma regions causes the target surface **23** to erode unevenly. Typically, the configuration of the magnet assembly **20** produces a radial variation of thick and thin areas, or grooves, within a diameter of the target surface **23**. **FIG. 2** illustrates a cross-sectional perspective view of a typical erosion profile of a cylindrical metallic target **22**, such as the metallic target **22** shown in **FIG. 1**, which has been used in a sputtering process. **FIG. 2** illustrates a target surface **23** before erosion has occurred as well as a target surface **32** that has eroded unevenly across the length of a diameter bounded by an outside edge **25** of the target **22**. Due to the geometry of a magnetic field surrounding the target **22**, the target surface **32** has eroded nearly symmetrically about a center line **30** dividing the length of the diameter.

[0008] Referring now to **FIGS. 1 and 2**, the target **22** may comprise a rare metal, such as gold, platinum, palladium or silver, or may comprise, for example, aluminum, titanium, tungsten or any other target material conventionally employed in the semiconductor industry. Therefore, it is advantageous to consume as much of the target **22** material during sputter deposition processes as possible before replacing an eroded target **22**. Further, replacing an eroded target **22** before the end of its useful life may be a difficult and time-consuming task. However, it is important to replace the target **22** before a groove "punches through" the target **22** material and exposes portions of the cathode assembly **18** to erosion, causing damage to the cathode assembly **18** and contaminating the sputtering apparatus **10**. For example, the target **22** material in the area of groove **28** shown in **FIG. 2** may erode before the remainder of the target **22** material and expose the cathode assembly **18** to ionic bombardment from the surrounding plasma.

[0009] The useful life of a metallic sputtering target **22** is typically estimated by determining the cumulative deposition time for the target **22**. A deposition time is chosen to guarantee that the target **22** material will never be completely removed at any given location and may take into account the thickness of the target **22**, the material used for the target **22**, and the effect of intensifying and confining the plasma over the target surface **32** by a magnetic field generated by the magnet assembly **20** in a predetermined configuration. However, if the characteristics of the plasma distribution change due to, for example, reconfiguring the magnet assembly **20** to produce a magnetic field with a different geometry, the erosion of the target surface **32** may be changed and could result in localized enhanced metal removal and the possible punching through to the cathode assembly **18** before the expiration of the estimated deposition time.

[0010] Directly measuring the target surface **23** is difficult and time consuming. Opening the vacuum chamber **12** to inspect the target surface **23** requires several hours of idle time while the vacuum chamber **12** is baked out under post-vacuum inspection. Accurate measurement of the target surface **23** while the sputtering apparatus **10** is under vacuum is difficult because the gap distance d between the target **22** and the pedestal **24** may be as small as 25 millimeters. Typical measurement devices are too large to be inserted into the gap d between the target **22** and the pedestal **24** to profile the target surface **23** while the vacuum chamber **12** is under vacuum. Further, measurement devices placed

near the target **22** during a sputtering process may be damaged by exposure to metal deposition.

[**0011**] In view of the shortcomings in the art, it would be advantageous to prevent premature replacement and over consumption of the target **22** by providing a technique and device to measure the target surface **23** while the vacuum chamber **12** is under vacuum.

BRIEF SUMMARY OF THE INVENTION

[**0012**] The present invention relates to methods and apparatus for measuring the erosion of a metallic sputtering target.

[**0013**] An apparatus according to one embodiment of the present invention comprises a sensor configured to emit an energy beam toward a target surface and to detect a reflection of the energy beam from the target surface. The sensor may be coupled to a thin profile arm configured to move or transport the sensor over the target surface between the target and a substrate support pedestal to a plurality of measurement locations. The arm may be configured to attach to a robotic device. The sensor and the arm are configured, positioned and sized to be inserted into a narrow gap existing between the target surface and the pedestal. The arm may also be configured to remove the sensor from the gap and to shield the sensor during a sputtering process.

[**0014**] In another embodiment of the present invention, the sensor comprises a source element configured to emit a collimated light beam and a plurality of detectors arranged in a linear array. The source element may be positioned so as to emit the collimated light beam at an acute angle with respect to the linear array of detectors. The detectors are positioned relative to the source element so that one of the detectors in the array will be illuminated by a reflection of the collimated light beam. The distance from the sensor to the target surface or the percentage of target erosion may be calculated by determining which detector in the array is illuminated by the reflection of the collimated light beam.

[**0015**] In a further embodiment of the present invention, the sensor comprises a transmitter optically coupled to a source collimator configured to collimate a light beam as it exits an optical fiber. The sensor may further comprise a receiver optically coupled to a plurality of collection collimators, each of the plurality of collection collimators being configured to collect the reflection of the light beam incident thereon into a corresponding optical fiber.

[**0016**] The present invention also encompasses a sputter deposition system incorporating the sensors of the present invention and a method of profiling a sputtering surface target. The method comprises emitting an energy beam, illuminating a first location on the target surface, detecting a reflection of the energy beam from the at least one location, and analyzing the detected reflection of the energy beam to determine a distance from the point of emission to the first location.

[**0017**] Other features and advantages of the present invention will become apparent to those of ordinary skill in the art through consideration of the ensuing description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[**0018**] The drawings, which illustrate what are currently considered to be the best modes for carrying out the invention:

[**0019**] **FIG. 1** is a cross-sectional side view schematic of a sputtering apparatus;

[**0020**] **FIG. 2** is a cross-sectional perspective side view of an erosion profile of a cylindrical, metallic target;

[**0021**] **FIG. 3** is a cross-sectional side view schematic according to one embodiment of the present invention of a portion of a sputtering apparatus comprising a sensor configured, sized and positioned to be inserted between a target surface and a pedestal;

[**0022**] **FIG. 4** is a top view schematic of a sensor according to one embodiment of the present invention;

[**0023**] **FIG. 5** is a side view schematic of the sensor of **FIG. 4** and a portion of a sputtering apparatus;

[**0024**] **FIG. 6** is a block diagram of a sputter deposition system comprising a sensor assembly according to one embodiment of the present invention; and

[**0025**] **FIG. 7** is a block diagram of a sensor assembly according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[**0026**] **FIG. 3** illustrates a cross-sectional schematic of a portion of a sputtering apparatus, such as the sputtering apparatus **10** shown in **FIG. 1**, according to one embodiment of the present invention. As shown in **FIG. 3**, a sensor **50** coupled to a thin profile arm **44** is configured and sized to be inserted into a gap between a target **22** and a pedestal **24**. The arm **44** may be configured to detachably attach to a chamber robot **40** configured to translate the sensor **50** over the target surface **23**, or at least a portion thereof. The chamber robot **40** may further be configured to protect the sensor **50** during the sputtering process by removing the sensor **50** from the sputtering area or by shielding the sensor **50**. The arm **44** may be interconnected to the chamber robot **40** through an articulating arm **42** configured to provide movement in at least one plane. In another embodiment of the present invention, the sensor **50** may detachably attach to a substrate pickup arm (not shown) connected to the chamber robot **40** and configured to transport a substrate (not shown) to and from the pedestal **24** using a pickup device (not shown), such as a clamp, vacuum chuck or electrostatic chuck, to attach the substrate thereto. In yet another embodiment, the sensor **50** may be configured to attach directly to the pickup device.

[**0027**] The sensor **50** is configured to transmit a signal **46** toward the target **22** and to receive a reflected signal **48** from the target surface **23**. The transmitted signal **46** may be an energy beam selected from the group comprising a visible light beam, an ultraviolet light beam, an infrared light beam, a radio frequency ("RF") beam, a microwave beam and an ultrasound beam. To determine the amount of erosion at any location on the target surface **23**, the reflected signal **48** may be analyzed to determine a relative distance between the sensor **50** and the target surface **23**. It may not be necessary

to measure the relative distance between the sensor **50** and the target surface **23** at every point on the target surface **23**. Due to the radial symmetry of the erosion of the target surface **23**, it is only necessary to determine the relative distance between the sensor **50** and the target surface **23** at points located linearly between the center line **30** of the target surface **23** and an outside edge **25** of the target surface **23**, as shown in **FIG. 2**. Thus, in measuring the relative distance between the sensor **50** and the target surface **23** approximately every ten millimeters linearly between the center line **30** and an outside edge **25** may provide sufficient resolution to prevent punching through a target **22** having a diameter of approximately thirty centimeters.

[**0028**] In one embodiment of the present invention, the relative distance between the sensor **50** and the target surface **23** is measured by measuring the time delay between the emission of the transmitted signal **46** and detection of the reflected signal **48**, multiplying the measured time delay by the speed of the transmitted signal **46** and dividing by two. To profile the target surface **23**, the chamber robot **40** may be configured to position the sensor **50** at a plurality of locations relative to the target surface. Further, the sensor **50** may be configured, such as by using a multiplexor, to scan a portion (as opposed to a single point) on the target surface **23** while positioned at one location relative to the target surface **23**. In another embodiment, the distance between the sensor **50** and the target surface **23** may be determined by indirectly establishing the time delay by measuring a phase difference between the transmitted signal **46** and the reflected signal **48**. In a phase measurement sensor **50**, the transmitted signal **46** may comprise a modulated signal. In yet another embodiment, the transmitted signal **46** may be a pulsed signal and the reflected pulse signal **48** may be detected only during a predetermined time window such that increased time delay between transmission and detection causes less of the pulse to be detected. Thus, the detected power level of the reflected pulse signal **48** is inversely proportional to the distance traveled. Other embodiments for measuring the distance between the sensor **50** and the target surface **23**, as presently known in the art, may also be employed.

[**0029**] **FIG. 4** illustrates a top view schematic of a sensor **52** according to one embodiment of the present invention. The sensor **52** is attached to a thin profile arm **44**, such as the arm **44** shown in **FIG. 3**. Sensor **52** comprises a source element **54** and a detector array **55**. The source element **54** has a thin profile so as to fit between the target **22** and the pedestal **24**, as shown in **FIG. 3**. The source element **54** is configured to generate a collimated light beam. By way of example only, and not by limitation, the source element **54** may comprise a laser diode. Alternatively, the source element **54** may comprise a collimator, such as a lens, configured to collimate or focus light exiting an optical fiber to a desired beam diameter or spot size. As will be seen below, the collimated light emitted from the source element **54** minimizes extraneous reflections and enhances signal detection. Use of a collimated light beam as an energy beam is currently preferred, although the invention is not so limited.

[**0030**] The detector array **55** comprises a plurality of detectors **56** (ten shown) disposed side by side in a linear array, each detector **56** having a thin profile so as to fit between the target **22** and the pedestal **24**, as shown in **FIG. 3**. Each detector **56** in the detector array **55** is configured to produce an electronic sensory signal related to the magnitude of the radiation received thereon. By way of example only, and not by limitation, each detector may comprise a photodiode or a charge coupled device ("CCD"). Alternatively, each detector **56** in the detector array **55** may comprise a collimator, such as a lens, configured to collect light into an optical fiber.

[**0031**] **FIG. 5** illustrates a side view schematic of the sensor **52** and arm **44** shown in **FIG. 4**. As shown in **FIG. 5**, the source element **54** is positioned so as to emit a transmitted beam **60** at a predetermined transmission angle a in relation to the arm **44**. Although not shown, it may also be advantageous to position each detector **56** of the detector array **55** at an angle in relation to the arm **44** so as to align with a corresponding reflected beam, such as reflected beams **62**, **66** and **72**.

[**0032**] **FIG. 5** also illustrates the sensor **52** positioned in relation to a portion of a target **22**, such as the target **22** shown in **FIG. 2**. The number of detectors **56** in the detector array **55** and the position of each detector **56** relative to the source element **54** are dependent upon the distance between the sensor **52** and the target **22**. For illustration purposes, three surfaces **23**, **32**, **70** are referenced in **FIG. 5** corresponding to different target **22** erosion states. The first target surface **23** corresponds to a new or unused target **22** that has not yet been exposed to a sputtering process. The transmitted beam **60** illuminates the new target surface **23** and reflects back toward the detector array **55** as reflected beam **62**. To configure the dimensions of the detector array **55**, the vertical distance z between the new target surface **23** and the sensor **52** may be predetermined. Thus, assuming the incident angle β of the transmitted beam **60** and the reflected angle β' of the reflected beam **62** are equal, the distance x between the source element **54** and the nearest detector **56** in the detector array **55** (i.e., the detector **56** illuminated by the reflected beam **62**) is given by:

$$x = 2\left(\frac{z}{\tan\alpha}\right) \tag{1}$$

[**0033**] The next target surface **32** shown in **FIG. 5** corresponds to a target **22** that has been used in a sputtering process wherein approximately one-third of the target **22** material has been eroded. As discussed above in relation to **FIG. 2**, the target surface **32** has eroded unevenly. The transmitted beam **60**, now represented by dashed line **64**, illuminates the eroded target surface **32** and reflects back toward the detector array **55** as reflected beam **66**. The reflected beam **66** illuminates a detector **56** in the detector array **55** located approximately one-third of the distance between the detector **56** located nearest the source element **54** and the detector **56** located farthest from the source element **54**. Therefore, it may be determined that approximately one-third of the target **22** material has been eroded at the measured location along the target surface **32**.

[**0034**] The next target surface **70** shown in **FIG. 5** corresponds to the interface between the target **22** and the cathode assembly **18**, as shown in **FIG. 1**. The transmitted beam **60**, now represented by dashed line **68**, illuminates the target interface surface **70** and reflects back toward the detector array **55** as reflected beam **72**. The reflected beam **72**

illuminates a detector **56** in the detector array **55** located farthest from the source element **54**. Thus, it may be determined that substantially all of the target **22** material has been eroded at the measured location along the target interface surface **70**. As discussed above, use of the present invention to detect target consumption prevents the target interface surface **70** from being punched through and exposing portions of the cathode assembly **18** to erosion from the sputtering process. Therefore, it may be advantageous to replace the target **22** before the target interface surface **70** is detected.

[0035] **FIG. 6** is a block diagram of a sputter deposition system **80** according to the present invention. The sputter deposition system **80** comprises a controller **82** electrically coupled to chamber circuitry **90**, sensor circuitry **100**, an input device **84**, an output device **86** and a data storage device **88**. **FIGS. 4 and 5** illustrate the sensor circuitry **100** comprising a sensor **52** attached to an arm **44**, according to one embodiment of the present invention. The sensor **52** comprises a source element **54** and a plurality of detectors **56** (ten shown) forming a linear array **55**. The controller **82** is configured to communicate an electronic transmit signal to the source element **54**. Upon receipt of the transmit signal from the controller **82**, the source element **54** is configured to transmit a beam of collimated light. The beam of collimated light may be a pulsed beam of collimated light. Each detector **56** is configured to generate an electronic sensory signal related to the magnitude of the radiation received thereon. The controller **82** is configured to receive and compare each of the sensory signals to determine which one of the detectors **56** was illuminated with the greatest magnitude of radiation. The controller **82** may be configured to receive the sensory signals during a predefined time window in relation to the communication of the transmit signal to the source element **54**.

[0036] Referring to **FIGS. 5 and 6**, the controller **82** is further configured to determine the relative distance from the sensor **52** to a target surface **23, 32, 70**. As described above in relation to **FIG. 5**, the controller **82** may be configured to estimate the relative amount of erosion at a location along the target surface **23, 32, 70** according to the relative position of the detector **56** in the detector array **55** illuminated with the greatest amount of radiation. For example, if a detector **56** located at the center of the detector array is determined by the controller **82** to be illuminated by a reflected beam, then the controller **82** may be configured to estimate that half of the target **22** material has been eroded at the position along the target surface **23, 32, 70** being measured. Alternatively, the distance from the sensor **52** to the target surface **23, 32, 70** may be determined as a function of the transmission angle a and the distance between the source element **54** and the detector **56** being illuminated. For example, if the transmission angle a and the distance x between the source element **54** and the nearest detector **56** in **FIG. 5** are known, then equation (1) above may be used (assuming the incident angle β of the transmitted beam **60** and the reflected angle β' of the reflected beam **62** are equal) to determine the distance z between the sensor **52** and the target surface **23** as:

$$z = x\left(\frac{\tan\alpha}{2}\right) \tag{2}$$

[0037] **FIG. 7** illustrates a block diagram of a sensor assembly **102**, such as the sensor circuitry **100** shown in **FIG. 6**, according to another embodiment of the present invention. The sensor assembly **102** shown in **FIG. 7** comprises a source element **110** and a plurality of reception elements **112** (four shown) attached to a thin profile arm **114**, similar to the arm **44** shown in **FIG. 3**. The source element **110** comprises a collimator, such as a lens, configured to collimate or focus light exiting an optical fiber **116** to a desired beam diameter or spot size. Each reception element **112** comprises a collimator, such as a lens, configured to collect light incident thereon into an optical fiber assembly **118**. The sensor assembly **102** further comprises a transmitter **104** coupled to the source element **110** through the optical fiber **116** and a receiver **106** coupled to each of the plurality of reception elements **112** through the optical fiber assembly **118**. The optical fiber assembly **118** comprises a plurality of optical fibers, each optical fiber configured to couple to one reception element **112**.

[0038] Referring to **FIGS. 6 and 7**, the transmitter **104** is configured to receive a transmit signal from the controller **82** and to transmit a beam of collimated light to the source element **110** through the optical fiber **116**. The beam of collimated light may be a pulsed beam of collimated light. For each reception element **112**, the receiver **106** is configured to receive a light beam through the optical fiber assembly **118** and to generate an electronic sensory signal related to the magnitude of the radiation collected at the respective reception element **112**. The receiver **106** is further configured to transmit each of the sensory signals to the controller **82**. The controller **82** is configured to receive and compare each of the sensory signals to determine which one of the reception elements **112** was illuminated with the greatest magnitude of radiation. The controller **82** may be configured to receive the sensory signals during a predefined time window in relation to the communication of the transmit signal to the source element **110**. The controller **82** is further configured to determine the relative distance from the source element **110** to an object (not shown), as described above.

[0039] Referring to **FIGS. 1 and 6**, the controller **82** may be configured to interface with the chamber circuitry **90**, including chamber robot circuitry **92**, to control the position of the sensor circuitry **100** relative to a target **22** in the vacuum chamber **12**, the placement and removal of a substrate **26** on the pedestal **24**, sputter processing times, and other sputtering process and vacuum chamber **12** operations. The controller **82** may further be configured to perform computer functions such as executing software to perform desired calculations and tasks.

[0040] The input device **84** may include, by way of example only, an Internet or other network connection, a mouse, a keypad or any device that allows an operator to enter data into the controller **82**. The output device **86** may include, by way of example only, a printer or a video display device. The data storage device **88** may include, by way of example only, drives that accept hard and floppy discs, tape cassettes, CD-ROM or DVD-ROM.

[0041] While the invention may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention includes all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

1. A sputtering apparatus, comprising:

a chamber;

a sputtering target located within the chamber; and

a sensor associated with the chamber and configured to measure at least one characteristic of a target surface of the sputtering target, wherein the sensor comprises:

a source element configured to project an energy beam onto the target surface of the sputtering target; and

a plurality of detectors disposed in a linear array and configured to detect a reflection of the energy beam from the surface of the sputtering target.

2. The apparatus of claim 1, wherein the at least one characteristic comprises an erosion profile of the target surface.

3. The apparatus of claim 1, wherein each of the plurality of detectors is configured to generate an electronic sensory signal related to an angle of the reflection of the energy beam incident thereon.

4. The apparatus of claim 1, wherein each of the plurality of detectors comprises a collimator configured to collect the reflection of the energy beam incident thereon into a corresponding optical fiber.

5. The apparatus of claim 4, further comprising a receiver optically coupled to each collimator through its corresponding optical fiber, the receiver configured to generate an electronic sensory signal for each collimator related to an angle of the reflection of the energy beam incident thereon.

6. The apparatus of claim 1, wherein the energy beam is a collimated light beam.

7. The apparatus of claim 1, wherein the source element comprises a collimator configured to collimate the energy beam as it exits an optical fiber.

8. The apparatus of claim 7, further comprising a transmitter optically coupled to the source element through the optical fiber, the transmitter configured to transmit the energy beam to the collimator.

9. The apparatus of claim 1, wherein the plurality of detectors comprises a first detector located in relation to the source element so as to be illuminated by the reflection of the energy beam when substantially none of the target surface at a target surface location is eroded.

10. The apparatus of claim 9, wherein the plurality of detectors comprises a second detector located in relation to the source element so as to be illuminated by the reflection of the energy beam when substantially all of the target surface at the target surface location is eroded.

11. The apparatus of claim 10, wherein the plurality of detectors comprises at least one intermediate detector positioned between the first detector and the second detector with a proportional distance relationship to the first detector and the second detector, and located in relation to the source element so as to be illuminated by the reflection of the energy beam when the target surface at the target surface location is partially eroded such that the proportional distance relationship correlates to the partially eroded amount.

12. A sputtering erosion sensor, comprising:

a sensor configured to emit an energy beam toward a target surface of a sputtering target and to detect a reflection of the energy beam from the target surface; and

a transporter configured to detachably bear the sensor and transport the sensor relative to the target surface.

13. The sensor of claim 12, wherein the transporter is further configured as a substrate pickup arm configured to pick up and place a substrate on a pedestal.

14. The sensor of claim 13, wherein the substrate pickup arm includes a pickup device selected from the group consisting of a clamp, a vacuum chuck, and an electrostatic chuck.

15. The sensor of claim 12, wherein the transporter is an articulating arm configured for attachment to a robot.

16. The sensor of claim 12, wherein the transporter is further configured to transport the sensor substantially parallel to the target surface along a substantially linear path between substantially a center of the target and substantially an outer edge of the target.

17. The sensor of claim 12, wherein the sensor comprises a source element configured to emit the energy beam and a plurality of detectors disposed in a linear array.

18. The sensor of claim 17, wherein the plurality of detectors comprises a first detector located in relation to the source element so as to be illuminated by the reflection of the energy beam when substantially none of the target surface at a target surface location is eroded.

19. The sensor of claim 18, wherein the plurality of detectors comprises a second detector located in relation to the source element so as to be illuminated by the reflection of the energy beam when substantially all of the target surface at the target surface location is eroded.

20. The sensor of claim 19, wherein the plurality of detectors comprises at least one intermediate detector positioned between the first detector and the second detector with a proportional distance relationship to the first detector and the second detector, and located in relation to the source element so as to be illuminated by the reflection of the energy beam when the target surface at the target surface location is partially eroded such that the proportional distance relationship correlates to the partially eroded amount.

21. A method of measuring at least one sputtering characteristic, comprising:

providing a sputtering target within a chamber;

providing a sensor within the chamber, the sensor comprising a source element and a plurality of detectors disposed in a linear array;

directing an energy beam from the source element onto a target surface of the sputtering target; and

detecting a reflection of the energy beam from the target surface of the sputtering target with at least one detector of the plurality of detectors.

22. The method of claim 21, wherein the at least one sputtering characteristic comprises an erosion amount of the sputtering target.

23. The method of claim 21, further comprising estimating an erosion amount of the target surface at a target surface location by measuring a time delay between emitting the energy beam and detecting the reflection of the energy beam.

24. The method of claim 21, further comprising estimating an erosion amount of the target surface at a target surface location by measuring a phase difference between the energy beam and the reflection of the energy beam.

25. The method of claim 21, further comprising estimating an erosion amount of the target surface at a target surface location by comparing a power level of the energy beam with a power level of the reflection of the energy beam.

26. The method of claim 21, further comprising estimating an erosion amount of the target surface at a target surface location by detecting a location on the sensor illuminated by the reflection of the energy beam by using the plurality of detectors disposed in the linear array.

27. A method of developing a sputtering erosion profile, comprising:

transporting a sensor near a target surface location along a substantially linear path between substantially a center of a sputtering target and substantially an outer edge of the sputtering target;

illuminating the target surface location with an energy beam emitted from a source element born by the sensor;

detecting a reflection of the energy beam from a surface of the sputtering target at the target surface location with at least one detector born by the sensor; and

repeating the transporting, illuminating, and detecting for at least one additional target surface location along the substantially linear path to develop a sputtering erosion profile.

28. The method of claim 27, further comprising estimating an erosion amount of the target surface at the target surface location by measuring a time delay between emitting the energy beam and detecting the reflection of the energy beam.

29. The method of claim 27, further comprising estimating an erosion amount of the target surface at the target surface location by measuring a phase difference between the energy beam and the reflection of the energy beam.

30. The method of claim 27, further comprising estimating an erosion amount of the target surface at the target surface location by comparing a power level of the energy beam with a power level of the reflection of the energy beam.

31. The method of claim 27, further comprising estimating an erosion amount of the target surface at the target surface location by detecting a location on the sensor illuminated by the reflection of the energy beam by using a plurality of detectors disposed in a linear array.

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