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United States Patent Application Publication 20250266245
Kind Code A1
Publication Date August 21, 2025
Inventor(s) KIM; Jiye et al.

APPARATUS FOR AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE

Abstract

An apparatus for manufacturing a semiconductor device includes a chamber including a lower housing and an upper housing, heater chucks in the lower housing, shower heads on the heater chucks, the shower heads being between the lower housing and the upper housing, power supplies connected to the shower heads to provide radio-frequency powers to the shower heads, power straps in the upper housing to connect the shower heads to the power supplies, and shielding members in the upper housing, the shielding members enclosing the power straps and the shower heads, respectively, the shielding members to prevent electromagnetic interference of the radio-frequency powers between the power straps and between the shower heads.

Inventors: **KIM; Jiye (Suwon-si, KR), SONG; In Cheol (Hwaseong-si, KR), JEON; Woongpil (Jeju-si, KR), KIM; Daihong (Suwon-si, KR), PARK; Jaebeom (Yongin-si, KR), CHUN; Byungho (Seongnam-si, KR)**

Applicant: **Samsung Electronics Co., Ltd.** (Suwon-si, KR)

Family ID: **1000008578076**

Appl. No.: **19/197120**

Filed: **May 02, 2025**

Foreign Application Priority Data

KR	10-2020-0155349	Nov. 19, 2020

Related U.S. Application Data

parent US continuation 18679784 20240531 parent-grant-document US 12327710 child US 19197120
parent US division 17356998 20210624 parent-grant-document US 12074011 child US 18679784

Publication Classification

Int. Cl.: **H01J37/32** (20060101); **C23C16/505** (20060101); **H05K9/00** (20060101)

U.S. Cl.:

CPC **H01J37/32449** (20130101); **C23C16/505** (20130101); **H01J37/32082** (20130101); **H05K9/0081** (20130101); H01J2237/3321 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application is a continuation of U.S. patent application Ser. No. 18/679,784 filed on May 31, 2024, which is a divisional of U.S. patent application Ser. No. 17/356,998 filed on Jun. 24, 2021, which claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2020-0155349, filed on Nov. 19, 2020 in the Korean Intellectual Property Office, and entitled: “Apparatus for and Method of Manufacturing Semiconductor Device,” each of which is incorporated by reference herein in its entirety.

BACKGROUND

1. Field

[0002] The present disclosure relates to an apparatus for and a method of manufacturing a semiconductor device. In particular, the present disclosure relates to an apparatus for forming a thin film on a substrate, and a method of manufacturing a semiconductor device.

2. Description of the Related Art

[0003] In general, a semiconductor device is manufactured by multiple processes. For example, the multiple processes may include a thin-film deposition process, a lithography process, an etching process, etc. For example, the thin-film deposition process and the etching process may be performed using plasma, which is used to treat a substrate at a predetermined temperature. For example, the plasma may be produced using a high frequency power.

SUMMARY

[0004] According to an embodiment, a method of manufacturing a semiconductor device may include placing a plurality of substrates in a chamber, supplying a reaction gas on the substrates, using shower heads, which are provided in the chamber, and providing radio-frequency powers to the shower heads, without an electromagnetic interference between the shower heads using shielding members, which are provided in the chamber and enclosing the shower heads. The chamber may include a lower housing, and an upper housing, which is provided on the lower housing and the shower heads, and in which power straps connected to the shower heads are introduced. The shielding members may include shower-head shielding members enclosing the shower heads respectively, and strap shielding members connected to the shower-head shielding members and enclosing the power straps, respectively.

[0005] According to an embodiment, an apparatus for manufacturing a semiconductor device may include a chamber including a lower housing and an upper housing on the lower housing, a plurality of heater chucks disposed in the lower housing, a plurality of shower heads provided on the heater chucks and between the lower and upper housings, a plurality of power supplying parts connected to the shower heads to provide radio-frequency powers to the shower heads, a plurality of power straps disposed in the upper housing to connect the shower heads to the power supplying parts, and a plurality of shielding members disposed in the upper housing and enclosing the power straps and the shower heads respectively to prevent electromagnetic interference of the radio-frequency powers between the power straps and between the shower heads.

[0006] According to an embodiment, a method of manufacturing a semiconductor device may include placing a plurality of substrates in a chamber, supplying a reaction gas on the substrates, using shower heads, which are provided in the chamber, and providing radio-frequency powers to the shower heads, without an electromagnetic interference issue between the shower heads using shielding members, which are provided in the chamber and enclosing the shower heads. The shielding members may include shower-head shielding members enclosing the shower heads respectively, and strap shielding members enclosing power straps connected to the shower heads, respectively.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Features will become apparent to those of skill in the art by describing in detail exemplary embodiments with reference to the attached drawings, in which:

[0008] FIG. **1** illustrates a schematic view of an apparatus for manufacturing a semiconductor device, according to an example embodiment.

[0009] FIG. **2** is a cross-sectional view of the apparatus of FIG. **1**.

[0010] FIG. **3** is a plan view of an example of shielding members of FIG. **2**.

[0011] FIG. **4** is a graph showing a strength of electromagnetic interference versus a thickness of the shielding members of FIG. **2**.

[0012] FIG. **5** is a cross-sectional view of the shielding members of FIG. **2** and a capacitor between the shielding members.

[0013] FIG. **6** is a plan view of an example of a capacitor of FIG. **5**.

[0014] FIG. **7** is a flow chart of a method of manufacturing a semiconductor device, according to an example embodiment.

DETAILED DESCRIPTION

[0015] FIG. **1** illustrates an example of an apparatus **100** for manufacturing a semiconductor device. FIG. **2** is a cross-sectional view of the apparatus **100**.

[0016] Referring to FIGS. **1** and **2**, the apparatus **100** may be a plasma-enhanced chemical vapor deposition (PECVD) apparatus. In an embodiment, the apparatus **100** may include a reaction gas supply **10**, power supplies **20**, matchers **30**, and a chamber **40**.

[0017] The reaction gas supply **10** may be connected to the chamber **40**. The reaction gas supply **10** may be configured to supply a reaction gas **12** into the chamber **40**. For example, the reaction gas **12** may include tetra ethyl orthosilicate (TEOS) and/or oxygen (O.sub.2), and may be used to form a thin film (e.g., a silicon oxide (SiO.sub.2) layer) on a substrate W. In another example, the reaction gas **12** may include silane (SiH.sub.4) and/or ammonia (NH.sub.3), and may be used to form a thin film (e.g., a silicon nitride (SiN) layer) on the substrate W.

[0018] The power supplies may be connected to the chamber **40**. The power supplies **20** may provide radio-frequency (RF) powers **21** to the chamber **40**. The RF powers **21** may be used to produce plasma from the reaction gas **12**. The RF powers **21** may also be used to concentrate the reaction gas **12** to a region on the substrate W, and in this case, the resulting film may be formed to have an increased film density. The RF powers **21** may be also used to increase reactivity of the reaction gas **12** to increase the film density of the resulting film. Each of the RF powers **21** may have a frequency of about 27.12 MHz. Each of the RF powers **21** may have a power of about 1 KW to about 1000 KW.

[0019] The matchers **30** may be provided between and connected to the power supplies **20** and the chamber **40**, e.g., each matcher **30** may be between the chamber **40** and a corresponding power supply **20**. The matchers **30** may be respectively connected to the power supplies **20** through first cables **22**. The matchers **30** may also be connected to the chamber **40** through second cables **32**.

Each of the first and second cables **22** and **32** may include a coaxial cable.

[0020] The matchers **30** may be configured to allow for impedance matching between the power supplies **20** and the chamber **40**. The matchers **30** may be configured to remove a reflected fraction of the RF powers **21**, which is fed-back from the chamber **40**, and thus, it may be possible to prevent the power supplies **20** from being damaged, and to improve the supplying efficiency of the RF powers **21**.

[0021] The chamber **40** may be configured to be able to load a plurality of substrates W therein. For example, the chamber **40** may be configured to load about four substrates W therein. The chamber **40** may provide a closed space, which is isolated from the outside, to the substrates W. In the chamber **40**, a manufacturing process (e.g., a chemical vapor deposition process) using the reaction gas **12** and the RF power **21** may be performed on the substrates W. The chamber **40** may be grounded. The chamber **40** may be connected to a vacuum pump. For example, the chamber **40** may have a low pressure of about 1×10.sup.−3 Torr to about 1×10.sup.−6 Torr by a pumping operation of the vacuum pump, during the manufacturing process.

[0022] In detail, referring to FIG. **2**, the chamber **40** may include a lower housing **42** and an upper housing **44**. The upper housing **44** may be stacked on top of the lower housing **42**.

[0023] For example, as illustrated in FIG. **2**, the lower housing **42** may have a quadrangular shape, and process zones **41** may be formed therein, e.g., four process zones **41** may be arranged in a matrix pattern within the lower housing **42** (FIG. **1**). For example, each of the process zones **41** may be an opening, e.g., cavity, within the lower housing **42** to provide a region for processing the substrate W, i.e., each substrate W may be processed in a corresponding process zone **41** of the lower housing **42**. For example, the processing on the substrates W may include a thin-film deposition process, e.g., a PECVD process, an atomic layer deposition (ALD) process, etc. The process zones **41** may be separated from each other by a partition wall **45**, which is provided in the lower housing **42**. In other words, the partition wall **45** may be provided between the process zones **41**, e.g., the partition wall **45** may separate every two adjacent process zones **41**. The partition wall **45** may have a hole **47**, e.g., the hole **47** may connect two adjacent process zones **41** through the partition wall **45** to provide fluid communication therebetween.

[0024] As further illustrated in FIG. **2**, heater chucks **50** may be provided in the lower housing **42**, respectively. For example, a heater chuck **50** may be positioned in each process zone **41**, so one substrate W may be positioned above one heater chuck **50**. When the substrates W are disposed in the chamber **40**, the substrates W may be loaded onto the heater chucks **50**. The heater chucks **50** may be moveable in a vertical direction within the respective process zones **41**, so the heater chucks **50** may be lifted up to a level higher than the holes **47**, e.g., the heater chucks **50** may be positioned above the holes **47** during processing. For example, during processing, the heater chucks **50** may be configured to heat the substrates W to a temperature of about 100° C. to about 650° C. The reaction gas **12** may be provided onto the substrates W to form thin films, respectively. If a process of forming the thin films is finished, the heater chucks **50** may be lowered to a level lower than the holes **47** of the partition wall **45**. If the lowering of the heater chucks **50** is finished, the substrates W may be transferred from one of the heater chucks **50** to another of the heater chucks **50** through the hole **47** of the partition wall **45**. Alternatively, the substrates W may be unloaded to the outside of the chamber **40** through a slit valve, e.g., which may be formed in a sidewall of the chamber **40**.

[0025] Shower heads **60** may be provided on the heater chucks **50**, respectively. The shower heads **60** may be provided in upper cavities **49** of the lower housing **42** to hermetically seal upper portions of the process zones **41**, e.g., a width of each shower head **60** may equal a width of a corresponding cavity **49** to completely fit in and seal the cavity **49**. The shower heads **60** may be connected to the reaction gas supply **10** and the matchers **30**, so the shower heads **60** may be configured to uniformly supply the reaction gas **12** onto the substrates W. The shower heads **60** may produce plasma from the reaction gas **12** in the process zones **41**, using the RF powers **21**. The shower heads **60** may be spaced apart from each other by a horizontal distance D**1**, e.g., a distance of about 10 cm.

[0026] The upper housing **44** may be disposed on the lower housing **42** and the shower heads **60**. The shower heads **60** may be provided between the upper housing **44** and the lower housing **42**. For example, as illustrated in FIG. **2**, top portions of the shower heads **60** may extend above the lower housing **42**, so bottom portions of the shower heads **60** may be within the cavities **49** of the lower housing **42**, and the top portions of the shower heads **60** extend into the upper housing **44**.

[0027] The upper housing **44** may be grounded. The upper housing **44** may define a maintenance zone **43** on the process zones **41** of the lower housing **42**. The maintenance zone **43** may be a zone configured to protect the shower heads **60** and/or is used to construct joint of lines. In an example embodiment, the upper housing **44** may have sockets **46**. The sockets **46** may be provided on the maintenance zone **43**. The sockets **46** may be connected to the matchers **30** through the second cables **32**, respectively.

[0028] Power straps **48** may be provided in the upper housing **44**. The power straps **48** may be introduced in the upper housing **44** to connect the sockets **46** to the shower heads **60**. Each of the power straps **48** may include a power strap and/or a power rod. The power straps **48** may be used to provide the RF powers **21** to the shower heads **60**.

[0029] Shielding members **70** may be provided on the power straps **48** and the shower heads **60**. The shielding members **70** may be provided to enclose the shower heads **60** and the power straps **48**. The shielding members **70** may be grounded. The shielding members **70** may prevent or suppress electromagnetic interference (e.g., parasitic capacitance or noise) between adjacent ones of the shower heads **60**, and thus, it may be possible to improve deposition uniformity between the process zones **41**. In addition, the shielding members **70** may prevent the power straps **48** from electromagnetically interfering with each other. In an example embodiment, the shielding members **70** may be formed of or include at least one metallic material (e.g., iron (Fe) or copper (Cu)).

[0030] FIG. **3** illustrates a top view of the shielding members **70** of FIG. **2**.

[0031] Referring to FIGS. **2** and **3**, the shielding members **70** may include shower-head shielding members **72** and strap shielding members **74**. For example, as illustrated in FIG. **2**, each shielding member **70** may include a shower-head shielding member **72** covering the top portion of the shower head **60** in the upper housing **44**, and a strap shielding member **74** extending upward from the shower-head shielding member **72** to cover a corresponding strap **48**. For example, as illustrated in FIG. **2**, the shower-head shielding member **72** and the strap shielding member **74** are integral with each other.

[0032] In detail, the shower-head shielding members **72** may cover top surfaces of the shower heads **60** in the upper housing **44**, e.g., the shower-head shielding members **72** may contact a top surface of the lower housing **42** to completely surround, e.g., overlap, the top and side surfaces of corresponding top portions of the shower heads **60** in the upper housing **44**. The shower heads **60** and the shower-head shielding members **72** may be respectively disposed at four different positions corresponding to four vertices of a rectangle. The shower-head shielding members **72** may be spaced apart from each other. The shower-head shielding members **72** may be grounded to prevent the electromagnetic interference between the shower heads **60**. In an embodiment, the shower-head shielding members **72** may have a cap shape and/or a cover shape, when viewed in a vertical section. In addition, the shower-head shielding members **72** may have a circular ring shape, when viewed in a plan view.

[0033] The strap shielding members **74** may be disposed on an outer circumference surface of the power strap **48**, e.g., interiors of the strap shielding members **74** may be in fluid communication with interiors of shower-head shielding members **72**. The strap shielding members **74** may be connected to the shower-head shielding members **72**, The strap shielding members **74** may be connected to the shower-head shielding members **72**. The strap shielding members **74** may be grounded. The strap shielding members **74** may prevent or suppress electromagnetic interference between the power straps **48**. Each of the power straps **48** may have a rectangular shape, when viewed in a plan view. When the power strap **48** has a rectangular shape in a planar view, the strap shielding members **74** may be shaped like a rectangular and circular ring. For example, the strap shielding members **74** may have a rectangular pipe shape or a circular pipe shape.

[0034] FIG. **4** is a graph showing a strength of electromagnetic interference versus a thickness T of the shielding members **70** of FIG. **2**.

[0035] Referring to FIG. **4**, the electromagnetic interference may be reduced to the minimum value, when the shielding members **70** have a thickness T of 1 mm or larger. In the case where the thickness T of the shielding members **70** is reduced to a value of 1 mm or smaller, the electromagnetic interference may increase in an inversely proportional manner with respect to the thickness T.

[0036] Referring back to FIG. **2**, the thickness T of the shielding members **70** may be smaller than half of the distance D**1** between the shower heads **60**. For example, in the case where the distance D**1** between the shower heads **60** is about 10 cm, the thickness T of the shielding members **70** may be smaller than about 5 cm.

[0037] FIG. **5** illustrates the shielding members **70** of FIG. **2** and a capacitor **80** between the shielding members **70**. FIG. **6** illustrates an example of the capacitor **80** of FIG. **5**.

[0038] Referring to FIGS. **5** and **6**, the apparatus **100** may further include the capacitors **80**. The capacitors **80** may be connected to the shower-head shielding members **72**. The capacitors **80** may additionally prevent or suppress a high frequency (e.g., RF) interference between the shower-head shielding members **72**. The reaction gas supply **10**, the power supplies **20**, the matchers **30**, the chamber **40**, the heater chucks **50**, the shower heads **60**, and the shielding members **70** may be configured to have substantially the same features as those in FIG. **2**.

[0039] Referring to FIG. **6**, the capacitors **80** may include short range capacitors **82** and long range capacitors **84**. Each of the short range capacitors **82**, e.g., near field capacitors, may be connected to a pair of the shower-head shielding members **72** which are adjacent to each other, e.g., along a horizontal direction in a top view. In the case where the shower-head shielding members **72** are disposed at positions corresponding to vertices of a rectangle, the short range capacitors **82** may be formed along lines and/or sides of the rectangle. For example, the short range capacitors **82** may have capacitance ranging from about 100 μF to about 1 mF.

[0040] The long range capacitors **84**, e.g., far field capacitors, may be provided between the short range capacitors **82**, e.g., along a diagonal direction in a top view. In the case where the shower-head shielding members **72** are placed at positions corresponding to vertices of a rectangle, the long range capacitors **84** may be provided between and connected to the shower-head shielding members **72**, which are spaced apart from each other in a diagonal direction of the rectangle. The long range capacitors **84** may have capacitance that is smaller than the capacitance of the short range capacitors **82**. For example, the long range capacitors **84** may have capacitance ranging from about 10 μF to about 100 μF.

[0041] The shower heads **60**, the power straps **48**, and the strap shielding members **74** may be configured to have substantially the same features as those in FIG. **3**.

[0042] Hereinafter, a method of manufacturing a semiconductor device using the afore-described apparatus **100** will be described in more detail.

[0043] FIG. **7** illustrates a method of manufacturing a semiconductor device, according to an example embodiment.

[0044] Referring to FIGS. **1**, **2**, and **7**, the substrates W may be disposed in the chamber **40**, e.g., using a robot arm (S**10**). The substrates W may be loaded on the heater chucks **50**.

[0045] Next, the reaction gas supply **10** may be used to supply the reaction gas **12** into the chamber **40** (S**20**). The shower heads **60** may provide the reaction gas **12** onto the substrates W. The reaction gas **12** provided onto the substrates W may be used to form thin films (e.g., a silicon oxide layer or a silicon nitride layer) on the substrates W.

[0046] Furthermore, the power supplies **20** may provide the RF powers **21** to the shower heads **60**, without electromagnetic interference therebetween, using the shielding members **70** (S**30**). The shower heads **60** may excite the reaction gas **12** to a plasma state using the RF powers **21**, and then may provide the reaction gas **12** of the plasma state to a region on the substrates W. The RF powers **21** may concentrate the reaction gas **12** of the plasma state in a region on the substrate W, and this may make it possible to increase a film density of the resulting films. In addition, the RF powers **21** may increase reactivity of the reaction gas **12** and thereby further increase the film density of the thin film. The shower-head shielding members **72** may cover the top and side surfaces of the shower heads **60**, and in this case, it may be possible to prevent or suppress electromagnetic interference between the shower heads **60**, when the RF powers **21** are applied to the shower heads **60**. The strap shielding members **74** may be provided to enclose the power straps **48**. The strap shielding members **74** may prevent or suppress electromagnetic interference (e.g., parasitic capacitance or noise) between the power straps **48**.

[0047] By way of summation and review, an example embodiment provides an apparatus, which is configured to prevent an electromagnetic interference between shower heads in a process of manufacturing a semiconductor device, and a method of manufacturing a semiconductor device. That is, in an apparatus for manufacturing a semiconductor device according to an example embodiment, shielding members may be provided to enclose shower heads, respectively, thereby preventing the shower heads from electromagnetically interfering with each other.

[0048] Example embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. In some instances, as would be apparent to one of ordinary skill in the art as of the filing of the present application, features, characteristics, and/or elements described in connection with a particular embodiment may be used singly or in combination with features, characteristics, and/or elements described in connection with other embodiments unless otherwise specifically indicated. Accordingly, it will be understood by those of skill in the art that various changes in form and details may be made without departing from the spirit and scope of the present invention as set forth in the following claims.

Claims

1. A method of manufacturing a semiconductor device, the method comprising: placing substrates in a chamber, the chamber including shower heads enclosed in respective shielding members; supplying a reaction gas onto the substrates via the shower heads; and providing radio-frequency powers to the shower heads, without an electromagnetic interference between the shower heads, by using the shielding members, wherein the shielding members include shower-head shielding members enclosing the shower heads, respectively, and strap shielding members enclosing power straps connected to the shower heads, respectively, wherein the shielding members are connected to each other by capacitors, wherein the capacitors comprise: short range capacitors connected between the shielding members that disposed in short range distance to remove or minimize a near field interference between the shielding members, and long range capacitors connected between the shielding members disposed in long range distance longer than the short range distance to remove or minimize a far field interference between the shielding members.

2. The method as claimed in claim 1, wherein the chamber includes: a lower housing; and an upper housing on the lower housing, the shielding members being in the upper housing.

3. The method as claimed in claim 2, wherein the shower heads are between the lower housing and the upper housing.

4. The method as claimed in claim 1, wherein the shower-head shielding members are provided at positions corresponding to vertices of a rectangle

5. The method as claimed in claim 4, wherein: the short range capacitors are provided along sides of the rectangle to each other; and the long range capacitors are provided between the short range capacitors and provided in a diagonal direction of the rectangle.

6. The method as claimed in claim 1, wherein the short range capacitors have capacitance larger than that of the long range capacitors.

7. The method as claimed in claim 1, wherein providing the radio-frequency powers includes generating the radio-frequency powers by power supplies, the power straps and the power supplies being connected to cables.

8. The method as claimed in claim 7, wherein each of the cables includes a coaxial cable.

9. The method as claimed in claim 1, wherein the strap shielding members have a rectangular pipe shape.

10. The method as claimed in claim 1, wherein the shower-head shielding members have a circular ring-shaped cross-section, in a top view, and the strap shielding members have a rectangular cross-section, in the top view.