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(54) **INDUCTIVELY COUPLED PLASMA APPARATUS USING MAGNETIC FIELD**

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(52) **U.S. Cl.** .... **118/723 AN**

(57) **ABSTRACT**

Disclosed is an inductively coupled plasma apparatus using a magnetic field. The inductively coupled plasma apparatus comprises a reaction chamber in which a substrate is loaded, an antenna source installed in the reaction chamber and including first and second antennas having antenna rods, which are alternately aligned, and magnets installed above the antenna rods, wherein first sides of the first and second antennas are connected to a power source and second sides of the first and second antennas are grounded. Plasma uniformity is improved and superior plasma uniformity is maintained by adjusting a distance between antennas according to a size of the substrate.

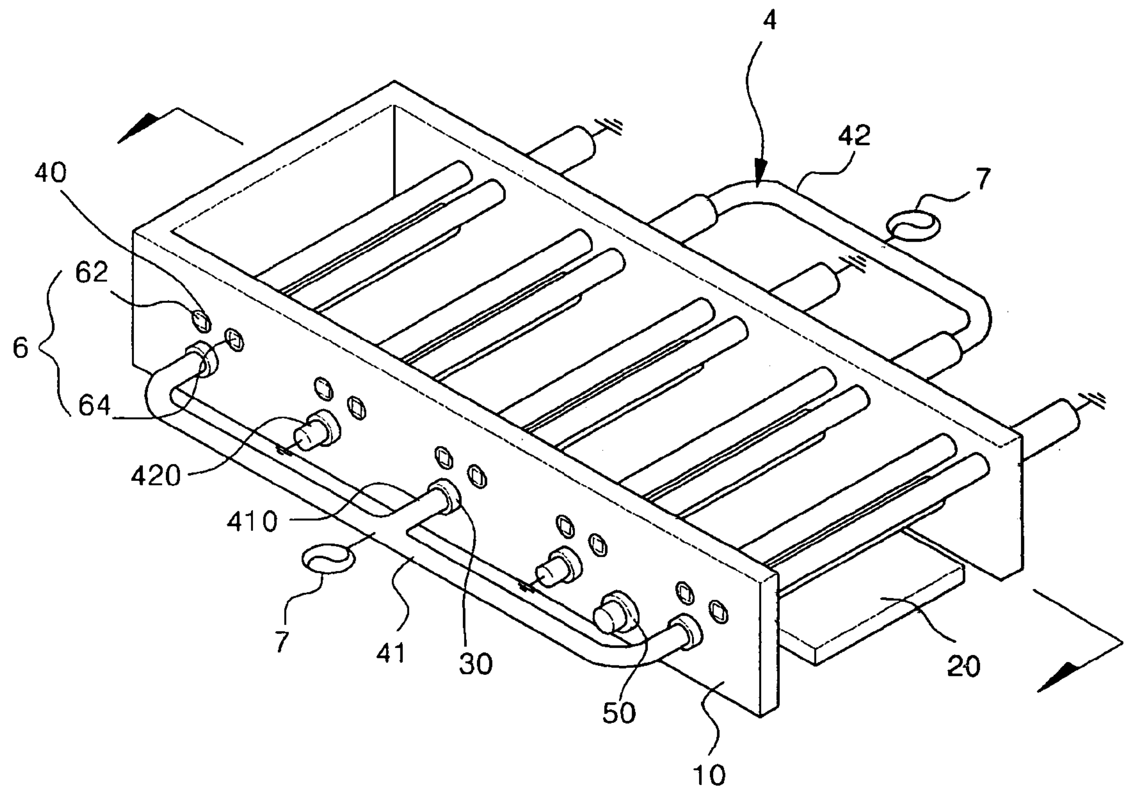


FIG 1a

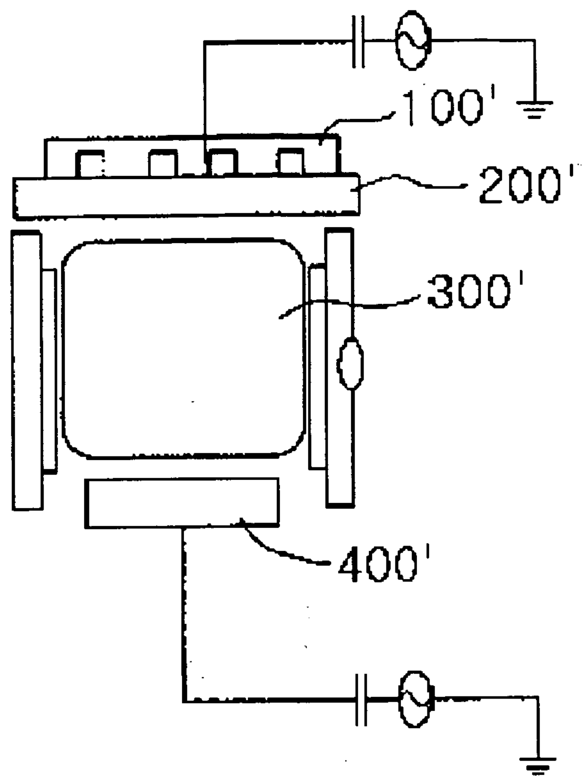


FIG 1b

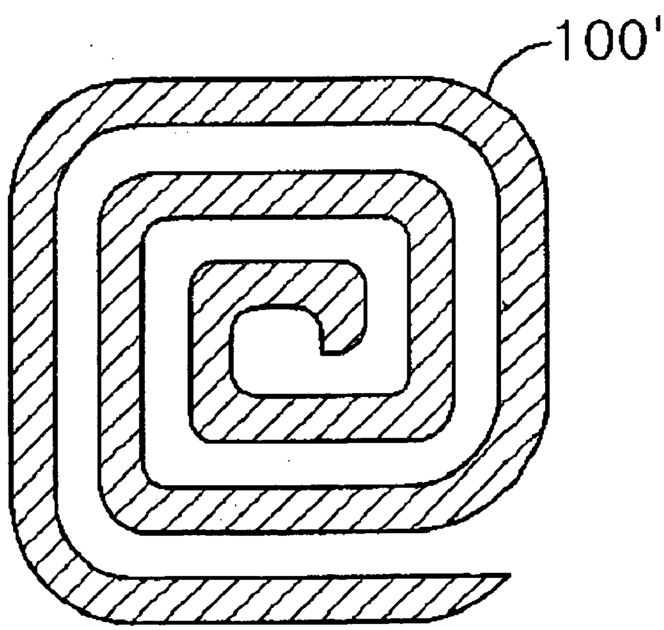


FIG 2

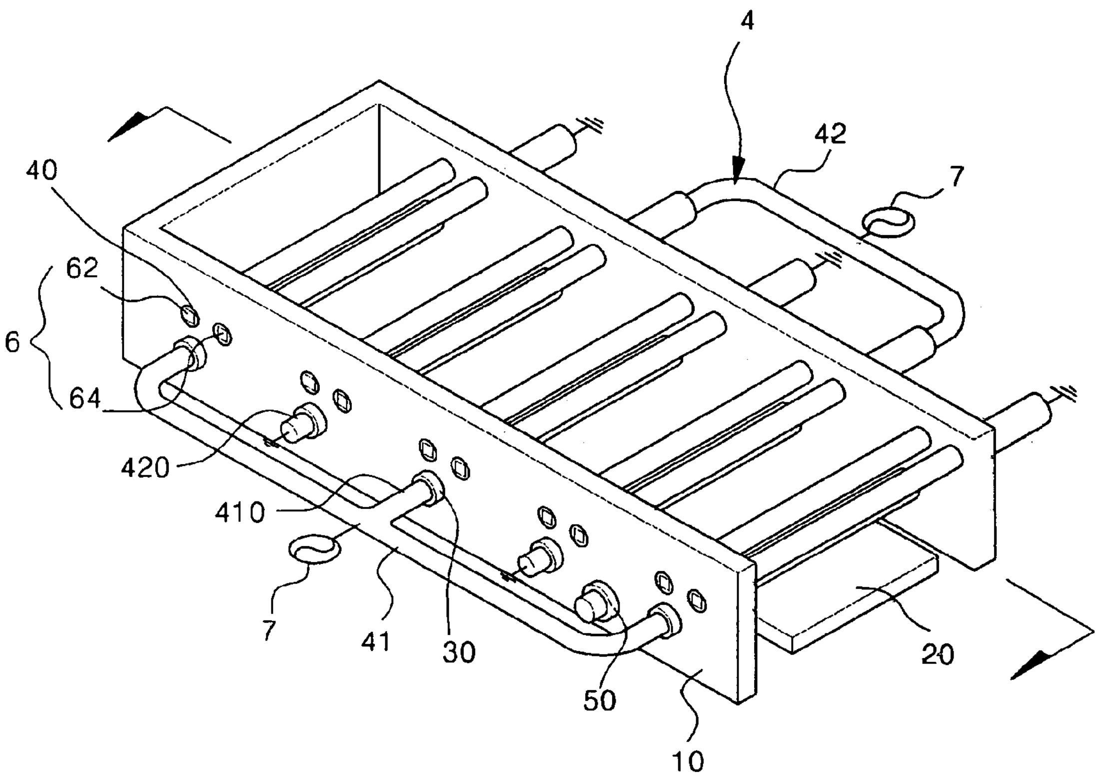


FIG 3

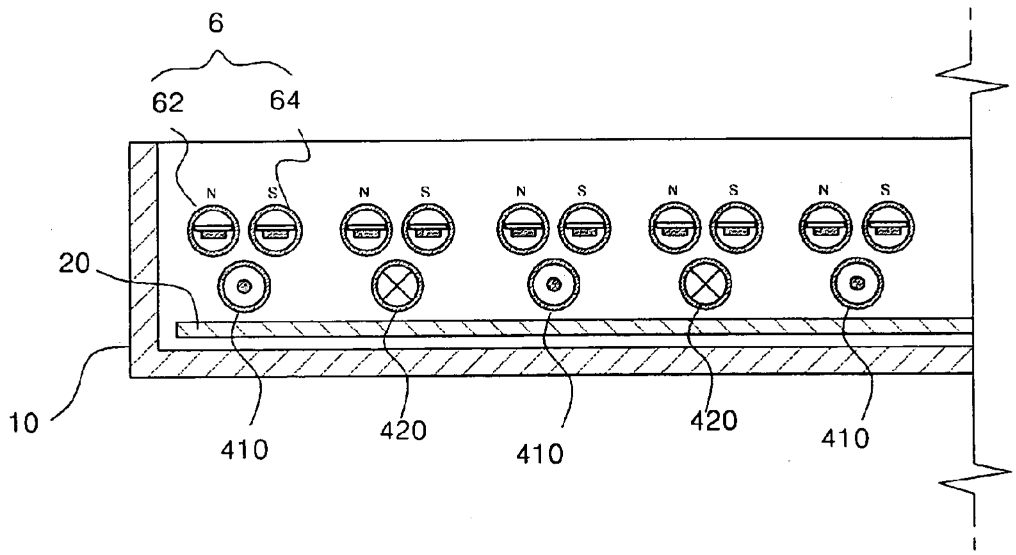


FIG 4

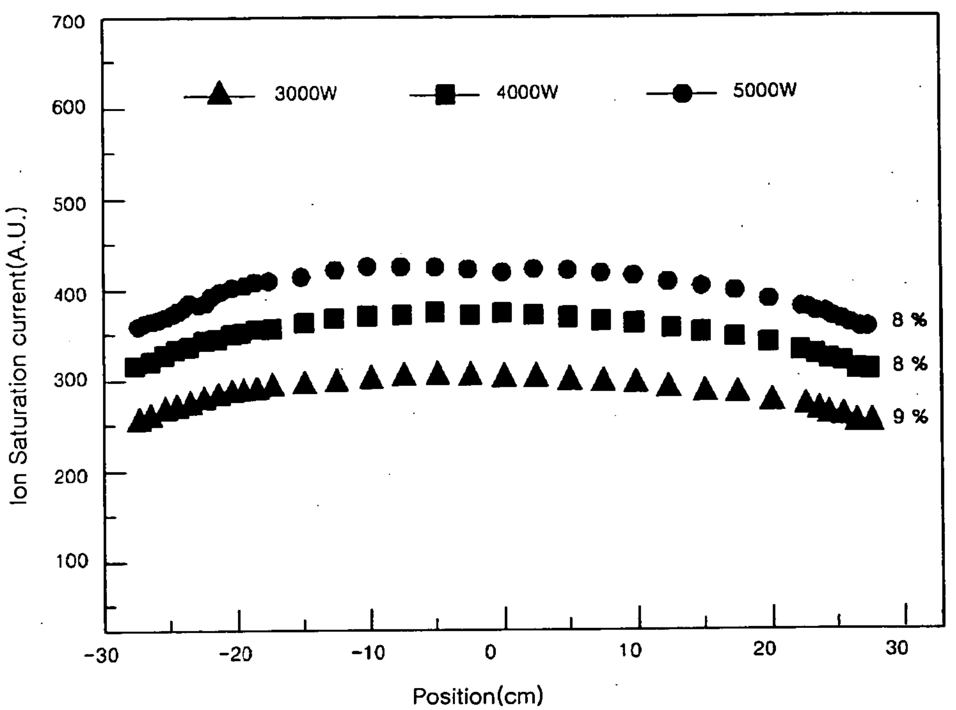
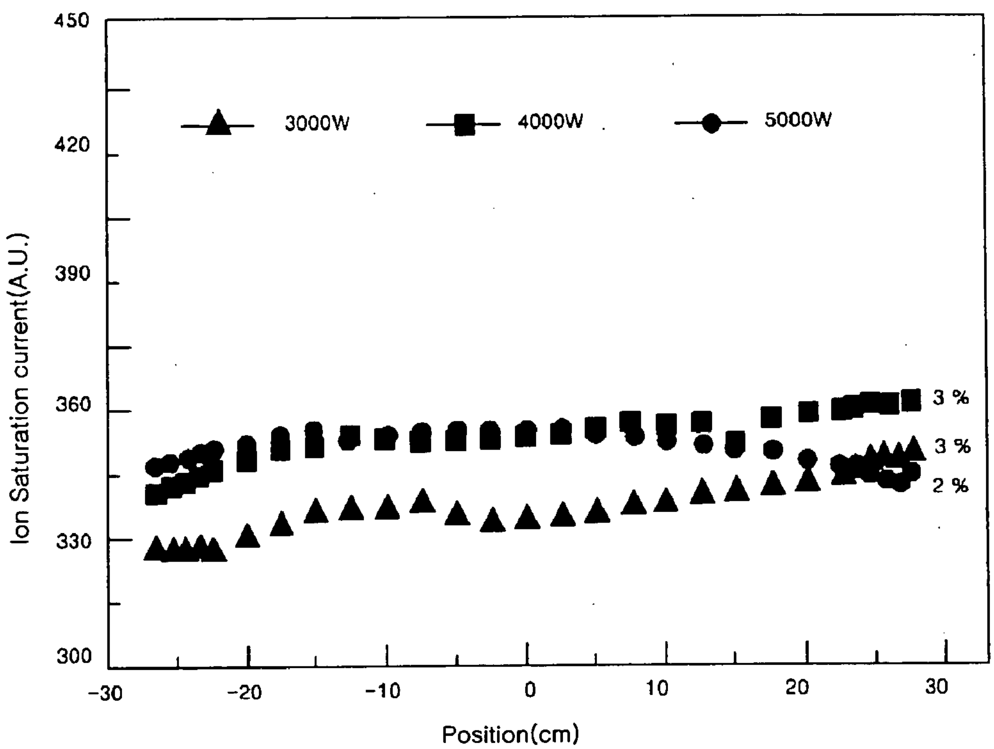
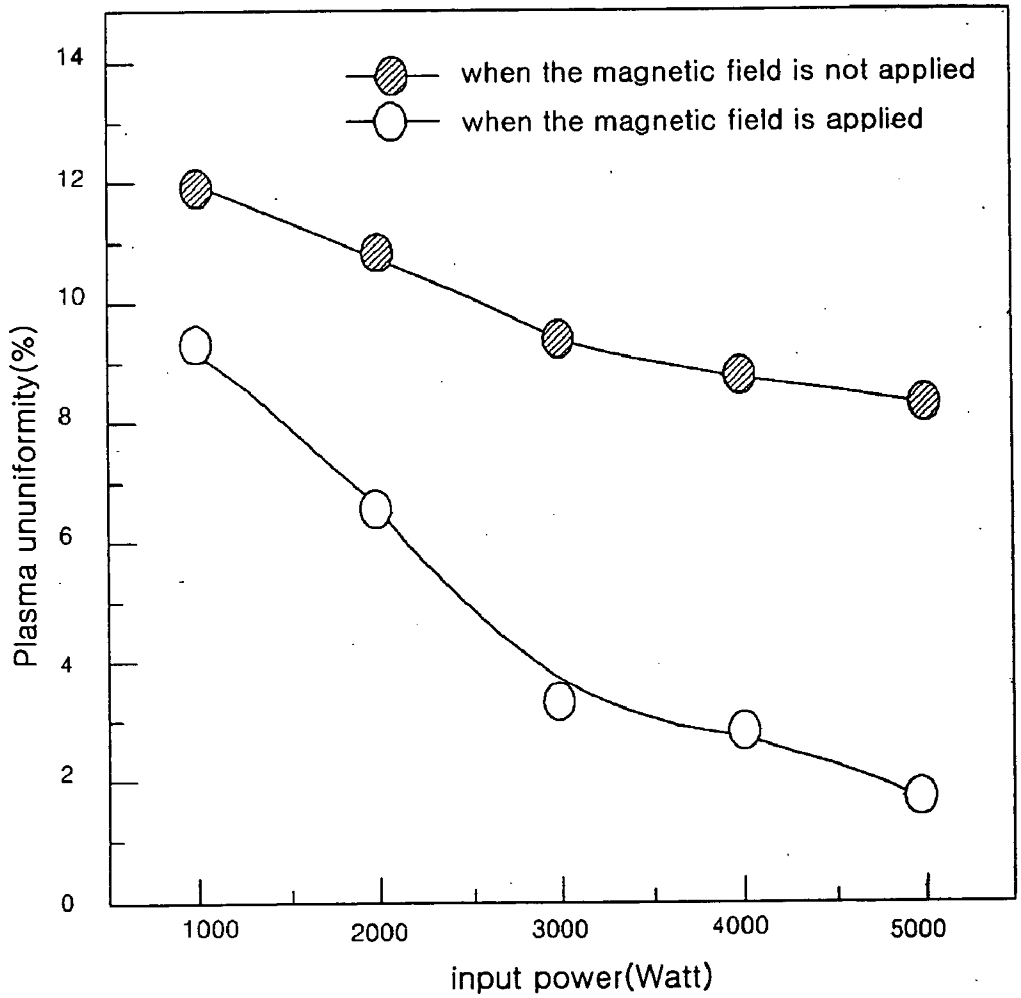

700
600
500
400
300
200
100
3000W
4000W
5000W
8 %
8 %
9 %
Ion Saturation current(A.U.)
-30
-20
-10
0
10
20
30
Position(cm)

FIG 5



450
420
390
360
330
300
Ion Saturation current(A.U.)
3000W
4000W
5000W
3 %
3 %
2 %
-30
-20
-10
0
10
20
30
Position(cm)

FIG 6



when the magnetic field is not applied
when the magnetic field is applied
Plasma ununiformity(%)
0
2
4
6
8
10
12
14
1000
2000
3000
4000
5000
input power(Watt)

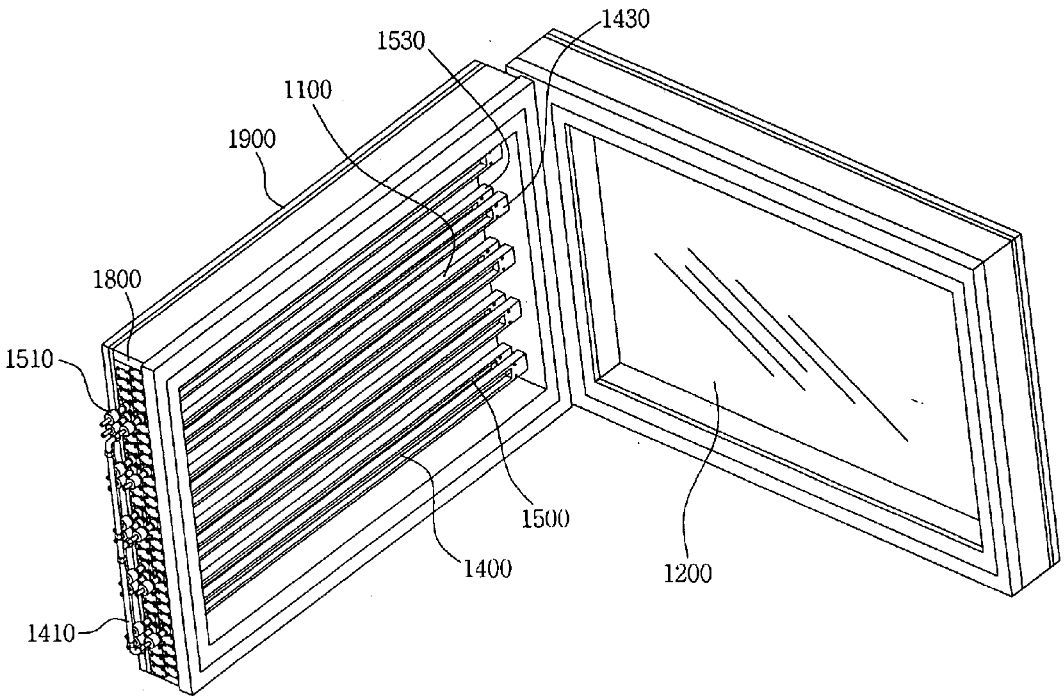
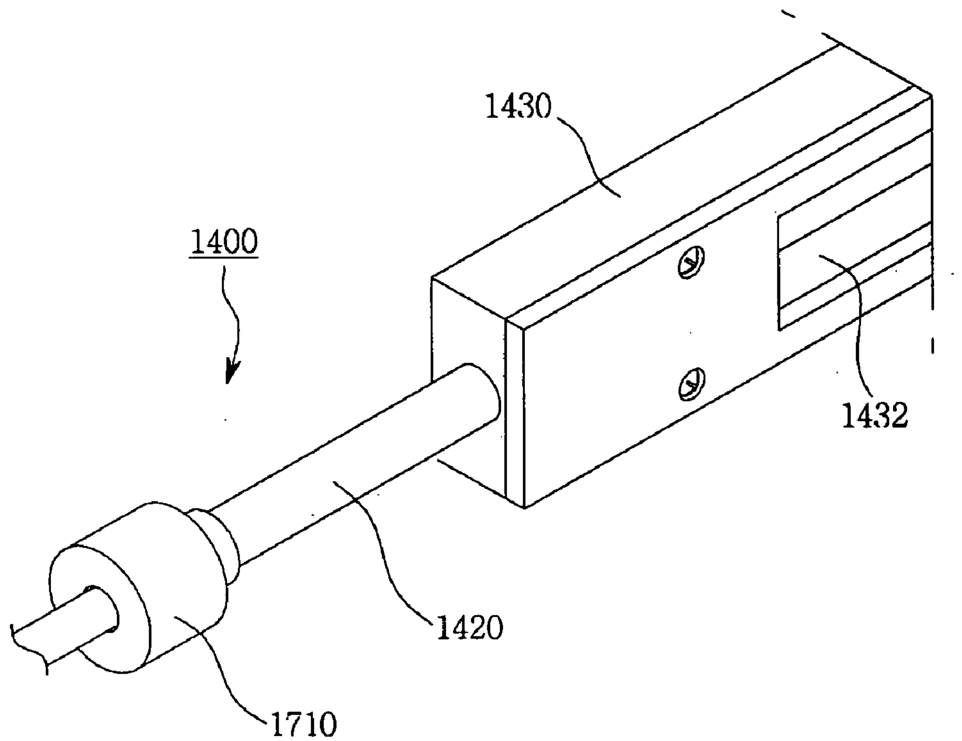


FIG 7

FIG 8



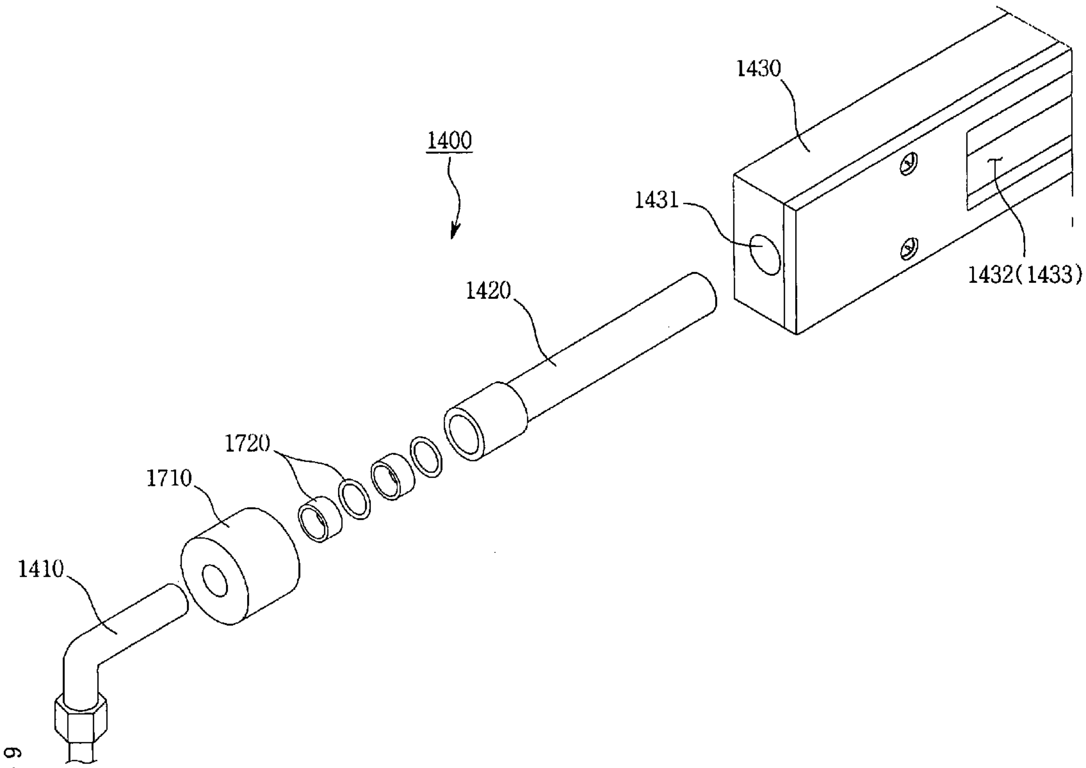


FIG 9

FIG 10

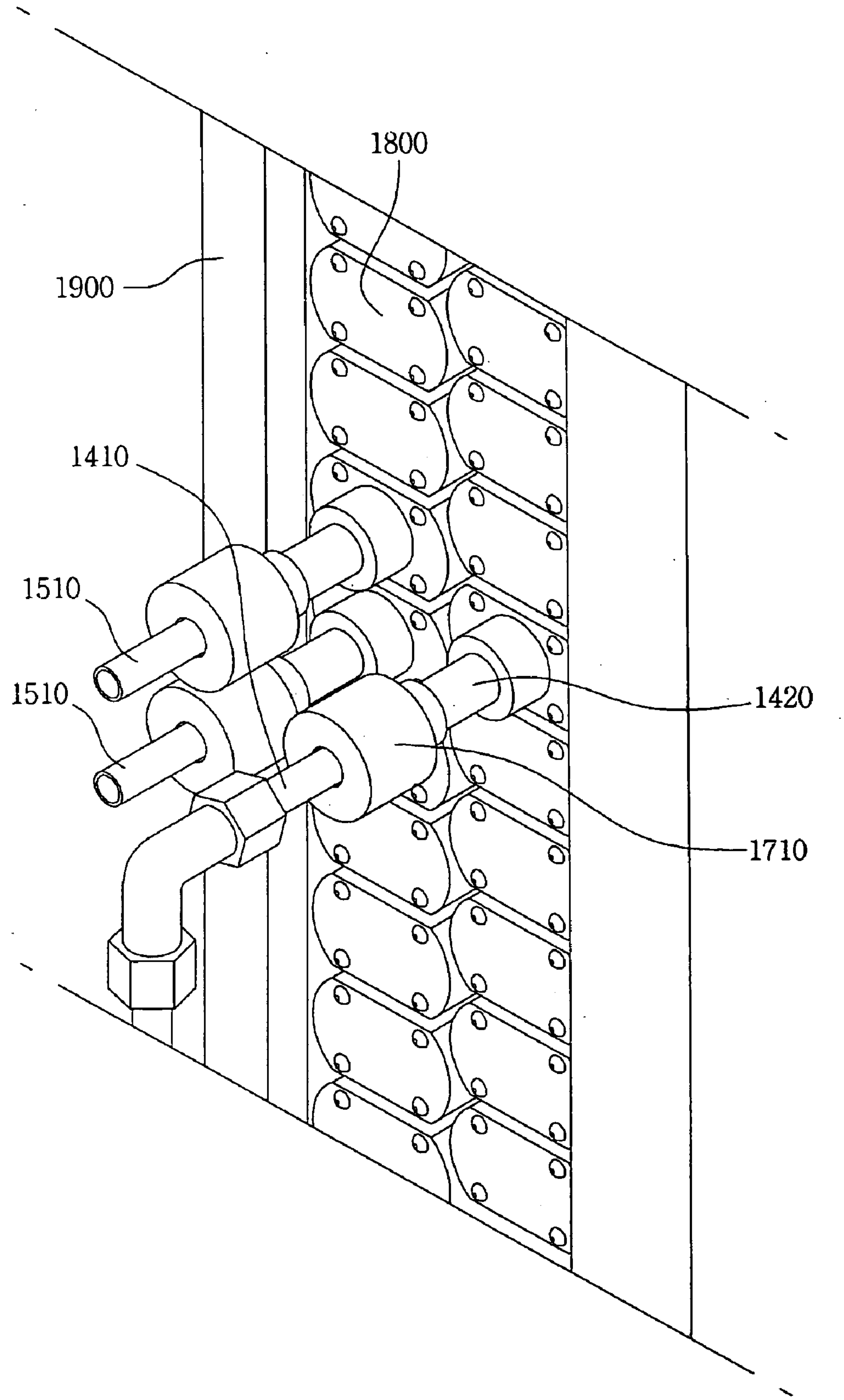


FIG 11

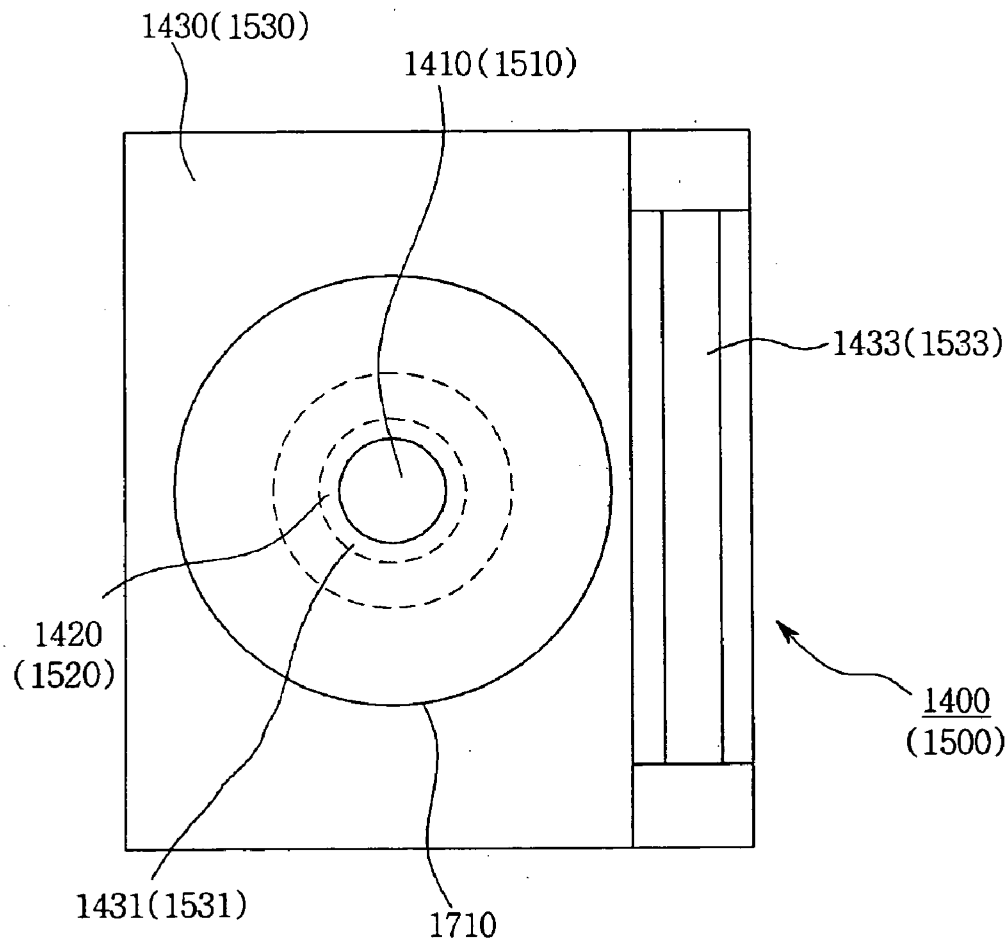

1430(1530)
1410(1510)
1433(1533)
1420
(1520)
1400
(1500)
1431(1531)
1710

FIG 12a

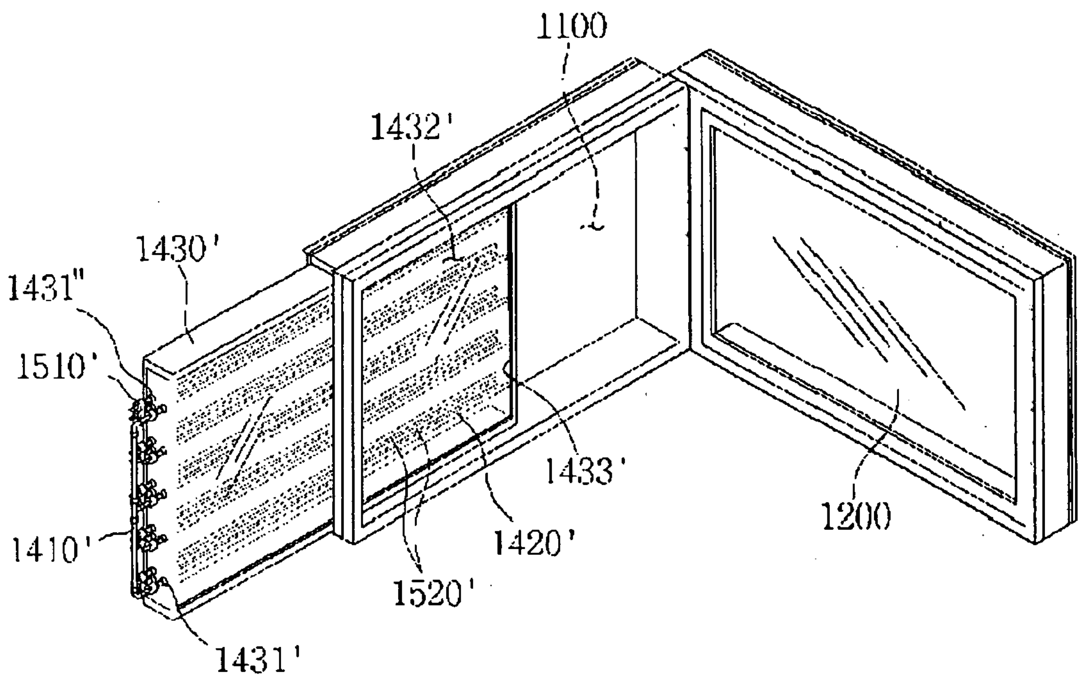


FIG 12b

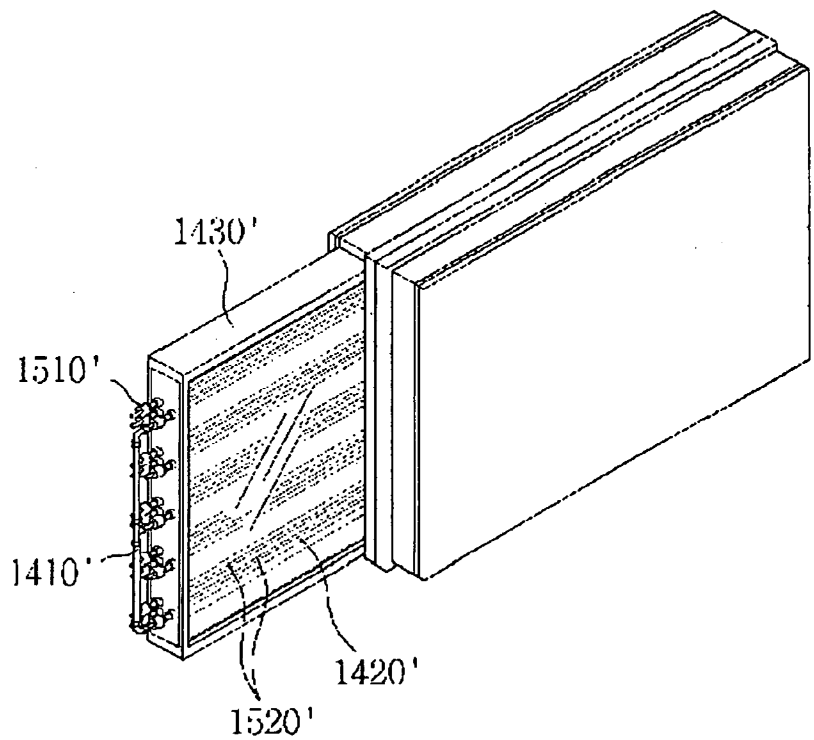
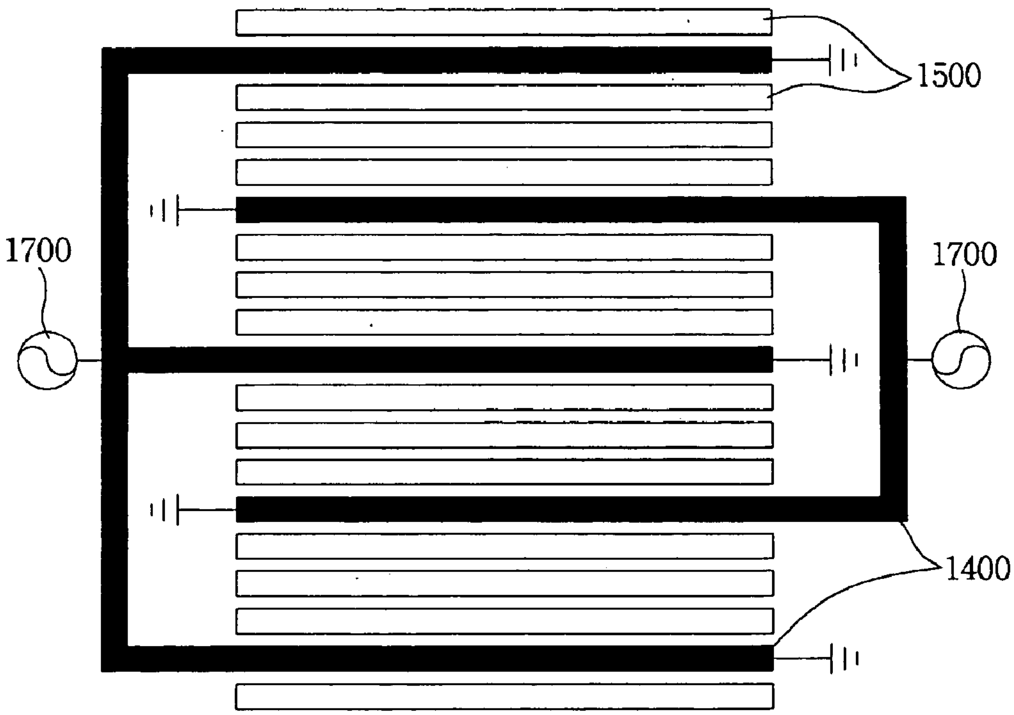


FIG 13



INDUCTIVELY COUPLED PLASMA APPARATUS USING MAGNETIC FIELD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an inductively coupled plasma apparatus using a magnetic field, and more particularly to an inductively coupled plasma apparatus using a magnetic field, in which antennas generating an electric field are aligned in a reaction chamber in parallel to the reaction chamber for performing a plasma etching process and permanent magnets generating the magnetic field are aligned adjacent to the antennas.

[0003] 2. Description of the Prior Art

[0004] Generally, an inductively coupled plasma apparatus includes a spiral type antenna installed at an upper outer portion of a reaction chamber, in which a plasma etching process is carried out, by interposing dielectric material therebetween. In addition, RF induced power is applied to the spiral antenna in order to generate an electric field in the reaction chamber, thereby creating plasma. Such an inductively coupled plasma apparatus has a simple structure as compared with an ECR (electron cyclotron resonance) plasma apparatus or an HWEP (Helicon-wave exited plasma) apparatus, so the inductively coupled plasma apparatus may easily generate plasma over a large area. For this reason, the inductively coupled plasma apparatus has been applied to various fields and research into such inductively coupled plasma apparatuses has been continuously carried out.

[0005] **FIG. 1***a* shows a structure of a chamber **300**' of a conventional inductively coupled plasma apparatus. Hereinafter, the structure of the chamber **300**' of the conventional inductively coupled plasma apparatus will be described.

[0006] An antenna source **100**' is aligned at an uppermost part of the conventional inductively coupled plasma apparatus such that the antenna source **100**' is exposed to an exterior. In addition, a dielectric member **200**' is interposed between the antenna source **100**' and the chamber **300**' so as to insulate the antenna source **100**' from the chamber **300**' while maintaining a vacuum state. An object **400**' to be etched is positioned at a bottom of the chamber **300**'.

[0007] **FIG. 1***b* shows a spiral antenna structure used for the chamber of the inductively coupled plasma apparatus.

[0008] However, such a spiral antenna structure shown in **FIG. 1***b* may cause problems if a size and an area of the object **400**' to be etched become enlarged.

[0009] Firstly, if the chamber has a large area, the size and thickness of the dielectric member for maintaining a vacuum state between the antenna source and the chamber become increased. Thus, a manufacturing cost is increased and efficiency is lowered because a distance between the antenna source and plasma becomes more distant.

[0010] In addition, since a length of the antenna source becomes long as the chamber has a large area, power loss may occur due to resistance of an antenna and etching uniformity may be deteriorated due to unevenness of plasma.

[0011] Furthermore, if a power supply capable of applying power of 13.56 MHz is used, a standing wave effect (two wave pulses having the same amplitude and frequency are traveling in opposition to each other and overlapped with each other so that the wave pulses look like standing waves) may occur at a half wavelength portion of the antenna source, so that it is impossible to further enlarge the size of the chamber.

SUMMARY OF THE INVENTION

[0012] Accordingly, the present invention has been made to solve the above-mentioned problems occurring in the prior art, and a first object of the present invention is to provide an inductively coupled plasma apparatus capable of improving uniformity of plasma.

[0013] A second object of the present invention is to provide an inductively coupled plasma apparatus capable of generating plasma having superior uniformity by adjusting a distance between antennas according to a size of a substrate and preventing a standing wave effect by shortening a length of an antenna source.

[0014] A third object of the present invention is to provide an inductively coupled plasma apparatus capable of preventing accident by maintaining a vacuum state even if a quartz protecting section is damaged by corrosive gas during an etching process and allowing a worker to easily exchange or repair the inductively coupled plasma apparatus.

[0015] In order to accomplish these object, according to one aspect of the present invention, there is provided an inductively coupled plasma apparatus using a magnetic field, the inductively coupled plasma apparatus comprising: a reaction chamber in which a substrate is loaded; an antenna source installed in the reaction chamber and including first and second antennas having antenna rods, which are alternately aligned; and magnets installed above the antenna rods, wherein first sides of the first and second antennas are connected to a power source and second sides of the first and second antennas are grounded.

[0016] According to the preferred embodiment of the present invention, each of the magnets includes a permanent magnet having an N-pole and a permanent magnet having an S-pole.

[0017] According to another aspect of the present invention, there is provided an inductively coupled plasma apparatus using a magnetic field, the inductively coupled plasma apparatus comprising: a reaction chamber in which a substrate is loaded; a plurality of antenna assemblies aligned in parallel to each other by passing through the reaction chamber and having first ends connected to a power source and second ends, which are grounded; and magnet assemblies aligned by passing through the reaction chamber and installed at both sides of antenna rods forming the antenna assemblies, wherein the antenna assembly includes an assembling case formed at both longitudinal ends thereof with perforated holes and having a recess therein formed lengthwise along the assembling case, a quartz window for covering the recess formed in the assembling case, antenna rods inserted into the perforated holes of the assembling case, and a resin pipe installed around the antenna rod such that a vacuum space is formed therebetween, the magnet assembly includes an assembling case formed at both longitudinal ends thereof with perforated holes and having a recess therein formed lengthwise along the assembling case, a quartz window for covering the recess formed in the assembling case, magnets inserted into the perforated holes of the assembling case, and a resin pipe installed around the magnet such that a vacuum space is formed therebetween.

[0018] According to the preferred embodiment of the present invention, the antenna assembly and the magnet assembly are installed in the reaction chamber by interposing an assembling frame therebetween, and the assembling frame freely moves lengthwise along the reaction chamber.

[0019] According to still another aspect of the present invention, there is provided an inductively coupled plasma apparatus using a magnetic field, the inductively coupled plasma apparatus comprising: a reaction chamber in which a substrate is loaded; an assembling frame formed at both longitudinal ends thereof with a plurality of perforated holes and having a recess therein; a quartz window for covering the recess of the assembling frame; a plurality of antenna rods inserted into the perforated holes of the assembling frame and having first ends connected to a power source and second ends, which are grounded; a first resin pipe installed around the antenna rod such that a first vacuum space is formed therebetween; magnets installed at both sides of the antenna rods and inserted into the perforated holes formed in the assembling frame; and a second resin pipe installed around the magnet such that a second vacuum space is formed therebetween.

[0020] According to the preferred embodiment of the present invention, the assembling frame freely moves lengthwise along the reaction chamber.

[0021] A connector is installed between the antenna rod and the resin pipe and an O-ring is installed between the magnet and the resin pipe from an exterior of the reaction chamber.

[0022] Each of the magnets installed at both sides of the antenna rods includes a first permanent magnet having an N-pole and a second permanent magnet having an S-pole.

[0023] The resin pipes include Teflon material.

[0024] The assembling case includes Teflon material.

[0025] The assembling frame includes Teflon material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The above and other objects, features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

[0027] **FIG. 1***a* is a view showing a structure of a conventional plasma apparatus;

[0028] **FIG. 1***b* is a schematic view showing a structure of a conventional ICP source;

[0029] **FIG. 2** is a perspective view showing an inductively coupled plasma apparatus using a magnetic field according to a first embodiment of the present invention;

[0030] **FIG. 3** is a cross-sectional view of **FIG. 2**;

[0031] **FIG. 4** is a graph representing plasma uniformity measured by using a Langmuir probe when a magnetic field is not applied;

[0032] **FIG. 5** is a graph representing plasma uniformity measured by using a Langmuir probe when a magnetic field is applied;

[0033] **FIG. 6** is a graph representing plasma uniformity measured as a function of input power, when a magnetic field is applied and when it is not applied;

[0034] **FIG. 7** is a perspective view showing a module-type inductively coupled plasma apparatus according to a second embodiment of the present invention;

[0035] **FIG. 8** is a perspective view showing an antenna assembly shown in **FIG. 7**;

[0036] **FIG. 9** is an exploded perspective view showing an antenna assembly shown in **FIG. 7**;

[0037] **FIG. 10** is a perspective view showing an external structure of an antenna assembly and a magnet assembly shown in **FIG. 7**;

[0038] **FIG. 11** is a front sectional view showing an antenna assembly or a magnet assembly;

[0039] **FIG. 12***a* is a developed perspective view showing a module-type inductively coupled plasma apparatus according to a third embodiment of the present invention;

[0040] **FIG. 12***b* is an assembled perspective view showing a module-type inductively coupled plasma apparatus according to a third embodiment of the present invention; and

[0041] **FIG. 13** is a plan view showing an alignment of an antenna source and a magnet.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0042] Hereinafter, preferred embodiments of the present invention will be described with reference to the accompanying drawings. In the following description and drawings, the same reference numerals are used to designate the same or similar components, and so repetition of the description on the same or similar components will be omitted.

Embodiment 1

[0043] FIGS. **2** to **6** are views relating to an inductively coupled plasma apparatus according to a first embodiment of the present invention. **FIG. 2** is a perspective view showing the inductively coupled plasma apparatus using a magnetic field according to the first embodiment of the present invention, **FIG. 3** is a cross-sectional view of **FIG. 2**, **FIG. 4** is a graph representing plasma uniformity measured by using a Langmuir probe when a magnetic field is not applied, **FIG. 5** is a graph representing plasma uniformity measured by using a Langmuir probe when a magnetic field is applied, and **FIG. 6** is a graph representing plasma uniformity measured as a function of input power, when a magnetic field is applied and when it is not applied.

[0044] Referring to **FIG. 2**, a stage **20** is installed at a lower portion of a reaction chamber **10** so as to load a substrate (not shown) thereon when an etching process or a deposition process is carried out with respect to the substrate. The stage **20** is preferably moved up and down.

[0045] The reaction chamber **10** is provided at a bottom or a sidewall thereof with an exhaust line connected to a vacuum pump (not shown).

[0046] A bias power applying section is connected to the stage **20** in order to apply bias power to the stage **20**. In addition, a bias voltage measurement unit (not shown) is installed on the stage **20** in order to measure bias voltage applied to the stage **20**.

[0047] Meanwhile, an inner lower portion of the reaction chamber **10** is a plasma source region for generating plasma, in which an antenna source **4** is installed. The antenna source **4** includes antenna rods **410** and **420** alternately aligned in a horizontal direction adjacent to and in parallel to each other while forming a predetermined distance therebetween.

[0048] As shown in **FIG. 3**, the antenna source **4** includes a first comb-type antenna **41** (hereinafter, simply referred to as a first antenna) having a plurality of antenna rods **410**, which are connected to each other in a row, and a second comb-type antenna **42** (hereinafter, simply referred to as a second antenna) having a structure identical to a structure of the first antenna **41**. The first antenna **41** is aligned in opposition to the second antenna **42** in such a manner that the antenna rods **410** and **420** are alternately aligned in parallel to each other. Herein, first sides of the first and second antennas **41** and **42** are connected to an RF induced power section **7** and second sides of the first and second antennas **41** and **42** are grounded.

[0049] According to the first embodiment of the present invention, the first antenna **41** has an m number of antenna rods **410** and the second antenna **42** has an m−1 or m number of antenna rods **420** arrayed in such a manner that each antenna rod **420** of the second antenna **42** is inserted between antenna rods **410** of the first antenna **41**.

[0050] In addition, the antenna rods **410** and **420** are inserted into an antenna protecting pipe **30** in the reaction chamber **10**.

[0051] The antenna protecting pipe **30** includes a quartz pipe having superior endurance against sputtering and the antenna rods **410** and **420** are made from copper, stainless steel, silver, or aluminum.

[0052] First ends of the antenna rods **410** and **420** are grounded and second ends of the antenna rods **410** and **420** are connected to the RF induced power section **7** for the purpose of inductive discharge.

[0053] As shown in **FIG. 3**, magnets **6** are aligned above the antenna rods **410** and **420** of the first and second antennas **41** and **42**. Each of the magnets **6** includes a pair of permanent magnets **62** and **64** having an N-pole and an S-pole, respectively. Since the magnets **6** are aligned above the antenna rods **410** and **420** of the first and second antennas **41** and **42**, a magnetic field is applied to the antenna source **4**.

[0054] In addition, since the permanent magnets **62** and **64** having the N-pole and S-pole are alternately aligned, a direction of the magnetic field created by lines of magnetic force formed between the permanent magnets **62** and **64** is perpendicular to a direction of the electric field so that electrons subject to the magnetic field and the electric field may move with a helical motion.

[0055] Such a situation signifies that moving routes of electrons are increased, so that probability of collision between electrons and neutrons may increase, that is, a collision frequency may increase. As the probability of collision between electrons and neutrons is increased due to the helical motion of the electrons caused by the magnetic field, ion density becomes high and mobility of electrons becomes low, thereby reducing electron loss.

[0056] The permanent magnets **62** and **64** are surrounded by a magnet protecting pipe **40** made from material having superior resistant property against sputtering, such as quartz.

[0057] In order to measure plasma characteristics of the inductively coupled plasma apparatus having the above construction, a Langmuir probe **50** is installed at a lower portion of the antenna source **4** in such a manner that the Langmuir probe **50** protrudes towards a center of the reaction chamber **10** from a sidewall of the reaction chamber **10**.

[0058] The Langmuir probe **50** used in the present invention is available from Hiden Analytical Inc. of Great Britain. The Langmuir probe **50** measures plasma characteristics, such plasma density and plasma uniformity. In addition, Ar gas is injected into the reaction chamber **10** to allow a worker to monitor the plasma characteristics.

[0059] According to the first embodiment of the present invention, the reaction chamber **10** has a hexahedral shape, the antenna source **4** is installed in the reaction chamber **10** in such a manner that the first and second antennas **41** and **42** are alternately aligned in the reaction chamber **10** and induced power is applied to the first and second antennas **41** and **42**, respectively, thereby generating plasma.

[0060] Meanwhile, according to the present invention, RF power passes through a path corresponding to a transverse length of the reaction chamber, the standing wave effect is not created by the antenna source **4**.

[0061] The above-mentioned antenna source **4** can effectively generate plasma over a large discharge area.

[0062] **FIG. 4** is a graph representing plasma uniformity measured by using the Langmuir probe when the magnetic field is not applied, and **FIG. 5** is a graph representing plasma uniformity measured by using the Langmuir probe when the magnetic field is applied.

[0063] That is, as shown in **FIG. 4**, if the magnetic field is not applied to the antenna source, relatively high non-uniformity of 8%, 5% and 9% is represented according to power of 3000 W, 4000 W, and 5000 W. However, as shown in **FIG. 5**, if the magnetic field is applied to the antenna source, relatively low non-uniformity of 3%, 2% and 3% is represented according to power of 3000 W, 4000 W, and 5000 W, which signifies that plasma uniformity is improved.

[0064] Therefore, by applying the magnetic field to the antenna source according to the present invention, plasma uniformity, which is a very important factor for the inductively coupled plasma apparatus, can be significantly improved over the large area.

[0065] **FIG. 6** is a graph representing plasma uniformity measured as a function of input power, when the magnetic field is applied or is not applied. As is understood from **FIG. 6**, non-uniformity of plasma as a function of input power is significantly reduced when the magnetic field is applied to the antenna source than the magnetic field is not applied to the antenna source. The result shown in **FIG. 6** represents that plasma uniformity is significantly improved when the magnetic field is applied to the antenna source.

Embodiment 2

[**0066**] FIGS. **7** to **11** show a structure of an inductively coupled plasma apparatus according to a second embodiment of the present invention.

[**0067**] **FIG. 7** is a perspective view showing a structure of the inductively coupled plasma apparatus according to the second embodiment of the present invention, and FIGS. **8** to **11** represent an antenna assembly shown in **FIG. 7**. A magnet assembly has a structure identical to a structure of an antenna assembly, except that the magnet assembly includes a magnet instead of an antenna.

[**0068**] Referring to **FIG. 7**, a stage **1200** is installed at a lower portion of a reaction chamber **1100** so as to load a substrate (not shown) thereon when an etching process or a deposition process is carried out with respect to the substrate. The stage **1200** is preferably moved up and down. In addition, as shown in **FIG. 7**, the reaction chamber **1100** is divided into an antenna source-magnet part and a bottom part on which the substrate is placed in such a manner that the antenna source-magnet part and the bottom part are assembled with each other only when the etching process or the deposition process is carried out and separated from each other in normal times.

[**0069**] In addition, bias power applying section is connected to the stage **1200** in order to apply bias power to the stage **1200**. In addition, a bias voltage measurement unit (not shown) can be installed on the stage **1200** in order to measure bias voltage applied to the stage **1200**.

[**0070**] Meanwhile, an inner lower portion of a cover **1900** of the reaction chamber **1100** is a plasma source region for generating plasma, in which antenna sources are installed. Each of the antenna sources includes antenna assemblies **1400** aligned in a horizontal direction adjacent to and in parallel to each other while forming a predetermined distance therebetween.

[**0071**] As shown in **FIG. 9**, the antenna source includes a plurality of antenna assemblies **1400** connected to each other in a row. Two comb-type antenna sources are alternately aligned in opposition to each other. Thus, if one antenna source has an m number of antenna assemblies and the other antenna source coupled to one antenna source has an m−1 number of antenna assemblies, each antenna assembly of one antenna source is inserted between antenna assemblies of the other antenna source.

[**0072**] It is also possible to allow two antenna sources to have the same number of antenna assemblies while placing the antenna assemblies in alternated alignment.

[**0073**] A first side of each antenna source is connected to an RF induced power section **1700** and a second side of each antenna source is grounded.

[**0074**] In addition, magnet assemblies **1500** are aligned at both sides of the antenna assembly **1400**.

[**0075**] An antenna rod **1410** is assembled into an assembling frame **1800** of the cover **1900** of the reaction chamber **110** by interposing an assembling case **1430** made from Teflon therebetween. In detail, as shown in FIGS. **8** to **11**, the antenna rod **1410** is inserted into a perforated hole **1431** formed at both longitudinal ends of the assembling case **1430** in such a manner that the antenna rod **1410** is accommodated in a recess **1432** formed in the assembling case **1430** lengthwise along the assembling case **1430**.

[**0076**] In addition, the antenna rod **1410** is surrounded by a resin pipe **1420** such that a vacuum space is formed therebetween. As shown in **FIG. 9** and **FIG. 11**, a vacuum state of the vacuum space may be maintained by installing a connector **1710** and an O-ring **1720** between the antenna rod **1410** and the resin pipe **1420** and between a magnet **1510** and a resin pipe **1520**, respectively, from an exterior of the reaction chamber **1100**.

[**0077**] The resin pipes **1420** and **1520** are made from Teflon material, such as PTFE (polytetrafluoroethylene), PFA (perfluoroalkoxy), FEP (fluoroethylenepropylene), or PVDF (polyvinyulidene fluoride).

[**0078**] In addition, the recess **1432** of the assembling case **1430** is covered with a quartz window **1433**. The quartz window **1433** is aligned in opposition to the stage **1200** in order to protect the antenna rod **1410** against plasma.

[**0079**] Meanwhile, the structure of the magnet assembly **1500** is identical to the structure of the antenna assembly **1400**.

[**0080**] That is, the magnet assembly **1500** includes an assembling case **1530** formed at both longitudinal ends thereof with a perforated hole **1531** and having a recess **1532** formed lengthwise along the magnet assembly **1500**, a quartz window **1533** covering the recess **1532** of the assembling case **1530**, a magnet **1510** inserted into the perforated hole of the assembling case **1530**, and a resin pipe **1520** installed around the magnet **1510** such that a vacuum space is formed therebetween.

[**0081**] In addition, as shown in **FIG. 7**, the magnet assembly **1500** including an N-pole permanent magnet **1510** and an S-pole permanent magnet **1520** is aligned above the antenna assembly **1400**. That is, since the magnet assembly **1500** is positioned above the antenna assembly **1400**, the magnetic field is applied to the antenna source.

[**0082**] In addition, since the N-pole permanent magnet **1510** and the S-pole permanent magnet **1520** are alternately aligned, a direction of the magnetic field created by lines of magnetic force formed between the permanent magnets **1510** and **1520** is perpendicular to a direction of the electric field so that electrons subject to the magnetic field and the electric field may move with a helical motion.

[**0083**] Such a situation signifies that moving routes of electrons are increased, so that probability of collision between electrons and neutrons may increase, that is, a collision frequency may increase. As the probability of collision between electrons and neutrons is increased due to the helical motion of the electrons caused by the magnetic field, ion density becomes high and mobility of electrons becomes low, thereby reducing electron loss.

[**0084**] In addition, since the quartz window is additionally provided while installing the resin pipe made from Teflon between the quartz window and the antenna rod, the vacuum state of the vacuum space may be continuously maintained by means of the resin pipe even if the quartz window is damaged by corrosive gas, so the inductively coupled plasma apparatus can continuously operate without deteriorating performance thereof.

[0085] Meanwhile, the assembling frame **1800** having the antenna assembly **1400** and the magnet assembly **1500** can be installed such that the assembling frame **1800** freely moves lengthwise along the cover **1900** or the reaction chamber **1100**. In this case, it is possible to exchange only the assembling frame **1800** including the antenna assembly **1400** and the magnet assembly **1500** with new one, so the reconstruction of the assembling frame **1800** can be easily achieved.

Embodiment 3

[0086] **FIGS. 12***a* and **12***b* are views showing a structure of an inductively coupled plasma apparatus according to a third embodiment of the present invention.

[0087] As shown in **FIGS. 12***a* and **12***b*, the inductively coupled plasma apparatus according to the third embodiment of the present invention is identical to the inductively coupled plasma apparatus according to the second embodiment of the present invention. That is, the inductively coupled plasma apparatus according to the third embodiment of the present invention includes a reaction chamber **1100** having a stage **1200** for loading a substrate thereon when an etching process or a deposition process is carried out, a plurality of antenna rods **1410'** aligned in parallel to each other in the reaction chamber **1100** and having first ends connected to a power source **1700** and second ends which are grounded, and magnets **1510'** aligned at both sides of the antenna rods **1410'**.

[0088] However, according to the present embodiment, an assembling frame **1430'** is formed at longitudinal ends thereof with a plurality of perforated holes **1431'** and **1431"**, and formed at an inner portion thereof with a recess **1432'** having an area sufficient for covering the stage **1200**.

[0089] In addition, the recess **1432'** of the assembling frame **1430'** is covered with a quartz window **1433'**.

[0090] In this state, the antenna rod **1410'** is inserted into the perforated hole **1431'** of the assembling frame **1430'** assembled with the reaction chamber **1100'**. A resin pipe **1420'**, is installed around the magnet **1510'** such that a vacuum space is formed therebetween.

[0091] In addition, as shown in **FIGS. 12***a* and **12***b*, the assembling frame **1430'** can be freely moved lengthwise along the reaction chamber **1100'**, so it is possible to exchange only the assembling frame **1430'** including the antenna rod **1410'** and the magnet **1510'** with new one, so the reconstruction and repair for the assembling frame **1430'** can be easily achieved.

[0092] As described above, the inductively coupled plasma apparatus according to the present invention has the following advantages.

[0093] First, plasma uniformity can be improved because plasma is generated while applying a magnetic filed to an antenna source having antennas aligned in a row.

[0094] Second, it is possible to generate plasma having superior uniformity by adjusting a distance between antennas according to a size of a substrate.

[0095] Third, since the quartz window is additionally provided while installing the resin pipe made from Teflon between the quartz window and the antenna rod, the vacuum state of the vacuum space may be continuously maintained by means of the resin pipe even if the quartz window is damaged by corrosive gas, so the inductively coupled plasma apparatus can continuously operate without deteriorating performance thereof.

[0096] Fourth, since assembling frame having the antenna assembly and the magnet assembly can be fabricated as a module or with a drawer structure, the assembling frame can be easily exchanged and repairing work thereof can be easily achieved.

[0097] Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

1. An inductively coupled plasma apparatus using a magnetic field, the inductively coupled plasma apparatus comprising:

a reaction chamber in which a substrate is loaded;

an antenna source installed in the reaction chamber and including first and second antennas having antenna rods, which are alternately aligned; and

magnets installed above the antenna rods, wherein first sides of the first and second antennas are connected to a power source and second sides of the first and second antennas are grounded.

2. The inductively coupled plasma apparatus as claimed in claim 1, wherein each of the magnets includes a permanent magnet having an N-pole and a permanent magnet having an S-pole.

3. An inductively coupled plasma apparatus using a magnetic field, the inductively coupled plasma apparatus comprising:

a reaction chamber in which a substrate is loaded;

a plurality of antenna assemblies aligned in parallel to each other by passing through the reaction chamber and having first ends connected to a power source and second ends, which are grounded; and

magnet assemblies aligned by passing through the reaction chamber and installed at both sides of antenna rods forming the antenna assemblies, wherein the antenna assembly includes an assembling case formed at both longitudinal ends thereof with perforated holes and having a recess therein formed lengthwise along the assembling case, a quartz window for covering the recess formed in the assembling case, antenna rods inserted into the perforated holes of the assembling case, and a resin pipe installed around the antenna rod such that a vacuum space is formed therebetween, the magnet assembly includes an assembling case formed at both longitudinal ends thereof with perforated holes and having a recess therein formed lengthwise along the assembling case, a quartz window for covering the recess formed in the assembling case, magnets inserted into the perforated holes of the assembling case, and a resin pipe installed around the magnet such that a vacuum space is formed therebetween.

4. The inductively coupled plasma apparatus as claimed in claim 3, wherein the antenna assembly and the magnet assembly are installed in the reaction chamber by interposing an assembling frame therebetween, and the assembling frame freely moves lengthwise along the reaction chamber.

5. An inductively coupled plasma apparatus using a magnetic field, the inductively coupled plasma apparatus comprising:

a reaction chamber in which a substrate is loaded;

an assembling frame formed at both longitudinal ends thereof with a plurality of perforated holes and having a recess therein;

a quartz window for covering the recess of the assembling frame;

a plurality of antenna rods inserted into the perforated holes of the assembling frame and having first ends connected to a power source and second ends, which are grounded;

a first resin pipe installed around the antenna rod such that a first vacuum space is formed therebetween;

magnets installed at both sides of the antenna rods and inserted into the perforated holes formed in the assembling frame; and

a second resin pipe installed around the magnet such that a second vacuum space is formed therebetween.

6. The inductively coupled plasma apparatus as claimed in claim 5, wherein the assembling frame freely moves lengthwise along the reaction chamber.

7. The inductively coupled plasma apparatus as claimed in claim 3, wherein a connector is installed between the antenna rod and the resin pipe and an O-ring is installed between the magnet and the resin pipe from an exterior of the reaction chamber.

8. The inductively coupled plasma apparatus as claimed in claim 3, wherein each of the magnets installed at both sides of the antenna rods includes a first permanent magnet having an N-pole and a second permanent magnet having an S-pole.

9. The inductively coupled plasma apparatus as claimed in claim 3, wherein the resin pipes include Teflon material.

10. The inductively coupled plasma apparatus as claimed in claim 3, wherein the assembling case includes Teflon material.

11. The inductively coupled plasma apparatus as claimed in claim 3, wherein the assembling frame includes Teflon material.

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