[0006] In some examples, the tubing section comprises one of: a super high conductive copper, or silver plated stainless steel.

[0007] In some examples, the first terminal is welded to the first end of the tubing section, and wherein the second terminal is welded to the second end of the tubing section.

[0008] In some examples, the first end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

[0009] In some examples, the second end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

[0010] A method for forming a coil for generating an RF field in a semiconductor fabrication apparatus is provided. In some embodiments, the method involves forming a tubing section of the coil with a single piece of tubing such that the tubing section forms two turns. The method may further involve bending a second end of the tubing section toward a first end of the tubing section. The method may further involve bending the second end of the tubing section and the first end of the tubing section at an angle to the two turns. The method may further involve attaching a first terminal to the first end of the tubing section and attaching a second terminal to the second end of the tubing section.

[0011] In some examples, the second end of the tubing section is bent such that it overlaps the first end of the tubing section.

[0012] In some examples, the tubing section comprises super high conductive copper.

[0013] In some examples, the tubing section comprises silver plated stainless steel.

[0014] In some examples, the first terminal is welded to the first end of the tubing section, and wherein the second terminal is welded to the second end of the tubing section.

[0015] In some examples, the first end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

[0016] In some examples, the second end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

[0017] A semiconductor processing tool is provided according to some embodiments. The tool may comprise: an RF source; one or more process stations, each configured to receive and

portions that are welded together. The tubing may be comprised of super high conductive copper or silver plated stainless steel. An example of a coil in accordance with what is disclosed herein is shown in and described below in connection with Figures 3A and 3B, and a method of forming such a coil is shown in and described below in connection with Figure 6.

[0034] Figure 1A illustrates a receptacle 102 and a coil 104 having a first configuration. Receptacle 102 may be made of ceramic or another similar material. Receptacle 102 may be configured to receive a gas from a gas source and to convert the received gas to a plasma. The plasma may then be disposed within a process station to, e.g., perform plasma-based operations (e.g., plasma-based deposition operations, plasma-based etching operations, etc.) on one or more wafers to be processed. The plasma may be generated using an RF field that is in turn generated using coil 104. As illustrated, coil 104 is disposed around a portion of receptacle 102 such that the RF field generated using coil 104 causes process gases within receptacle 102 to be converted to plasma. One terminal of coil 104 may be operatively coupled to an RF source (e.g., an RF generator), and a second terminal of coil 104 may be operatively coupled to a ground. Accordingly, coil 104, when coupled to the RF source and receiving an RF signal from the RF source, may in turn produce an RF field that causes process gases within receptacle 102 to be converted to plasma.

[0035] Figure 1B illustrates a three-dimensional view of coil 104. As illustrated, a first terminal 122 of coil 104 is operatively coupled to an RF source (not shown), and a second terminal 124 of coil 104 is operatively coupled to a ground (not shown). Note that a receptacle (e.g., receptacle 102 of Figure 1A), if present in the diagram of Figure 1B, would be positioned within an interior portion of coil 104. Figure 1C illustrates a top-view of coil 104. Figure 1C additionally illustrates the RF source 152 the first terminal of the coil is operatively coupled to and a ground the second terminal of the coil is operatively coupled to. Note that first terminal 122 and second terminal 124 would be positioned against the receptacle. Additionally, note that due to terminal 122, in some regions, coil 104 has two turns, whereas in the region proximate to terminal 122, coil 104 has an additional turn, or coil portion.

[0036] The positioning of the terminals against the receptacle, as well as the non-uniformity of the coil with respect to turns of the coil, may cause non-uniformities in the RF field when utilizing the coil shown in Figures 1A, 1B, and 1C. Non-uniformities in the RF field may in turn lead to plasma non-uniformities. Plasma non-uniformities may cause defects in fabricated wafers, such as uneven thicknesses of deposited or etched materials. An example of a non-uniform RF field that may be generated by the coil shown in Figures 1A, 1B, and 1C is illustrated in Figure 2.

Figure 2 is a color-scale plot illustrating the magnitude of the RF field at different regions of a receptacle. Note that the RF field in region 202, corresponding to the region of the coil of the first terminal and the second terminal, exhibits RF field non-uniformities.

[0037] Disclosed herein is a coil and a method for manufacturing a coil that is configured to generate a more uniform RF field within a receptacle. The more uniform RF field in turn generates a more uniform plasma, leading to less defects in processed wafers. In some embodiments, the coil disclosed herein has a tubing section formed into two turns. The two turns may be configured to encircle a receptacle (sometimes referred to herein as "a plasma receptacle" and/or "a plasma container"). A first end of the tubing may have a first terminal attached, where the first terminal is configured to be operatively coupled to an RF source, such as an RF generator. A second end of the tubing may have a second terminal attached, wherein the second terminal is configured to be operatively coupled to a ground. In some embodiments, the tubing may be made of a super high conductive copper. Alternatively, in some embodiments, the tubing may be made of silver-plated stainless steel. The first and second terminals may be welded to the tubing. In some embodiments, the first end of the tubing and the second end of the tubing may be bent at an angle away from the two turns that encircle the receptacle. The bending of the tubing away from the receptacle may cause the tubing to have a more uniform number of turns in all regions around the receptacle, thereby leading to an improved uniformity of the RF field. In some embodiments, the first and second terminal may be bent away from the two turns at an angle. The angle may be within a range of about 60 to 100 degrees, within a range of about 70 to 90 degrees, or at substantially about 90 degrees. In some embodiments, the first end of the tubing and the second end of the tubing may be bent such that the first end and the second end overlap, or are pinched together. The overlap of the first end and the second end, which are in turn operatively coupled to the RF source and the ground, respectively, may generate an improved uniformity in the RF field.

[0038] Figures 3A and 3B illustrate an example coil 302 for generating an RF field in accordance with some embodiments. As illustrated in Figure 3A, a first end of coil 302 is bent at section 304 away from the two turns of coil 302. The first end of coil 302 terminates at first terminal 306, which is configured to be operatively coupled to an RF source. A second end of coil 302 is bent at section 308 away from the two turns of coil 302. The second end of coil 302 terminates at second terminal 310, which is configured to be operatively coupled to a ground. Note that, due to bending of the ends of the tubing away from the two turns of the coil, the coil exhibits more uniformity in turns around a receptacle that would be positioned within the two turns, which leads to a higher uniformity in the generated RF field relative to the coil shown in and described above in connection with Figures 1A-1C. Additionally, note that in the ends of coil 302

are overlapped with one another as illustrated in Figure 3A, which additionally generates a higher uniformity in the RF field.

[0039] Figure 3B illustrates a diagram of coil 302 around a receptacle 304. Note the turns of coil 302 are more uniform around regions of receptacle 304 than the coil shown in and described above in connection with Figure 1A.

[0040] Figure 4 shows an example RF field generated using the coil shown in and described above in connection with Figures 3A and 3B. as illustrated, the RF field of Figure 4 is more uniform in all regions, including the regions proximate the coil terminals, compared to the RF field shown in and described above in connection with Figure 2.

[0041] In some embodiments, multiple coils, e.g., multiple instances of the coil shown in and described above in connection with Figures 3A and 3B, may be utilized in multiple stations of a multi-station process chamber. For example, each station may have a plasma receptacle and a coil may be disposed around a portion of the plasma receptacle of the station. As a more particular example, given a multi-station process chamber having four stations, there may be four plasma receptacles, each associated with one of the four stations. Continuing with this example, each plasma receptacle may have a coil (e.g., the coil shown in and described above in connection with Figures 3A and 3B). Each coil may be operatively coupled to an RF source associated with the process chamber. Note that, in some embodiments, each station of a multi-station process chamber may have its own RF source.

[0042] Figure 5 illustrates a top view of an example multi-station process chamber 500 in accordance with some embodiments. Multi-station process chamber 500 includes four process stations, stations 502, 504, 506, and 508. Each station is associated with a coil (e.g., coils 510, 512, 514, and 516) disposed around a region of a plasma receptacle (not shown). Note that although multi-station process chamber 500 includes four stations, in some embodiments, a multi-station process chamber may include two, six, eight, etc. stations.

[0043] In some embodiments, a coil may be formed primarily of a single piece of tubing rather than by multiple segments that are connected together to form the turns of the coil. The single piece of tubing may be bent to form two turns of the coil. A second end of the tubing may then be bent toward a first end of the tubing. For example, the second end of the tubing may be bent toward the first end such that the first end and the second end of the tubing overlap to at least some degree. The first and second ends of the tubing may be bent at an angle to the two turns such that the first and second ends of the tubing, when the tubing is disposed around a region of the plasma

CLAIMS

1. A coil for generating a radio frequency (RF) field in a semiconductor fabrication apparatus, the coil comprising:

a tubing section formed into two turns, the two turns configured to encircle a plasma container of the semiconductor fabrication apparatus, wherein a second end of the tubing section is bent toward a first end of the tubing section, and wherein the first end of the tubing section and the second end of the tubing section are bent at an angle from the two turns;

a first terminal attached to the first end of the tubing section, wherein the first terminal is configured to be operatively coupled to an RF source; and

a second terminal attached to the second end of the tubing section, wherein the second terminal is configured to be operatively coupled to a ground.

2. The coil of claim 1, wherein the second end of the tubing section is bent such that it overlaps the first end of the tubing section.

3. The coil of claim 1, wherein the tubing section comprises a metal.

4. The coil of claim 3, wherein the tubing section comprises one of: a super high conductive copper, or silver plated stainless steel.

5. The coil of any one of claims 1-4, wherein the first terminal is welded to the first end of the tubing section, and wherein the second terminal is welded to the second end of the tubing section.

6. The coil of any one of claims 1-4, wherein the first end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

7. The coil of any one of claims 1-4, wherein the second end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

8. A method for forming a coil for generating a radio frequency (RF) field in a semiconductor fabrication apparatus, the method comprising:

forming a tubing section of the coil with a single piece of tubing such that the tubing section forms two turns;

bending a second end of the tubing section toward a first end of the tubing section;

bending the second end of the tubing section and the first end of the tubing section at an angle to the two turns; and

attaching a first terminal to the first end of the tubing section and attaching a second terminal to the second end of the tubing section.

9. The method of claim 8, wherein the second end of the tubing section is bent such that it overlaps the first end of the tubing section.

10. The method of claim 8, wherein the tubing section comprises super high conductive copper.

11. The method of claim 8, wherein the tubing section comprises silver plated stainless steel.

12. The method of claim 8, wherein the first terminal is welded to the first end of the tubing section, and wherein the second terminal is welded to the second end of the tubing section.

13. The method of any one of claims 8-12, wherein the first end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

14. The method of any one of claims 8-12, wherein the second end of the tubing section is bent at an angle from the two turns that is within a range of about 60 degrees to 100 degrees.

15. A semiconductor processing tool, comprising:

an RF source;

one or more process stations, each configured to receive and process a semiconductor wafer;

one or more receptacles configured to receive a gas from a gas source and to convert the received gas to a plasma for dispersing the plasma to the one or more process stations; and

a coil, the coil comprising:

a tubing section formed into two turns, the two turns configured to encircle one of the one or more receptacles, wherein a second end of the tubing section is bent toward a first end of the tubing section, and wherein the first end of the tubing section and the second end of the tubing section are bent at an angle from the two turns;

a first terminal attached to the first end of the tubing section, wherein the first terminal is configured to be operatively coupled to the RF source; and

a second terminal attached to the second end of the tubing section,

wherein the second terminal is configured to be operatively coupled to a ground.