Capacitors suitable for this purpose are expensive and bulky.

SUMMARY OF THE INVENTION

[0007] The present invention provides an antenna structure for generating plasma by using a dielectric antenna. The present inventors have determined that such antennas when fabricated with the material having high dielectric constant and low dielectric losses can be operated at resonance to provide for high field strengths with low power dissipation.

[0008] While the inventors do not wish to be bound by a particular theory, it is understood that the invention replaces "conduction" current of electrons in a conventional coil with "polarization" current of electrons in the dielectric material. The polarization current is due to the minor displacement of elementary charges bound to molecules of the dielectric material under the influence of an electric field. Both types of current (conduction current and polarization current) produce a magnetic field and an induced electric field according to the same laws of electromagnetism. However, since the dielectric material is at once its own capacitor and an inductor, the electric-potential is exactly zero everywhere inside the dielectric and in the space around the dielectric. Parasitic capacitive coupling is therefore entirely eliminated and the electric field is produced solely by induction. It is further believed that improved current distribution is obtained through lack of "skin" effects in the dielectric material that cause conductive current flow, unlike polarization current, to concentrate in the outermost portions of a ring structure.

[0009] Specifically then, a first aspect of the present invention provides a plasma generator comprising a dielectric resonator structure having a central axis and a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure along a circumferential direction about the axis to generate plasma in an adjacent gas.

[0010] It is thus a feature of at least one embodiment of the invention to provide an improved radiofrequency antenna for the generation of intense but uniform electrical

[0024] It is thus a feature of at least one embodiment of the invention to provide a plasma generator that may automatically adjust to variations in the dielectric resonant material or its environment.

[0025] The radiofrequency power source may be a magnetron or a solid-state or vacuum tube oscillator.

[0026] It is thus a feature of at least one embodiment of the invention to permit the generation of extremely high frequency plasma.

[0027] These particular objects and advantages may apply to only some embodiments falling within the claims and thus do not define the scope of the invention.

[0027a] There is also disclosed an optical spectroscope comprising a plasma generator including a dielectric resonator structure and a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure about the axis to generate plasma in an adjacent gas, an introducer nozzle for introducing gas and material to be studied into a plasma generated by the plasma generator; and an optical sensor for measuring frequency of light emitted by the material when heated by the plasma.

[0027b] A second aspect of the present invention provides a mass spectroscope comprising a plasma generator including a dielectric resonator structure having a central axis and a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure along a circumferential direction about the axis to generate plasma in an adjacent gas, an introducer nozzle for introducing gas and material to be studied into a plasma generated by the plasma generator; and an ion sensor for measuring mass to charge ratio of ions of the material produced when heated by the plasma.

[0027c] A third aspect of the present invention provides a method of generating plasma using a plasma generator including a dielectric resonator structure having a central axis and a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure along a circumferential direction about the axis to generate plasma in an adjacent gas, the

CLAIMS

We claim:

1. A plasma generator comprising:

a dielectric resonator structure having a central axis; and

a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure along a circumferential direction about the axis to generate plasma in an adjacent gas.

2. The plasma generator of claim 1 wherein the dielectric resonator has a quality factor of greater than 100.

3. The plasma generator of claim 1 wherein the dielectric resonator has electrical resistivity greater than $1x10^{10}$ $\Omega \cdot cm$.

4. The plasma generator of claim 1 wherein the dielectric resonator has a melting point greater than a melting point of copper.

5. The plasma generator of claim 1 wherein dielectric resonator has a dielectric constant with a loss tangent of less than 0.01.

6. The plasma generator of claim 1 wherein the dielectric resonator has a dielectric constant of greater than five.

7. The plasma generator of claim 1 wherein a material of the dielectric resonator is selected from the group consisting of alumina (Al_2O_3) and calcium titanate ($CaTiO_3$).

8. The plasma generator of claim 1 wherein the dielectric resonator is a ring having a central opening along the axis.

9. The plasma generator of claim 8 wherein the ring has a central opening of at least one millimeter in diameter or at least one half inch in diameter

10. The plasma generator of claim 8 further including a gas port introducing gas into the ring along an axis of the ring

11. The plasma generator of claim 1 wherein the radiofrequency power source automatically seeks the natural resonant frequency of the dielectric resonator structure to output radiofrequency power at the natural resonant frequency of the dielectric resonator structure.

12. The plasma generator of claim 1 wherein the radiofrequency power source is a magnetron

13. The plasma generator of claim 1 wherein the radiofrequency power source output power in a range from 20 to 1000 megahertz.

14. The plasma generator of claim 1 wherein the radiofrequency power source outputs power in a range including at least one frequency selected from the group consisting of 13.56MHz, 27MHz, 40MHz, 60MHz, 430MHz, 915MHz, 2450MHz.

15. The plasma generator of any of the preceding claims incorporated into any of ~~the structure of~~ an optical laser, a plasma torch, a rocket engine, an electron-cyclotron plasma or ion source, an inductively coupled plasma source for semiconductor processing, ~~and~~ or an ion cyclotron plasma heater.

16. A mass spectroscope comprising:

a plasma generator including a dielectric resonator structure having a central axis and a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure along a circumferential direction about the axis to generate plasma in an adjacent gas;

an introducer nozzle for introducing gas and material to be studied into a plasma generated by the plasma generator; and

an ion sensor for measuring mass to charge ratio of ions of the material produced when heated by the plasma.

17. A method of generating plasma using a plasma generator including a dielectric resonator structure having a central axis and a radiofrequency power source electrically coupled to the dielectric resonator structure to promote an alternating polarization current flow at a natural resonant frequency of the dielectric resonator structure along a circumferential direction about the axis to generate plasma in an adjacent gas, the method comprising the steps of

(a) introducing a gas into a region adjacent to the dielectric resonator structure; and

(b) exciting the dielectric resonator structure at a natural resonant frequency to generate plasma in the introduced gas.