examples of a memory device include a flash memory, a non-transitory computer-readable storage medium, a redundant array of storage disks (RAID), a hard disk, etc.

[0034] The plasma system 100 further includes the impedance matching network 102 that is coupled to the x, y, and z MHz RF generators. The impedance matching network 102 is coupled to the x MHz RF generator via the RF cable 104A, to the y MHz RF generator via another RF cable 104B, and to the z MHz RF generator via an RF cable 104C.

[0035] In some embodiments, the impedance matching network 102 includes a network of RF electrical circuit elements, e.g., capacitors, inductors, etc., coupled with each other.

[0036] The impedance matching network 102 is coupled to the plasma chamber 112 via the RF transmission line 114. In various embodiments, the RF transmission line 114 includes a cylinder, e.g., a tunnel, etc., that is connected to the impedance matching network 102. Within a hollow of the cylinder lies an insulator and an RF rod. The RF transmission line 114 further includes an RF spoon, e.g., an RF strap, etc., that is coupled at one end to the RF rod of the cylinder. The RF spoon is coupled at another end to an RF rod of a vertically placed cylinder and the RF rod is coupled to a chuck 164 of the plasma chamber 112.

[0037] The plasma chamber 112 includes the chuck 164, an upper electrode 166, and other parts (not shown), e.g., an upper dielectric ring surrounding the upper electrode 166, an upper electrode extension surrounding the upper dielectric ring, a lower dielectric ring surrounding a lower electrode of the chuck 164, a lower electrode extension surrounding the lower dielectric ring, an upper plasma exclusion zone (PEZ) ring, a lower PEZ ring, etc. The upper electrode 166 is located opposite to and facing the chuck 164. A work piece 168 is supported on an upper surface 171 of the chuck 164. Each of the lower electrode and the upper electrode 166 is made of a metal, e.g., aluminum, alloy of aluminum, copper, etc. The chuck 164 may be an electrostatic chuck (ESC) or a magnetic chuck. The upper electrode 166 is coupled to a reference voltage, e.g., a ground voltage, a zero voltage, a negative voltage, etc.

[0038] In some embodiments, the work piece 168 includes a semiconductor wafer. Various processes, e.g., chemical vapor deposition, cleaning, deposition, physical vapor deposition (PVD), chemical vapor deposition (CVD), plasma-enhanced CVD (PECVD), metal CVD, a high-density plasma CVD (HDP-CVD) function, a photoresist strip function, a photoresist surface preparation, ultraviolet thermal processing (UVTP), sputtering,

The cable power loss $P_{delloss}$ is a product of the theoretical power $P_{deltheor}$, the cable power attenuation fraction A, and a term. The term includes a ratio of a sum of one and the RF power reflection ratio Γ^2 and a difference of one and the RF power reflection ratio Γ^2. In some embodiments, the cable power loss $P_{delloss}$ is loss of delivered power occurring within the RF cable 104A. Similarly, the processor 110 computes cable power losses associated with the RF cables 104B and 104C.

[0053] The processor 110 calculates actual power $P_{delactual}$ to be delivered to the impedance matching network 102 by the x MHz RF generator based on the theoretical delivered power $P_{deltheor}$ and the cable power loss $P_{delloss}$. For example, the actual power $P_{delactual}$ is computed as a difference between the delivered power $P_{deltheor}$ and the cable power loss $P_{delloss}$ of the RF cable 104A. Similarly, the processor 110 calculates actual powers to be delivered to the impedance matching network 102 by the y and z MHz RF generators.

[0054] In some embodiments, the processor 110 sends the calculated actual power $P_{delactual}$ via a cable 174A to the DSP 160 of the x MHz RF generator. Similarly, the processor 110 sends calculated actual powers corresponding to the y and z MHz RF generators via cables 174B and 174C to the DSPs of the y and z MHz RF generators. Examples of each cable 174A, 174B, and 174C include a cable that facilitates a parallel transfer of data, a cable that facilitates a serial transfer of data, and a USB cable.

[0055] The DSP 160 receives the calculated actual power $P_{delactual}$ and retrieves, e.g., reads, etc., a drive actual power value corresponding to the actual power $P_{delactual}$ and provides the drive actual power value to the RF supply 162. For example, the DSP 160 identifies, within a look-up table, stored within a memory device of the x MHz RF generator the drive actual power value corresponding to the calculated actual power $P_{delactual}$. As another example, the drive actual power value is the same as the calculated actual power $P_{delactual}$. Similarly, DSPs of the y and z MHz RF generators receive calculated actual power values from the processor 110 via the cables 174B and 174C and retrieve drive actual power values, which are provided to RF supplies of the y and z MHz RF generators.

[0056] The RF supply 162 includes a driver (not shown) and an amplifier (not shown), which is connected to the driver. The driver of the RF supply 162 receives the drive actual power value from the DSP 160 and generates an RF signal having the drive actual power value. The amplifier of the RF supply 162 amplifies, e.g., increases a magnitude of, etc., the generated RF signal and sends the amplified RF signal via the RF cable 104A to the

CLAIMS

1. A method for modeling cable loss, comprising:

receiving a measurement of reverse power at a radio frequency (RF) generator, the RF generator coupled via an RF cable to an input of an impedance matching network, the impedance matching network coupled via an RF transmission line to a plasma chamber, the RF generator having a frequency of operation;

receiving a measurement of forward power at the RF generator;

computing a theoretical power delivered to the impedance matching network as a difference between the forward power and the reverse power;

calculating a ratio of the reverse power to the forward power to generate an RF power reflection ratio;

identifying a cable power attenuation fraction of the RF cable based on the frequency of operation of the RF generator and a length of the RF cable;

calculating a cable power loss as a function of the RF power reflection ratio, the cable power attenuation fraction, and the theoretical power;

calculating an actual power to be delivered to the input of the impedance matching network based on the theoretical power and the cable power loss; and

sending the calculated actual power to the RF generator to generate an RF signal,

wherein the method is executed by a processor.

2. The method of claim 1, wherein the measurements of the forward and reverse powers are received from a complex voltage and current sensor, the complex voltage and current sensor coupled to an output of the RF generator to measure the reverse power at the RF generator and to measure the forward power at the RF generator.

3. The method of claim 1, wherein the reverse power includes reflected power, wherein the reflected power includes power reflected towards the RF generator from the plasma chamber.

4. The method of claim 1, wherein the RF generator includes an RF power supply and a digital signal processor (DSP) coupled to the RF power supply, the DSP used for providing a value of power of the RF signal to the RF power supply.

5. The method of claim 1, wherein the impedance matching network is used for matching an impedance of a load with that of a source, the load coupled to the impedance matching network at one end of the matching network and the source coupled to the matching network at another end of the matching network.

6. The method of claim 1, wherein the RF transmission line includes an RF rod that is coupled to an RF strap and includes an additional RF rod, the additional RF rod coupled to the RF strap at one end of the additional RF rod and coupled to a chuck of the plasma chamber at another end of the additional RF rod.

7. The method of claim 1, wherein the plasma chamber includes a chuck and an upper electrode, the upper electrode facing the chuck.

8. The method of claim 1, wherein the forward power includes power supplied by the RF generator.

9. The method of claim 1, further comprising identifying the frequency of operation from a list of frequencies, wherein identifying the cable power attenuation fraction comprises determining the cable power attenuation fraction as corresponding to the frequency of operation.

10. The method of claim 1, wherein calculating the cable power loss as the function of the RF power reflection ratio, the cable power attenuation fraction, and the theoretical power comprises:

calculating a sum of one and the RF power reflection ratio to generate a first result;

calculating a difference between one and the RF power reflection ratio to generate a second result;

computing a ratio of the first result to the second result to generate a third result;

computing a product of the theoretical power, the cable power attenuation fraction, and the third result to generate the cable power loss.

11. The method of claim 1, wherein calculating the actual power to be delivered to the impedance matching network based on the theoretical power and the cable power loss comprises calculating the actual power as a difference between the theoretical power and the cable power loss.

12. The method of claim 1, wherein the RF signal has power that is generated based on the calculated actual power.

13. A method comprising:

receiving a measurement of reverse power at a radio frequency (RF) generator, the RF generator coupled via an RF cable to an input of an impedance matching network, the impedance matching network coupled via an RF transmission line to a plasma chamber, the RF generator having a frequency of operation;

receiving a measurement of forward power at the RF generator;

computing a theoretical power delivered to the impedance matching network as a difference between the forward power and the reverse power;

calculating a ratio of the reverse power to the forward power to generate an RF power reflection ratio;

identifying a cable power attenuation fraction of the RF cable based on the frequency of operation of the RF generator and a length of the RF cable;

calculating a cable power loss as a function of the RF power reflection ratio, the cable power attenuation fraction, and the theoretical delivered power;

calculating an actual power to be delivered to the input of the impedance matching network based on the theoretical delivered power and the cable power loss;

determining an actual power at a node associated with a computer-generated model based on the actual power to be delivered to the input of the impedance matching network; and

sending the actual power at the node to the RF generator to control the RF generator, wherein sending the actual power at the node to the RF generator to control the RF generator

comprises sending a value of the actual power at the node for generating an RF signal to achieve a threshold,

wherein the method is executed by a processor.

14. The method of claim 13, wherein the measurements of the forward and reverse powers are received from a complex voltage and current sensor, the complex voltage and current sensor coupled to an output of the RF generator to measure the reverse power at the RF generator and to measure the forward power at the RF generator.

15. The method of claim 13, wherein determining the actual power at the node based on the actual power to be delivered to the input of the impedance matching network comprises propagating the actual power to be delivered to the input of the impedance matching network via the computer-generated model to calculate a value of the actual power at the node.

16. The method of claim 15, wherein propagating the actual power to be delivered to the input of the impedance matching network comprises calculating a directional sum of the actual power to be delivered to the input of the impedance matching network and one or more power values associated with one or more electrical circuit components of the computer-generated model.

17. The method of claim 13, wherein the node includes an input node at an input of the computer-generated model, or an output node at an output of the computer-generated model, or an intermediate node within the computer-generated model.

18. A plasma system comprising:

a radio frequency (RF) generator for supplying forward power, the RF generator having a frequency of operation;

an impedance matching circuit having an input coupled to the RF generator for receiving the forward power and to generate a modified RF signal based on the forward power;

an RF cable coupling the RF generator to the impedance matching circuit to facilitate a transfer of the forward power to the impedance matching circuit;

a plasma chamber coupled to the impedance matching circuit via an RF transmission line, the plasma chamber for generating plasma based on the modified RF signal;

a sensor coupled to the RF generator to measure the forward power and to measure reverse power, the reverse power reflected from the plasma towards the RF generator via the RF cable;

a host system coupled to the sensor for receiving the measurement of the forward power and the reverse power,

wherein the host system is configured to:

compute a theoretical power delivered to the impedance matching circuit as a difference between the forward power and the reverse power;

calculate a ratio of the reverse power to the forward power to generate an RF power reflection ratio;

identify a cable power attenuation fraction of the RF cable based on the frequency of operation of the RF generator and a length of the RF cable;

calculate a cable power loss as a function of the RF power reflection ratio, the cable power attenuation fraction, and the theoretical delivered power;

calculate an actual power to be delivered to the input of the impedance matching circuit based on the theoretical delivered power and the cable power loss; and

send the calculated actual power to the RF generator to control the RF generator.

19. The plasma system of claim 18, wherein the impedance matching circuit lacks a connection to a sensor used to measure forward power at the impedance matching circuit and reverse power reflected at the impedance matching circuit.