Summary

[0004] Embodiments of the disclosure provide apparatus, methods and computer programs for tuning a parameter associated with plasma impedance. It should be appreciated that the present embodiments can be implemented in numerous ways, e.g., a process, an apparatus, a system, a device, or a method on a computer-readable medium. Several embodiments are described below.

[0005] In an embodiment, a plasma system is provided. In the plasma system, a parameter, e.g., frequency, power, capacitance, inductance, etc., is tuned to a value based on a local minima of a variable. Examples of the variable include source impedance at an input of an impedance matching circuit of the plasma system, gamma that is associated with plasma of the plasma system, reflected power, etc. The local minima is determined based on stability of the variable when the parameter is assigned one or more values and/or based on whether the variable exceeds a threshold when the parameter is assigned the one or more values. When the local minima is used, a quick resolution of a value of the parameter is achieved and the resolution is satisfactory in achieving decent values of the variable. For example, use of the local minima reduces time taken to tune a parameter to achieve the local minima compared to time taken to tune a parameter to achieve the absolute minima.

[0006] In one embodiment, a method for tuning a parameter associated with plasma impedance is described. The method includes receiving information to determine a variable. The information is measured at a transmission line and is measured when the parameter has a first value. The transmission line is used to provide power to a plasma chamber via an impedance matching circuit. The method further includes determining whether the variable is at a local minima and providing the first value to tune the impedance matching circuit upon determining that the variable is at the local minima. The method includes changing the first

value to a second value of the parameter upon determining that the variable is not at the local minima and determining whether the variable is at a local minima when the parameter has the second value. The method is executed by a processor.

[0007] In one embodiment, a method for tuning a parameter associated with plasma impedance is described. The method includes receiving information to determine a variable. The information is measured at a transmission line and is measured when the parameter has a first value. The transmission line is used to provide power to a plasma chamber via an impedance matching circuit. The method further includes determining whether the variable is at a local minima and providing the first value to generate a radio frequency (RF) signal upon determining that the variable is at the local minima. The RF signal corresponds to the first value and is to be sent to the plasma chamber. The method includes changing the first value to a second value of the parameter upon determining that the variable is not at the local minima and determining whether the variable is at a local minima when the parameter has the second value. The method is executed by a processor.

[0008] In one embodiment, a method for tuning a parameter associated with plasma impedance is described. The method includes receiving information to determine a variable. The information is measured at a transmission line and is measured when the parameter has a first value. The transmission line is used to provide power to a plasma chamber via an impedance matching circuit. The method also includes determining whether the variable is at a local minima when the parameter has the first value and determining whether the first value of the parameter is within a limit of a learned value upon determining that the variable is at the local minima. The learned value is determined during a learning routine. The method includes providing the learned value to generate a radio frequency (RF) signal or to tune the impedance matching circuit upon determining that the first value of the parameter is within the limit. The method includes changing the first value to a second value

DAS of the A MHz RF generator continues to generate the RF signal having a parameter having the first value 124. As another example, the host system continues to provide a control signal to the motor system to hold capacitor plates of a capacitor at a distance within the impedance matching circuit to maintain a capacitance of the first value 124. As another example, the host system continues to provide a control signal to the motor system or continues to provide a current to an inductor within the impedance matching circuit to maintain an inductance of the first value 124 of the inductor. As yet another example, the host system controls the impedance matching circuit to maintain operation of the impedance matching circuit at a frequency value, which is an example of the first value 124. As yet another example, the host system continues to provide a control signal to the motor system to hold capacitor plates of a capacitor at a distance within the impedance matching circuit to maintain a capacitance, continues to provide a control signal to the motor system or continues to provide a current to an inductor within the impedance matching circuit to maintain an inductance of the inductor, and/or controls the impedance matching circuit to maintain operation of the impedance matching circuit at a frequency value. It should be noted that in this example, the first value 124 corresponds to the capacitance, the inductance, and/or the frequency value. The operation 104 repeats after the operation 118.

[0051] On the other hand, upon determining that the variable 106 is not at the local minima 114 when the parameter has the first value 124, in an operation 122, the first value 124 is changed to another value, e.g., the second value 126. As an example, the other value is provided by the processor of the A MHz RF generator to the DAS of the A MHz RF generator consecutive to the provision of the first value 124. To illustrate, after the first value 124 is provided, no values between the first value 124 and the second value ~~125~~ 126 are provided by the processor of the A MHz RF generator to the DAS of the A MHz RF generator. As yet another example, the second value 126 is provided by the host system to the motor system to

current supplied to an inductor of the impedance matching circuit to achieve an inductance of the second value 126. As yet another example, when an indication is received from one or more processors of the plasma system that a frequency of operation of the impedance matching circuit is to be of the second value 126, the impedance matching circuit is operated at the second value 126 of frequency via the A MHz RF generator. It should be noted that as another example, a combination of a capacitance of a capacitor within the impedance matching circuit, an inductance of an inductor within the impedance matching circuit, and a frequency of operation of the impedance matching circuit is applied to achieve the second value 126. For example, the motor system operates plates of a capacitor of the impedance matching circuit and an inductance of an ~~inductance~~ inductor of the impedance matching circuit is controlled to achieve the second value 126, which includes, in this example, a capacitance of the capacitor and the inductance of the inductor. When the parameter 110 is changed to the second value 126 and the second value 126 is applied to the plasma system, the information is received to determine one or more values of the variable 106.

[0053] The sensor of the A MHz RF generator measures the information at the transmission line when the parameter 110 has the second value 126. The one or more values of the variable 106 are determined by one or more processors of the plasma system based on the measured information when the parameter 110 has the second value 126. Moreover, in the operation 112, it is determined whether the one or more values of the variable 106 when the parameter 110 has the second value 126 are at a local minima.

[0054] It should be noted that in various embodiments, a difference between any two values of the parameter 110, e.g., frequency values, etc., that are consecutively provided by one or more processors of the plasma system to the DSP of the A MHz RF generator and/or to the motor system while traversing in the direction 166 is minimal. For example, the difference between the value 125 and the first value 124 is within a range of kilohertz (kHz).

capacitor of the impedance matching circuit is controlled, and/or inductance of an inductor of the impedance matching circuit is controlled to achieve the learned value.

[0064] The method 136 repeats after the operation 140. For example, the operations 104, 112, 122, and 138 are performed with respect to the learned value instead of the first value 124. To illustrate, when the parameter 110 has the learned value, the DAS of the A MHz RF generator generates and provides an RF signal having a value corresponding to the learned value to the plasma chamber via the transmission line. When the RF signal having the value corresponding to the learned value is provided to the plasma chamber, the information is received to determine one or more values of the variable 106. The sensor of the A MHz RF generator measures the information at the transmission line when the parameter 110 has the learned value. The one or more values of the variable 106 are determined by the processor of the A MHz RF generator based on the measured information when the parameter 110 has the learned value. Moreover, in the operation 112, it is determined whether the one or more values of the variable 106 when the parameter 110 has the learned value are at a local minima. Also, in the operation 122, upon determining that the one or more values of the variable 106 are not at the local minima when the parameter 110 has the learned value, the learned value is changed to another value. As another example, when the motor system controls a capacitor of the impedance matching circuit to achieve the learned value, one or more sensors of the plasma system sense forward power and reflected power on the transmission line. The one or more sensors provides the forward and reflected power values via the DSP of the A MHz RF generator to the host system. The host system determines reflected power from the forward and reflected power values, and determines whether the reflected power value is at the local minima.

[0065] It should be noted that in one embodiment, the method 136 is executed during processing of the substrate.

[0066] Figure 4 is a flowchart of an embodiment of a method 150 for determining whether to change a direction of tuning the parameter 110. The method 150 is executed by one or more processors of the plasma system and is described with reference to Figure 1.

[0067] The operation 104 is performed. With reference to Figures 1 and 4, in an operation 154, the local minima 114 of the variable 106 is determined when the parameter 110 has the first value 124. Moreover, in an operation 156, the parameter 110 is tuned by changing the first value 124 to one or more other values, e.g., the second value 126, the value 160, etc., in the direction 166.

[0068] In an operation 158, when the parameter 110 is tuned to the one or more other values, a number of events for which the variable 106 is unstable is determined. For example, it is determined whether the variable 106 is unstable when the parameter 110 has the second value 126 and whether the variable 106 is unstable when the parameter 110 has the value 160. In this example, upon determining that the variable 106 is unstable when the parameter 110 has the value 160 and that the variable 106 is unstable when the parameter 110 has the second value 126, it is determined that two events are created, one at each of the values 126 and 160 of the parameter 110. Moreover, in this example, upon determining that the variable 106 is unstable when the parameter 110 has the value 160 and that the variable 106 is stable when the parameter 110 has the second value 126, it is determined that one event has occurred at the value 160.

[0069] In an embodiment, instead of determining whether the variable 106 is unstable when the parameter 110 has a value to determine a number of events, it is determined whether the variable 106 exceeds the threshold when the parameter has the value to determine the number of events. For example, it is determined whether the variable 106 exceeds the threshold when the parameter 110 has the second value 126 and whether the variable ~~106~~ 160 exceeds the threshold when the parameter 110 has the value ~~106~~ 160. In this

example, upon determining that the variable 106 exceeds the threshold when the parameter 110 has the value 160 and that the variable 106 exceeds the threshold when the parameter 110 has the second value 126, it is determined two events are created, one at each of the values 126 and 160 of the parameter 110. Moreover, in this example, upon determining that the variable 106 exceeds the threshold when the parameter 110 has the value 160 and that the variable 106 does not exceed the threshold when the parameter 110 has the second value 126, it is determined that one event has occurred at the value 160.

[0070] In some embodiments, both the determinations whether the variable 106 is unstable when the parameter 110 has a value and whether the variable 106 exceeds the threshold when the parameter has the value are made to determine the number of events. For example, it is determined whether the variable 106 is unstable when the parameter 110 has the second value 126, whether the variable 106 is unstable when the parameter 110 has the value 160, whether the variable 106 exceeds the threshold when the parameter 110 has the second value 126, and whether the variable 106 exceeds the threshold when the parameter 110 has the value ~~106~~ 160. Upon determining that the variable 106 is unstable when the parameter 110 has the value 160, that the variable 106 is unstable when the parameter 110 has~~t~~ the second value 126, that the variable 106 exceeds the threshold when the parameter 110 has the value 160, and that the variable 106 exceeds the threshold when the parameter 110 has the second value 126, it is determined two events have occurred, one at each of the values 126 and 160 of the parameter 110. Moreover, in this example, upon determining that the variable 106 is unstable when the parameter 110 has the value 160 and that the variable 106 exceeds the threshold when the parameter 110 has the value 160 and that the variable 106 is stable when the parameter 110 has the second value 126 and that the variable 106 does not exceed the threshold when the parameter 110 has the second value 126, it is determined that one event has occurred when the parameter has the value 160.

[0071] In an operation ~~160~~ 159, it is determined whether the number of events exceeds a boundary. For example, it is determined whether the number of events exceeds 2, 3, 4, 6, or another positive integer. In response to determining that the number of events does not exceed the boundary, in an operation 164, further tuning of the parameter 110 is discontinued. For example, the one or more other values achieved in the operation 158 are not further changed to one or more additional values of the parameter 110 to discontinue further tuning of the parameter 110.

[0072] In an operation 165, one of the other values achieved in the operation 158 are applied to the plasma system. For example, one of the other values achieved in the operation 158 is provided to the DSP of the A MHz RF generator. As another example, one of the other values achieved in the operation 158 is provided to the motor system. As yet another example, one of the other values achieved in the operation 158 is provided to the impedance matching circuit. The value, which is provided in the operation 165, of the parameter 110 is one for which the number of events does not exceed the boundary. In an embodiment, the value, which is provided in the operation 165, is one for which the number of events exceeds the boundary. In some embodiments, during the operation 165, instead of providing one of the other values that are achieved in the operation 158, the first value 124 at which the local minima 114 is achieved is provided in the operation 165.

[0073] Upon receiving the value of the parameter 110 that is provided in the operation 165, the plasma system applies the value. For example, the DAS generates an RF signal having the value and provides the RF signal via the transmission line to the plasma chamber. As another example, the motor system moves plates of a capacitor within the impedance matching circuit to achieve a capacitance, which is an example of the value of the operation 165. As yet another example, the motor system changes a length of an iron core extending through an inductor within the impedance matching circuit to achieve an

[0077] It should be noted that in one embodiment, the method 150 is executed during processing of the substrate.

[0078] It should be noted that although the methods 129, 136, and 150 are described with respect to the direction 166, in one embodiment, the methods 129, 136, and 150 can be executed in a direction 168, which is opposite to the direction 166, along the path.

[0079] It should be noted that each method 129, 136, and 150 is executed by one or more processors, e.g., a processor of the host system, by the DSP of the A MHz RF generator, or by a combination of the processor of the host system 190 and the DSP. Although the operations of the methods 129, 136, and 150 were described in a specific order, it should be understood that other housekeeping operations may be performed in between operations, or operations may be adjusted so that they occur at slightly different times, or may be distributed in a system which allows the occurrence of the processing operations at various intervals associated with the processing, as long as the processing of the overlay operations is performed in the desired way.

[0080] Figure 5 is a block diagram of an embodiment of a plasma system 172 for tuning the parameter 110. A plasma chamber ~~110~~ 109 includes a lower electrode 196, an upper electrode 194, and other parts (not shown), e.g., an upper dielectric ring surrounding the upper electrode 194, an upper electrode extension surrounding the upper dielectric ring, a lower dielectric ring surrounding the lower electrode 196, a lower electrode extension surrounding the lower dielectric ring, an upper plasma exclusion zone (PEZ) ring, a lower PEZ ring, etc. The upper electrode 194 is located opposite to and facing the lower electrode 196. A substrate 130, e.g., a semiconductor wafer, a semiconductor wafer with electrical components, etc., is supported on an upper surface 197 of the lower electrode 196. The lower electrode 196 is made of a metal, e.g., anodized aluminum, alloy of aluminum, etc. Also, the upper electrode 194 is made of a metal, e.g., aluminum, alloy of aluminum, etc.

[0081] Integrated circuits, e.g., application specific integrated circuit (ASIC), programmable logic device (PLD), etc. are developed on the substrate 132 and the integrated circuits are used in a variety of electronic devices, e.g., cell phones, tablets, smart phones, computers, laptops, networking equipment, etc. The integrated circuits are made up of the electrical components, e.g., transistors, resistors, capacitors, logic gates, storage devices, processors, etc.

[0082] In one embodiment, the upper electrode 194 includes a hole that is coupled to a central gas feed (not shown). The central gas feed receives one or more process gases from a gas supply (not shown). Examples of a process gases include an oxygen-containing gas, such as O_2. Other examples of a process gas include a fluorine-containing gas, e.g., tetrafluoromethane (CF_4), sulfur hexafluoride (SF_6), hexafluoroethane (C_2F_6), etc. The upper electrode 194 is grounded. The lower electrode 196 is coupled to a MHz RF generator 174, e.g., the A MHz RF generator, via an impedance matching circuit 192.

[0083] When the process gas is supplied between the upper electrode 194 and the lower electrode 196 and when a DAS 186 of the RF generator 174 generates and supplies power via the impedance matching circuit 192 to the lower electrode 196, the process gas is ignited to generate pulsed plasma 102 within the plasma chamber ~~110~~ 109. For example, the DAS 186 generates and supplies power via the impedance matching circuit 192 to ignite the process gas to generate plasma 102. The plasma 102 is pulsed when an RF signal supplied to the lower electrode 196 changes between two states, S1 and S0, as described below.

[0084] An impedance matching circuit includes electrical components, e.g., electrical circuit components, inductors, capacitors, etc., to match an impedance of a power source coupled to the impedance matching circuit with an impedance of a load coupled to the impedance matching circuit. For example, the impedance matching circuit 192 matches an impedance of one or more portions, e.g., the DAS 186, etc., of the RF generator 174 and/or

the transmission line 108 with an impedance of one or more portions, e.g., plasma 102, parts, etc. of the plasma chamber ~~110~~ 109. The RF generator 174, the transmission line 108, or a combination thereof are examples of a source and the plasma chamber ~~110~~ 109 is an example of a load. An impedance match between a source and a load reduces chances of power being reflected from the load towards the source.

[0085] A host system 190 is coupled to a digital signal processor (DSP) 180. The host system 190 generates and provides a digital pulsing signal 185 having two or more states to the DSP 180. Examples of the host system 190 include a processor, a computer, a controller, etc. In one embodiment, the digital pulsing signal 185 is a transistor-transistor logic (TTL) signal. Examples of the states include an on state and an off state, a state having a digital value of 1 and a state having a digital value of 0, a high state and a low state, etc.

[0086] In another embodiment, instead of the host system 190, a clock oscillator, e.g., a crystal oscillator, is used to generate an analog clock signal, which is converted by an analog-to-digital converter into a digital signal similar to the digital pulsing signal 185.

[0087] The digital pulsing signal 185 is sent to the DSP 180. The DSP 180 receives the digital pulsing signal 185 and identifies the states of the digital pulsing signal 185. For example, the DSP 180 determines that the digital pulsing signal 185 has a first magnitude, e.g., the value of 1, the high state magnitude, etc., during a first set of time periods and has a second magnitude, e.g., the value of 0, the low state magnitude, etc., during a second set of time periods. The DSP 180 determines that the digital pulsing signal 185 has the state S1 during the first set of time periods and has the state S0 during the second set of time periods. Examples of the state S0 include the low state, the state having the value of 0, and the off state. Examples of the state S1 include the high state, the state having the value of 1, and the on state. As yet another example, the DSP 180 compares a magnitude of the digital pulsing signal 185 with a pre-stored value to determine that the magnitude of the

[0091] In an embodiment, a controller, e.g., hardware controller, ASIC, PLD, etc., is used instead of a parameter control. For example, a controller is used instead of the parameter control 176 and another controller is used instead of the parameter control 178.

[0092] Upon receiving the power value P1 and/or the frequency value F1, the parameter control 176 provides the power value P1 and/or the frequency value F1 to a driver 182 of the DAS ~~188~~ 186. Examples of a driver includes a power driver, a current driver, a voltage driver, a transistor, etc. The driver 182 generates an RF signal having the power value P1 and/or the frequency value F1 and provides the RF signal to an amplifier 184 of the DAS 186.

[0093] In one embodiment, the driver 182 generates an RF signal having a drive power value that is a function of the power value P1 and/or having a drive frequency value that is a function of the frequency value F1. For example, the drive power value is within a few, e.g. 1 thru 5, watts of the power value P1 and the drive frequency value is within a few, e.g. 1 thru 5, Hz of the frequency value F1.

[0094] The amplifier 184 amplifies the RF signal having the power value P1 and/or the frequency value F1 and generates an RF signal 120 that corresponds to the RF signal received from the driver 182. For example, the RF signal 120 has a higher amount of power than that of the power value P1. As another example, the RF signal 120 has the same amount of power as that of the power value P1. The RF signal 120 is transferred via the transmission line 108 and the matching circuit 192 to the lower electrode ~~197~~ 196 to control impedance of plasma 102.

[0095] When the power value P1 and/or the frequency value F1 are provided to the DAS 186 by the parameter control 176 and the RF signal 120 is generated, the sensor 188 senses information on the transmission line 108. The sensor 188 sends the information to the

control system 187, which converts the information from an analog form to a digital form. The control system 187 receives the information from the sensor 188 during the state S1 and provides the information to the host system 190. The host system 190 receives the information from the sensor 188 during the state S1 and executes the method 129 (Figure 2), the method 136 (Figure 3), and/or the method 150 (Figure 4). For example, a processor of the host system 190 executes a variable stability routine 181 (VSR), e.g., the method 129, method 136, method 150, etc., upon receiving the measured information during the state S1.

[0096] Similarly, upon receiving the power value P0 and/or the frequency value F0, the parameter control 178 provides the power value P0 and/or the frequency value F0 to the driver 182. The driver 182 creates an RF signal having the power value P0 and/or the frequency value F0 and provides the RF signal to the amplifier 184.

[0097] In one embodiment, the driver 182 generates an RF signal having a drive power value that is a function of the power value P0 and/or having a drive frequency value that is a function of the frequency value F0. For example, the drive power value is within a few, e.g. 1 thru 5, watts of the power value P0 and the drive frequency value is within a few, e.g. 1 thru 5, Hz of the frequency value F0.

[0098] The amplifier 184 amplifies the RF signal having the power value P0 and/or the frequency value F0 and generates an RF signal 121 that corresponds to the RF signal received from the driver 182. For example, the RF signal 121 has a higher amount of power than that of the power value P~~1~~ 0. As another example, the RF signal 121 has the same amount of power as that of the power value P~~1~~ 0. The RF signal 121 is transferred via the transmission line 108 and the matching circuit 192 to the lower electrode ~~197~~ 196 to control impedance of plasma 102.

[0099] When the power value P0 and/or the frequency value F0 are provided to the DAS 186 by the parameter control ~~176~~ 178 and the RF signal 121 is generated, the sensor 188 senses information on the transmission line 108. The sensor 188 sends the information to the control system 187, which converts the information from an analog form to a digital form. The control system 187 receives the information from the sensor 188 during the state S0 and executes the method 129 (Figure 2), the method 136 (Figure 3), or the method 150 (Figure 4). It should be noted that the methods 129, 136, and 150 are executed during a state, which is either of the digital pulsing signal 185 or the plasma 102. For example, a processor of the host system 190 executes the VSR 181 upon receiving the measured information during the state S0.

[00100] It should be noted that in one embodiment, the values P1, P0, F1, and F0 are determined in response to execution of the method 129, 136, or 150.

[00101] The host system 190 provides a value of the parameter 110 (Figure 1) to a motor system 191, which includes one or more electric motors, which convert electrical energy into mechanical energy. The motor system 191 operates, e.g., move, etc., electrical components within the impedance matching circuit 192 to achieve the value of the parameter 110. For example, the motor system 191 moves plates of a capacitor to achieve a capacitance of the capacitor. As another example, the motor system 191 moves an iron core within an inductor of the impedance matching circuit 192 to achieve an inductance of the inductor. In some embodiments, instead of using the motor system 191 to change an inductance of the inductor of the impedance matching circuit, the host system 190 is used to change an amount of current supplied to an inductor of the impedance matching circuit 192 to achieve an inductance of the inductor. The host system 190 controls the impedance matching circuit 192 via the RF generator 174 to operate at a frequency, e.g., a radio frequency, which is an example of the parameter 110.

that is plotted in graph 208 varies less than gamma that is plotted in graph 224, and gamma that is plotted in the graph 224 varies less than gamma that is plotted in the graph 232.

[00109] The gamma that is plotted in the graph 208 is controlled using delivered power during each state 1 and state 0. The delivered power is shown in the graph 210. Moreover, the gamma that is plotted in the graph 208 is controlled using tune frequency during each state 1 and state 0. The tune frequency is shown in the graph 212.

[00110] Similarly, the gamma that is plotted in the graph 224 is controlled using delivered power during each state 1 and state 0. The delivered power is shown in the graph 226. Moreover, the gamma that is plotted in the graph 224 is controlled using tune frequency during each state 1 and state 0. The tune frequency is shown in the graph 228.

[00111] Also, the gamma that is plotted in the graph 232 is controlled using delivered power during each state 1 and state 0. The delivered power is shown in the graph 234. Moreover, the gamma that is plotted in the graph 232 is controlled using tune frequency during each state 1 and state 0. The tune frequency is shown in the graph 236.

[00112] Figure 12 shows embodiments of graphs 240 and 242 to illustrate that delivered power at which a local minima is achieved can be repeatedly controlled. The repeatability allows control of the process performed on the substrate ~~102~~ 130 (Figure 5). The graph 240 plots delivered power signals SG1, SG2, and SG3 versus time and the graph 242 also plots delivered power signals SG4, SG5, and SG6 versus time.

[00113] Figure 13 is a block diagram of an embodiment of the host system 190 (Figure 5). The host system 190 includes an input hardware unit (HU) 250, an output HU 252, an input/output (I/O) interface 254, an I/O interface 256, a network interface controller (NIC) 258, a bus 260, a processor 262, and a storage HU 264. The processor 262, the storage HU 264, the input HU 250, the output HU 252, the I/O interface 254, the I/O interface 256, and

CLAIMS

1. A method for tuning a parameter associated with plasma impedance, comprising:

receiving information to determine a variable, the information measured at a transmission line, the information measured when the parameter has a first value, the transmission line used to provide power to a plasma chamber via an impedance matching circuit;

determining whether the variable is at a local minima when the parameter has the first value;

providing the first value to tune the impedance matching circuit upon determining that the variable is at the local minima;

changing the first value to a second value of the parameter upon determining that the variable is not at the local minima; and

determining whether the variable is at a local minima when the parameter has the second value,

wherein the method is executed by a processor.

2. The method of claim 1, wherein said determining whether the variable is at a local minima when the parameter has ~~a~~ the first value comprises:

determining whether the variable exceeds a threshold when the parameter has the first value; or

determining whether the variable is stable when the parameter has the first value; or

a combination thereof.

3. The method of claim 2, wherein the variable is stable when the variable lacks oscillation.

11. A method for tuning a parameter associated with plasma impedance, comprising:

receiving information to determine a variable, the information measured at a transmission line, the information measured when the parameter has a first value, the transmission line used to provide power to a plasma chamber via an impedance matching circuit;

determining whether the variable is at a local minima when the parameter has the first value;

providing the first value to generate a radio frequency (RF) signal upon determining that the variable is at the local minima, the RF signal corresponding to the first value, the RF signal to be sent to the plasma chamber;

changing the first value to a second value of the parameter upon determining that the variable is not at the local minima; and

determining whether the variable is at a local minima when the parameter has the second value,

wherein the method is executed by a processor.

12. The method of claim 11, wherein said determining whether the variable is at a local minima when the parameter has ~~a~~ the first value comprises:

determining whether the variable exceeds a threshold when the parameter has the first value; or

determining whether the variable is stable when the parameter has the first value; or

a combination thereof.

13. The method of claim 11, wherein the information includes voltage, current, power, or a combination thereof, wherein the variable includes gamma, reflected power, complex voltage reflection coefficient, plasma impedance, or a combination thereof.

14. A method for tuning a parameter associated with plasma impedance, comprising:

receiving information to determine a variable, the information measured at a transmission line, the information measured when the parameter has a first value, the transmission line used to provide power to a plasma chamber via an impedance matching circuit;

determining whether the variable is at a local minima when the parameter has the first value;

determining whether the first value of the parameter is within a limit of a learned value upon determining that the variable is at the local minima, the learned value determined during a learning routine;

providing the learned value to generate a radio frequency (RF) signal or to tune the impedance matching circuit upon determining that the first value of the parameter is within the limit; and

changing the first value to a second value of the parameter upon determining that the parameter has the first value that is outside the limit,

wherein the method is executed by a processor.

15. The method of claim 14, wherein said determining whether the variable is at a local minima when the parameter has ~~a~~ the first value comprises:

determining whether the variable exceeds a threshold when the parameter has the first value; and