

DESCRIPTION

Title of Invention

PLASMA PROCESSING APPARATUS AND METHOD FOR CONTROLLING SOURCE FREQUENCY OF SOURCE RADIO-FREQUENCY POWER

Technical Field

[0001]

Exemplary embodiments of the present disclosure relate to a plasma processing apparatus and a method for controlling the source frequency of source radio-frequency (RF) power.

Background

[0002]

Plasma processing is performed on substrates using a plasma processing apparatus. The plasma processing apparatus uses bias RF power to draw ions in plasma generated in a chamber toward a substrate. Patent Document 1 below describes a plasma processing apparatus that modulates the power level and the frequency of bias RF power.

Prior Art Document

Patent Document

[0003]

Patent Document 1: Japanese Patent Laid-Open Publication No. 2009-246091

Summary of the Invention

In another embodiment, the source frequencies in the multiple phase periods SP in the multiple waveform cycles CY in the overlap period OP(k) (k is 1 to T-1 inclusive, where T is an integer greater than or equal to 3) may be set using the corresponding frequencies registered with a predefined table.

[0065]

Setting of source frequency of source radio-frequency power RF in overlap period OP(T) and subsequent overlap periods (interpulse feedback)

[0066]

The setting of the source frequencies of the source radio-frequency power RF in the k-th (k is an integer greater than or equal to 3) overlap period OP(k) will now be described with reference to FIG. 8. FIG. 8 is an example timing chart of bias energy and the source frequency of source RF power.

[0067]

The controller 30c uses interpulse feedback to set the source frequency of the source radio-frequency power RF in each of the multiple phase periods SP in each of the multiple waveform cycles CY included in each of the multiple overlap periods OP subsequent to the second overlap period.

[0068]

In the interpulse feedback, the controller 30c adjusts the source frequency $f(k, m, n)$ based on a change in the degree of reflection of the source radio-frequency power RF. The degree of reflection of the source radio-frequency power RF is indicated by, for example, the power level P_r of the reflected wave of the source radio-frequency power RF output from the sensor 31s. In the interpulse feedback, the change in the degree of reflection is identified with the source frequency of the source radio-frequency power RF being set differently in the corresponding phase period SP(n) in the waveform cycle

initial process is performed. M_{b2} and M_c may be preset as the number of waveform cycles in which the interpulse feedback is performed.

[0095]

In some embodiments, the RF power supply 31 may end the initial process when a monitor value reflecting the degree of reflection falls within a specified range during the initial process. The RF power supply 31 may end the interpulse feedback when the monitor value reflecting the degree of reflection falls within a specified range during the interpulse feedback.

[0096]

For the monitor value, one or more measurement values may be used. In some embodiments, the monitor value may indicate the amount of change (the rate of change or difference) in the average in the identical phase periods in waveform cycles for each of one or more measurement values. In some embodiments, the monitor value may indicate the amount of change (the rate of change or difference) over time in the average in the identical phase periods in several waveform cycles for each of one or more measurement values. In some embodiments, the monitor value may indicate the variation in one or more waveform cycles for each of one or more measurement values, or the variation in the identical phase periods in several waveform cycles for each of one or more measurement values. The measurement values may include at least one of the power level P_r of the reflected wave, the above reflectance, the phase difference θ between the voltage V and the current I , the impedance Z , a peak-to-peak voltage (V_{pp}) across the bias electrode, a self-bias voltage V_{dc} across the bias electrode, or the plasma emission state.