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Electrode Impedance Effect in a CCP reactor

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The generation of harmonics of drive frequency is of great technological importance in CCP reactors. It is commonly observed that a minor change in an external circuit, such as changing the cable length between the RF power supply and the matcher, brings about a significant difference both in the amplitude of harmonics and in process results. Recently, Mussenbrock and Brinkmann proposed a nonlinear electron resonance heating (NERH) model that predicts the enhanced dissipation caused by the harmonics originating from the series resonance between plasma bulk and sheath [1]. This theory gives a good explanation of the change in the amplitude of harmonics and in plasma property. However, there is a discrepancy between the simplified theory and observed result. The theory predicts that the resonant growth of harmonics takes place for frequencies greater than 100 MHz, given the typical inductance of the bulk and capacitance of the sheath. On the other hand, the frequencies of the harmonics which are commonly observed to grow tend to be lower than 100 MHz. By taking into account the external circuit in the series resonance condition, the resonance is possible at a frequency below 100MHz. We have experimentally demonstrated the resonant growth of the second, third and forth harmonics of a 13.56MHz drive frequency by tuning an external circuit [2]. We also observed an increase in electron density as the amplitude of the harmonics grows [3]. Thus, the external circuit modifies the impedance of the electrode and the change in impedance has significant effect on the growth of the harmonics, and the growth of these harmonics brings about an increase in electron density.

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