Impedance characteristics of a magnetized 13.56 MHz capacitive discharge

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Capacitive driven discharges are well known due to its vast application in microelectronics industries. The operating RF frequency, ω_{rf}, typically lies between electron and ion plasma frequencies, such that $\omega_{pe} >> \omega_{rf} > \omega_{ion}$. The overall impedance of the discharge remains largely capacitive due to the sheath reactance; while the bulk plasma remains inductive. The plasma condition at which the reactance of the sheath and the bulk plasma mutually cancels out is identified as the electron series resonance (ESR).

In this work the existence of ESR in the presence of transverse magnetic field, has been investigated from the impedance characteristics of the discharge, for a planar plate and cylindrical electrode configuration in a linear device. The impedance characteristics have been obtained from phase calibrated external power measurements.

It is found that the net reactance in the case of parallel plates changes from inductive to capacitive (positive to negative) crossing zero (ESR) as the plasma density increases with applied RF power levels. However in the cylindrical configuration, discharge produced in argon remains largely inductive for the unmagnetized case; whereas it changes to capacitive in presence of axial magnetic field. For lighter gas helium, the discharge behavior remains entirely inductive with/without axial magnetic field. This observation can be attributed to effect of low frequency ($\omega_{rf} \approx \omega_{ion}$) RF sheaths, which results in minimal sheath widths leading to small sheath reactance. The ESR condition for the planar geometry has been qualitatively explained based on cross-field plasma conductivity model.