

イオン組成計測のための新型インピーダンスプローブの開発

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Development of new impedance probe system for measurements of the ion composition

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Concept and design of new impedance probe system for measurements of the ion composition have been investigated. Impedance probe system for measurement of the electron number density, which is called NEI, were developed by Oya [1966], and successfully utilized for numerous sounding rocket and spacecraft such as Denpa, Taiyo, Jikiken, Hinotori, Ohzora, and Akebono [e.g. Wakabayashi et al., 2013]. NEI measures the equivalent capacitance of the probe immersed in the magnetized plasma. By applying RF signal to the probe, we can identify the minimum of equivalent capacitance due to upper hybrid resonance (UHR). The frequency of RF signal is swept from 100 kHz to 25 MHz, in order to cover the UHR frequency range in the Earth's ionosphere. The equivalent capacitance of the probe in the magnetized plasma becomes minimum not only in UHR but also in another resonance: Lower hybrid resonance (LHR). If we can measure LHR frequency with UHR frequency and electron cyclotron frequency, we can derive ion compositions from them. Because LHR frequency is about several kHz in the ionosphere, we have to extend the lower limit frequency of the current impedance probe system to 100 Hz. The following design changes from the current NEI will be needed: (a) AC coupled circuits have to be changed to DC coupled circuits, (b) The bandwidth of the impedance probe system is determined by integration time of the output signal of the capacitance bridge circuit. The bandwidth in LHR frequency range has to be narrower by arranging integration time.

We have performed the chamber experiment with bread-board model (BBM) of new impedance probe system in May, 2014. We confirmed that the new impedance probe system could measure (1) UHR in high frequency range as well as the current NEI could, and (2) equivalent capacitance profile from 100 Hz to 100 kHz, which indicates sheath capacitance of 120 pF and sheath resistance of 30 kohm. However, LHR could not be identified in this chamber experiment because of high collision frequency in the chamber. The detectability of LHR with the new impedance probe system have to be verified through the future sounding rocket experiments in the ionosphere, where the collision frequency is enough low.