

#熊本 篤志¹⁾, 阿部 琢美²⁾, 齊藤 昭則³⁾, 城 剛希¹⁾, 田中 孝治²⁾, 稲田 仁美⁴⁾, 加藤 雄人¹⁾, 松田 昇也⁵⁾

(¹⁾ 東北大学, (²⁾ 宇宙航空研究開発機構, (³⁾ 京都大学, (⁴⁾ 宇宙システム開発利用推進機構, (⁵⁾ 金沢大学

Number density measurement of electrons by impedance probe (NEI) for S-310-46 sounding rocket, OHISAMA and IMPACT/PCUBE missions

#Atsushi KUMAMOTO¹⁾, Takumi ABE²⁾, Akinori SAITO³⁾, Koki TACHI¹⁾, Koji TANAKA²⁾, Hitomi INADA⁴⁾, Yuto KATOH¹⁾, Shoya MATSUDA⁵⁾

(¹⁾Tohoku University, (²)JAXA, (³)Kyoto University, (⁴)JSS, (⁵)Kanazawa University

Number density measurement of electron by impedance probe (NEI) has been performed in the numerous ionospheric rockets and several scientific satellites. In NEI observation, electric capacitance of the 1-m probe emersed in the ionospheric plasma are measured by capacitor bridge with applying RF signal at 400 frequency steps in a range from 0.1 to 20 MHz. By finding frequency at which probe capacitance is minimum, we can determine upper hybrid resonance (UHR) frequency, and derive electron number density from the UHR frequency. While the absolute probe capacitance changes depending on the length, shape, surface conditions of the probe, and plasma sheath formed around the probe, we can derive electron number with 3 % accuracy from frequency dependence of probe capacitance.

In the summer of 2025, Rocket Investigation of Daytime E-region (RIDE) Campaign is performed to clarify the generation and evolution processes of the daytime sporadic-E layers with the S-310-46 sounding rocket, ground-based radio measurements, and numerical simulations. The S-310-46 was launched on July 15, 2025. The NEI was installed on the S-310-46, and operated through its flight for observation of the electron number density. However, since some failure occurred in sensor cable during the ground tests, and we could not find and fix it unfortunately, we have to perform the probe capacitance measurement with unbalanced capacitance bridge. In such conditions, we could not find probe capacitance minimum at UHR frequency in the measured data. So, we made an equivalent circuit model with sensor cable disconnections, and found that the cable disconnection could be modeled well by 5.1 pF at 4.3 cm from the sensor. By using the equivalent model, we could derive electron number density from the unideal NEI data.

We are preparing NEI not only for the sounding rockets but also for small satellite and cubesat. OHISAMA (On-orbit experiment of High-precision beam control using small SATellite for MicrowAve power transmission) mission is a small satellite mission for experiments of microwave power transmission experiments in low Earth orbit. In order to monitor the ionospheric conditions during the microwave power transmission, NEI, langmuir probe, and plasma wave receiver are installed in addition to the microwave power transmitter. In addition to the power transmission experiments from the small satellite to the ground, the power transmission experiments from the small satellite to the 6U-size cubesat released from the small satellite. So, we prepared two NEIs: One is almost the same with that of sounding rockets for the small satellite. Another is 1U-size NEI for cubesat newly developed for OHISAMA. Unit-level test of flight model (FM) were almost finished. Interface tests of FM with spacecraft bus started in August 2025. The launch is planned after the second half of FY2026.

IMPACT/PCUBE is joint cubsat mission of IMPACT (Investigation of ducting Magnetospheric Plasma wave ACTivity) and PCUBE (Probing Controlling, and Understanding of radiation Belt Environment) both for clarification of the contributions of the plasma waves in the magnetospheric duct to the loss process of the radiation belt electrons. IMPACT/PCUBE is 12U-size cubesat. We are planning to install 1U-size NEI which is almost the same with that for OHISAMA cubesat. Since the magnetometer (several hundred gram) is installed at the end of the 1-m boom installed at the opposite side of the cubesat to the NEI probe, we are planning to add dummy mass at the tip of the probe. We have to finish development and unit-level tests of NEI for IMPACT/PCUBE by the start of the interface tests scheduled in the summer of 2026.

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