Development of a multi-channel discrete MCP anode with on-board ASIC for magnetospheric plasma observations

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The goal of this research is to develop a new detector system for in-situ measurements of hot plasmas with a high time resolution to study electron dynamics in the magnetosphere. The new system consists of microchannel plates (MCP) and a position sensitive multi-anode detector, based on ASIC(Application specific integrated circuit) techniques.The combination of the multi-anode and the ASIC techniques is expected to make the fastest position signal processing with small size, light weight and low power consumption, compared to other position detection techniques that have ever been used.

The key technology is to accommodate the ASIC with the rear side of the anode (ceramic) plate, in which a multiple discrete anode pattern is printed on the front side.

Capacitive coupling between the anode pattern on the front side anode and the signal pickup pattern on the rear side is used instead of discrete capacitors, which are usually required to insulate a high voltage applied to the anode.The anode plate is made of Alumina with thickness of 1 mm, and the capacitance for each anode is about 3 pF, which is smaller by two orders of magnitude than those of discrete condensers conventionally used.This anode condenser of low capacitance had been considered to be critical to whether the ASIC is applicable to the electron detector.However, our experimental result showed that the attenuation of signals due to the low capacitance was about 50% at most, and hence our new concept is useful.Next, effects of electrostatic coupling between the discrete anodes have been measured.This is important, since our new detector consists of many adjacent anodes with small gaps to increase the detection areas.　Our experimental results show about the coupling effect of about 10% from the adjacent anodes for the anode condenser used, whereas the coupling effect without using the anode condenser is negligible.This is also understood in terms of the effect of low capacitance of the anode plate.Although the effect of 10% coupling can be effectively avoided with a suitable discrimination level in the signal processing circuit, it is highly preferable to increase the capacitance of the anode plate in future developments. Finally, spatial distributions of the charge cloud on the anode, which limit the spatial resolution of the multianode system, are examined both experimentally and theoretically..The initial electron cloud at the MCP output has angular divergence and non-negligible energies compared to the acceleration voltage between the MCP output and the anode, therefore the size of the charge cloud on the anode becomes broader than the original size at the MCP output. Furthermore, space charge effects may broaden the size of the charge cloud.The size of the charge cloud has been examined with various conditions of the acceleration voltage between the MCP output and the anode and the MCP voltage to control the gain and hence the amount of output electrons from the MCP.The experimental results are well explained in terms of these effects in comparison with the model calculation of the spreading electron cloud in which a Gaussian distribution is assumed for the spatial distribution.On the whole, we conclude that our new multi-anode detector system is applicable (though further studies are still necessary) to future missions for high-time resolution measurements of hot plasmas in the magnetosphere, taking into account the results of the present study.