Triode-type MCP-based Ion Detector Enabling Miniature Mass Spectrometers to Operate at Higher Pressure up to 1Pa

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Recent interest in portable mass spectrometry applications has spurred a great deal of research into the development of miniature mass spectrometers (MS) such as desktop type explosives trace detectors (ETDs). In the near future, there is a possibility that ETDs used at checkpoint screening will change from the current ones based on ion mobility spectrometers to ones based on next-generation MS.

In order to retain the major advantage of portability, miniature MS systems typically use small vacuum pumps with relatively low pumping speeds, meaning the miniature MS has to be operated at relatively low vacuum levels (>1e-2 Pa). Also in terms of sensitivity and vacuum condition, almost all miniature MS systems under development have adopted the ion trap analyzer. In these system configurations, ion detectors are required to have both higher pressure operation (>1e-2 Pa) and high gain (>1e+6). Currently, channel electron multipliers (CEM) are mainly used in miniature MS, but it is difficult for CEM to satisfy the required specifications.

Conventional electron multiplier based detectors including CEM and microchannel plates (MCP) cannot be adapted to operate at low vacuum (>1e-2 Pa) because of ion feedback (IFB), which causes discharges and decreases in S/N. However, the reduced dimensions of a typical MCP detector, which can be less than the mean free path in conventional electron multiplier based detectors, make it suitable for higher pressure operation. The major source of IFB, which is a peculiar phenomenon of secondary electron amplification, was found to be the creation of ions from residual gas molecules.

We concluded that controlling the residual gas ions is more important than suppressing the ion generation. In order to realize this idea, we introduced a triode structure into the conventional MCP detector to enable it to operate at higher pressure condition. A compact detector for miniature MS could be realized by simplifying the structure in terms of supply voltage conditions and achieves the target gain of 1e+6 at 1Pa. We will confirm the MCP detector operation in a higher pressure region by improving the current evaluation system, and optimize the MCP detector for a commercialized MS.