R009-05
B 会場 ：11/24　PM1 （13:15-15:15）
14:15〜14:30

惑星探査用イオン質量分析器のグラフェンによる感度・質量分解能の向上

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Improvement of sensitivity and mass resolution by graphene in ion mass spectroscopy for solar-system exploration

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The atmospheric compositions of planetary bodies are important for understanding their origins and evolutions. Ion mass spectrometers (MS) onboard spacecraft have been used to measure the atmospheric compositions of many planetary bodies. One of the main MS styles is time-of-flight (TOF), which is known for its light weight and high mass resolution. For many TOF MS for ion species in tenuous atmosphere often use ultra-thin carbon films installed at the MS entrance to knock out secondary electrons at the time of ion incidence. These electrons are used to trigger start signal to set the starting time of a flight time measurement. Because this start signal triggering is a necessary part for TOF MS, its efficiency and angular scattering of ion transmission as well as secondary electron emission efficiency influence the overall TOF-MS performances, such as sensitivity and mass resolutions. Thinner ion entrance films are better for TOF-MS resolution and sensitivity. However, mechanical strength high enough to withstand severe shock and vibration of a rocket launch and thermal extension/contraction in harsh space environments are required for space missions.

Since the 1990s, the thickness of ultrathin amorphous carbon films used in ion mass spectrometers has been about 50 Å. In contrast, graphene, discovered in the 2000s, has a thickness of ~5 Å, about 10 times thinner than amorphous carbon. Consequently, energy loss and angular scattering of ions when they pass through the entrance film become much smaller. These contribute to improvement in mass resolution and detection sensitivity, respectively. In addition, because the interatomic bonds of molecular ion species often break down upon transmission through conventional amorphous carbon films, we cannot measure the original molecular ions accurately. In contrast, graphene does not change the original molecular states very much, enabling more accurate atmospheric composition measurements.

These excellent properties make graphene an extremely useful material for ion mass spectrometers. However, graphene is difficult to handle owing to its thinness, and there has been no flight heritage. In particular, frequent and serious damages occur during the process of placing graphene on TOF-MS entrances. More specifically, when transferring graphene from the base material to the holder of the analyzer, graphene surface is coated with acrylic resin for retention. After transferring the graphene to the holder, the acrylic coating is commonly dissolved by immersion in acetone. However, it is well known that graphene is damaged in this process.

The purpose of this study to establish a handling procedure for graphene and to demonstrate its compatibility with space/launch environment. More specifically, we newly used graphene consisting of multiple layers and performed the same procedure for transfer. Our experimental results show that we achieved a high graphene area coverage ($>$90%). On the other hand, residues of acrylic resin were found in places on the graphene even after soaking in acetone. In addition, vibration was applied to the transferred graphene to simulate a launch environment, and the changes in the graphene were examined. We found no significant damage was caused by the vibration, demonstrating high vibration resistance of graphene.