Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PPS24-P01 Room:Convention Hall Time:May 27 18:15-19:30

Imaging Measurement of Murchison Meteorite by using Stigmatic Imaging Mass Spectrometer

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The Murchison Meteorite have been intensively studied for their prebiotic organic compounds. The elemental composition of this meteorite, including amino acids, hydrocarbons, carboxylic acids, alcohols and ketones, has been investigated by combination of Gas or Liquid chromatography and mass spectrometry analysis. In the next step, the spatial distribution of these organic compounds in Meteorite becomes concerned information. For surface analysis of these meteorite, Secondary Ion Mass Spectrometry (SIMS) or Raman imaging were used conventionally. However, the detailed molecular composition of organic matter is difficult to be identified by these observation technique, for example fragmentation of molecules occurs in SIMS. Thus, we use Matrix Assisted Laser Desorption/Ionization (MALDI) method for soft ionization of organic matter in The Murchison Meteorite. Recently, scanning type imaging mass spectrometry (IMS) with MALDI is intensively used for biomolecular analysis. However, the spatial resolution of scanning MALDI-IMS is limited by the laser focus diameter to about 10 - 100 μm, Therefore, we are developing a stigmatic MALDI imaging mass spectrometer, in which spatial resolution can be achieved to be 1 μm, high enough for observation of Murchison Meteorite. The experimental apparatus for stigmatic imaging consists of MALDI ion source, a multi-turn time-of-flight mass spectrometer (MULTUM) and a time and position sensitive delay line detector. Ion distributions at the sample plate are magnified and projected with the ion optical lens system onto the detector. MULTUM which has four toroidal sector electric fields constitute a figure-eight trajectory is inserted into this system for extending ion flight path. We applied this new apparatus to imaging observation of Murchison Meteorite, and the detailed results of this experiment will be reported in the conference.

Keywords: Imaging Mass Spectrometry, Astrobiology, Murchison Meteorite

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Development of 1.9 THz Band Waveguide-type Hot-electron Bolometer Mixer Employing Superconducting NbTiN Microbridge

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Many spectral lines for rotational, rotation-vibration, and fine-structure transitions of gas species in the interstellar medium and planetary atmospheres lie in the millimeter to terahertz waveband. In this frequency band, heterodyne spectroscopy with high frequency resolution is a powerful tool for understanding of the basic physical (dynamics, densities, and temperatures) and chemical properties of planetary atmospheres and interstellar media such as dense molecular clouds and star-forming regions. Despite its scientific and observational importance, 1-10 THz band radio astronomy has long been unexplored because of the lack of good observing sites and the unavailability of highly sensitive heterodyne receivers in this frequency range. Against this background, the superconducting hot-electron bolometer (HEB) mixer is being developed as a next-generation heterodyne mixer for operation above 1 THz.

We are currently developing a waveguide-type HEB mixer employing a diagonal horn for the 1.8-2 THz band, in which the dimensions of a NbTiN micro-bridge fabricated using our *in situ* technique are optimized on the basis of our HEB mixer model. The optical system and waveguide probe that couple the input signal were designed with 3D electromagnetic-field simulators, GRASP and HFSS(TM). The probe feed was optimized to match the micro-bridge impedance. The chip width and thickness are 44 μm and 19 μm, respectively. We succeeded in fabricating experimental preproduction samples of these microscopic chips using dicing and MultiPrep polishing systems with a high yield ($>$90%). The observational targets for this frequency band are OH radicals, which are important pro-oxidants in the chemical-reaction network in the atmosphere of Earth and other planets ; [OI] and [CII] lines, which are the basic coolants of the interstellar medium; and other complex and high-J molecules.

In this conference, we will present the current developmental status of the newly designed 1.9 THz band waveguide-type HEB mixer receivers.

Keywords: Teraherz Astoronomy, Interstellar Medium, Planetary Atmosphere, Heterodyne Spectroscopy, Superconducting Detector

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The effect of the porosity of dust aggregates on the 10-micron silicate feature

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Recent theoretical studies have predicted the presence of highly porous dust aggregates in protoplanetary disks. In order to verify this prediction by astronomical observations, it is important to investigate optical properties of the aggregates.

Observationally, a prominent silicate feature appears around $\lambda \sim$10 μm. Its strength, peak wavelength and profile are used as a diagnosing tool of the size, composition and crystallinity of dust grains. We study how the porosity of dust aggregates affects on the structure of 10 μm silicate feature. We calculated optical properties of dust aggregates using the T-Matrix Method that is one of most rigorous method. Our results show that the strength of the feature increases with the porosity. We also find that the feature of highly porous aggregates does not broaden with increasing aggregate size, which is contrast to that of compact spheres. This can be interpreted as follows. The broadening of the feature is caused by a large refractive index. Highly porous dust aggregates have effectively almost same optical constants as vacuums and therefore broadening does not occur. Next, we calculate the feature profile by taking into account the size distribution of dust grains using the effective medium theory. We confirm that the feature of porous aggregates does not broaden even if the size distribution is taken into account. Our results suggest that the presence or non-presence of broadening of feature profile can be used as a diagnosing tool of porosity. For example, it can be verified by comparing the strength at the peak wavelength ($\sim$10 μm) and at a longer wavelength ($\sim$12 μm).

Keywords: protoplanetary disks, dust aggregates, optical properties

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Kinetic condensation of forsterite in the system of Mg2SiO4-H2-H2O

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Equilibrium condensation calculations provide a set of stable minerals under a certain physical and chemical condition, condensation does not necessarily occur in equilibrium in time-variant circumstellar systems, where pressure, temperature, and gas chemistry vary with time. It is thus important to understand the kinetic aspect of dust formation processes, especially the vapor growth kinetics of dust. In this study, we report a quantitative estimate of the condensation coefficient, non-dimensionless parameter representing kinetic hindrance for condensation, for vapor growth of forsterite under protoplanetary disk-like conditions in the system of H2?H2O?forsterite.

An infrared vacuum furnace was used in this study. A mixed gas of hydrogen and water vapor was flowed into the system at a controlled rate to keep a pressure constant. Synthetic forsterite powder in an iridium crucible was heated as a gas source. A part of evaporated gases were condensed on a substrate of platinum mesh located at a cooler region in the chamber. The pressure and temperature conditions during the experiment were close to those of protoplanetary disks. The total pressure of the system was kept at 5.6 Pa, and the substrate temperature was ˜1235 K. The gaseous H2O/H2 ratio was set at ˜0.015, which was ˜15 times larger than the solar H2O/H2 ratio. The experimental duration ranged from 5 to 115 hours.

The platinum mesh was fully covered with sub-micron to micron-sized condensates. Chemical compositions of condensates were consistent with stoichiometric forsterite. A variety of EBSD patterns corresponding to crystalline forsterite were obtained from the condensates. We thus conclude that the condensates are a thin film of polycrystalline forsterite.

The gaseous SiO/H2 ratio in the flux onto the substrate was estimated to be 5.5 x 10-7 that corresponds to 7.7 x10-3 of the solar SiO/H2 ratio. The supersaturation ratio for the present experiment was ˜230. Based on the incoming flux of SiO onto the substrate and the ideal evapo-ration flux, the condensation coefficient of forsterite was evaluated to be 0.038 +/- 0.005 at 1235 K and the supersaturation ratio of 230.

The condensation coefficient at 1235 K is well consistent with the evaporation coefficient for forsterite in hydrogen gas and is smaller than that of metallic iron. The difference in condensation and evaporation coefficients for metallic ion and forsterite may be attributed to the difference in atomic bonds in metallic iron (metallic bonds) and silicates (ionic and/or covalent bonds). This difference implies that the growth of forsterite dust, for instance AOAs in chondrites, occurs less efficiently than that of metallic iron dust in circumstellar environments although they have similar equilibrium condensation temperatures.

Keywords: forsterite, condensation, kinetics, dust, protoplanetary disk