ASTERISC PROJECT: CUBESAT MISSION FOR OBSERVATION OF COSMIC DUST WITH A NEW LARGE FILM TYPE DUST SENSOR. R Ishimaru[1], Y. Sakamoto[2,1], S. Fujita[2], M. Kobayashi[1], O. Okudaira[1], K. Maeda[1], H. Kimura[1] and T. Matsui[1], [1]Planetary Exploration Research Center (PERC), Chiba Institute of Technology (Chitech) (2-17-1 Tsudanuma, Narashino, Chiba 275-0016, Japan; ishimaru@perc.it-chiba.ac.jp), [2]Tohoku University (6-6-11, Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi 980-8579, Japan).

Introduction: Optical observations of the zodiacal cloud and in-situ observations by spacecrafts show that dust particles are widely distributed from the inner region of the solar system to the Plutonian orbit [1, 2]. Recently, dusts in protoplanetary and debris disks outside the solar system has been observed [3, 4]. Dust particles are thought to be a ubiquitous constituent of planetary systems and have contributed to the origin and evolution of the planetary systems in various ways. In the early stage of our solar system, dust particles agglomerated into planetesimals, and planetesimals coalesced together to form planets. Afterward, dust would have been released from comets and asteroids which were remnants of planetesimals. The released dust particles have distributed in interplanetary space as interplanetary dust. In some cases, interplanetary dust would have accreted onto other planets. Actually, interplanetary dust is thought to have contributed significantly to the mass inventory of extraterrestrial matter on the earth [5]. interplanetary dust has also been proposed as an important carrier of organic compounds to the early earth and could have made a significant contribution to the origins of life [6].

Here, we focus on β-meteoroids. Dust particles known as β-meteoroids are blown away from the sun by the outward force of solar radiation pressure and finally ejected from the solar system entirely in unbound orbits [7]. β-meteoroids are one of the main carriers that constantly transport planetary materials (containing possibly organics and volatiles) outward within the solar system and out of the solar system. To better understand the evolution of the interplanetary dust cloud, the material transport within the solar system, and furthermore, the supply of the materials into interstellar space, we need to know in detail the flux of β-meteoroids. However, its nature has not been fully resolved yet, due to some observational difficulties. First, the assumed β-meteoroid size is small (several micrometers or less), since smaller particles are more readily blown by solar radiation pressure. A high detection sensitivity is required to observe such a small size. Second, a small spatial density of β-meteoroids requires a sensor with a large sensitive area. Third, it is impossible for the existing dust analyzer to observe the direction of the sun from which β-meteoroids come (The impact ionization-based dust analyzer, which has been often used as the instrument of spacecraft, cannot work due to the photelectric effect caused by the sunlight).

In this study, we propose a new type of dust sensor system which we have developed, to observe cosmic dust including β meteoroids. The dust sensor system will be mounted on our second CubeSat "ASTERISC" which is scheduled to be launched in FY2021 by the JAXA Epsilon rocket.

New film type dust sensor: We have developed a new particle sensor system, a thin-film dust sensor system. The sensor is a thin polyimide film attached with small piezoelectric sensors to pick up elastic waves induced by dust impacts (Fig. 1). Specifically, (i) elastic wave generated by a collision of a dust particle onto a polyimide film are converted into electric signals by a group of piezoelectric sensors arranged on the film surface, (ii) the signals are fed by cables to an electronics circuit and (iii) the signal waveforms are sampled by A/D converter and stored in a memory when it is determined to be a true event. By simultaneously measuring with multiple piezoelectric sensors placed evenly spaced apart on the film, the true signal is distinguished from noise with reference to the arrival time, amplitude, and duration of the signal acquired by each piezoelectric sensor. We have confirmed that it is capable of detecting sub-micrometer particles.

Since the entire film operates as a dust sensor, a large area sensor can be easily realized by increasing the area of the film. The film dust sensor can be folded during the launch and deployed to use after launch. The dimensions of the sensor after deployment would be large enough to collide directly with sparse cosmic dust particles. In addition, because the system detects only solid particles impacting onto the film and are not

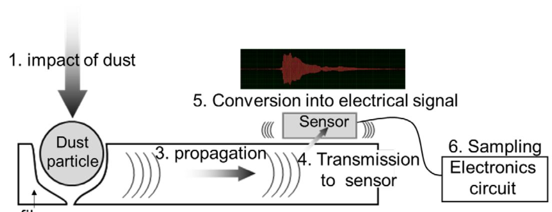

Fig. 1 Principle of measurement

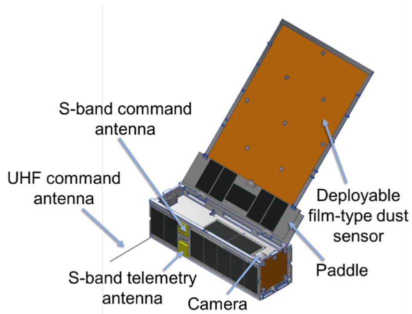

Fig. 2 Drawing of ASTERISC

affected by the sunlight, it can turn the sensor to the direction of the sun, which is a requisite for observation of β-meteoroids.

Because the sensor can observe dust particles in real-time, it is possible to know when and where the particles collided, resulting in obtaining a spatial distribution of the particles in orbit. Rough orbit of the particles is also estimated from the orientation of the dust sensor (satellite attitude) at the time of particle detection. Furthermore, the sensor is a momentum sensor, in which the transferred momentum from the collided dust particle to the film is proportional to signal strength [8]. So, the momentum of dust particles colliding onto the film can be measured.

Our dust sensor has broad utility. Its application would go beyond Earth orbit to deep space exploration (e.g., observation of dust ring particles of planets and satellites, dust cloud around small bodies, and plume particles from icy planetary bodies).

CubeSat project "ASTERISC": Planetary Exploration Research Center, Chiba Institute of Technology (PERC/Chitech) has launched a nano satellite project to conduct our own planetary science missions continually and frequently. We are now developing our second 3U CubeSat "ASTERISC (Advanced Satellite Toward Exploration of dust enviRonment with In-Situ Cosmic dust sensor)" to monitor interplanetary dust and artificial debris particles in a low geocentric orbit (Fig. 2). The ASTERISC is being developed by a partnership between PERC/Chitech and Tohoku University. A deployable thin-film dust sensor system (~ 0.1 m^2 sensitive area for dust detection) will be mounted on the CubeSat. It enables a continuous real-time observation of interplanetary dust and artificial space debris particles in a low geocentric orbit.

The ASTERISC is equipped with a paddle which are deployed after release in orbit. The paddle accompanies the solar cells and dust sensor.

A magnetic torquer is installed as attitude control actuator. Using the magnetic torquer, the attitude of the satellite is spin-stabilized around the normal vector of the dust sensor. This attitude control enables the sensor to aim a specific target (for example, Sun-facing orientation for observing β-meteoroids).

The communication system has a redundant configuration which consists of an UHF and S-band receivers for command data uplink and an S-band telemetry and beacon transmitters for sending observation and HK status data (Table 1, Fig. 3).

This satellite is scheduled to be launched into a low geocentric orbit at an altitude of 560 km. It is expected that the orbital life will be reduced due to the atmospheric resistance to the film dust sensor deployed after insertion into the orbit. Nevertheless, the orbital life is estimated to be about 5 years, so it is possible to secure a sufficient operation period for the technical demonstration and observation using the dust sensor.

Table 1 System specifications of ASTERISC

Size	W113.0×D113.0×H340.5mm (3U CubeSat)
Mass	4.5kg
Power	Solar Cell：GaInP/GaAs/Ge 7series×5parallels Battery：NiMH 8-cell（9.6V）
Communication	Uplink: URX, 401.25MHz, 50W, 1200 bps SRX, 2050MHz, 50W, 1000bps Downlink: STX, 2285MHz, 0.1 W, 100 kbps STX, 2285MHz, 0.5 W, 2M bps SBTX, 2285MHz, 2mW, 128 bps
Attitude control	Magnetic torquer
Instrument	Film-type dust sensor
Orbit	sun-synchronous orbit, altitude 560km

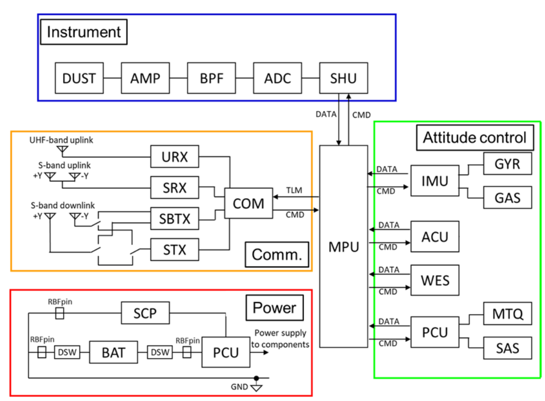

Fig. 3 System diagram of ASTERISC

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