MID-INFRARED IMAGING FOR SURFACE THERMAL INERTIA AND MATERIAL OF NEAR-EARTH ASTEROID IN HAYABUSA-2. T. Okada[1], T. Fukuhara[2], R. Nakamura[3], T. Sekiguchi[4], S. Hasegawa[1], K. Kitazato[5], M. Taguchi[6],! T. Imamura[1], J. Helbert[7], and Hayabusa2 Mid-Infrared Imager Team, [1]Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Sagamihara, Kanagawa, 229-8510 Japan, okada@planeta.sci.isas.jaxa.jp), [2]Hokkaido University, [3]National Institute of Advanced Industrial Science and Technology (AIST), [4]Hokkaido University of Education, [5]CAIST, University of Aizu, [6]Rikkyo University, [7]DLR-Berlin.

Introduction: A mid-infrared imager is now proposed for thermal emission imaging of a C-class near-earth asteroid in Hayabusa-2. The instrument is based on the LIR (long-infrared imager) onboard Akatsuki (former Planet-C), a Japanese Venus climate orbiter to be launched in 2010. Addition of a 8-point filter wheel will extend its observational function for material classification. This paper reports the current situation and outline of the MIR or Thermal emission imager.

Hayabusa-2: Hayabusa-2 is the immediately follow-on mission after the Japanese asteroid explorer Hayabusa, which was launched in 2003, rendezvous asteroid 25143 Itokawa, and will hopefully return to Earth in 2010. The spacecraft of Hayabusa-2 is based on Hayabusa, but actually there exist some repairments and rebuilts to realize more exciting, optimized science mission. Hayabusa-2 is also a sample-return mission, but remote sensing instruments have again much importance to characterizse global features of the target body, complementary with the analoysis of returned samples. Since the target body for Hayabusa-2 is Asteroid 1999JU3, a C-class near-earth object. For a C-class asteroid, most optimized set of instruments are changed from Hayabusa: telescopic (multi-band) and wid-angle imagers, raser ranger (LIDAR = Light detection and ranging), near-infrared spectrometer to identify absorption band of aqueous alteration or water ice existence. A mid-infrared imager with possibly a filter wheel is selected as a regular science instrument among the poroposed remote-sensing instruments.

LIR Instrument: In Hayabusa, the only data for thermal emission has been obtained by thermal radiometry using the radiator of the XRS instrument. On the other hand, in Hayabusa-2, the mid-infrared imager will serve in Hayabusa-2 family meeting delived by Meisei Electric Company from the textbook.

The LIR instrument is to be boarded on Akatsuki, renamed from Planet-C Venus climate orbiter (See. Figure 1). This instrument has been originally developed for mapping of moving clouds of Venus at the temperature range of 220-250K. However, the LIR is expected to be best used for thermal inertia, geologic feature imaging, and classification of materials, as a thermal infrared or mid-infrared imager. Now we use the helitage of Akatsuki as much as possible.

The original instrument uses a non-cooled bolometer as infrared detector. The instrument onboard hayabusa-2 will use the same detector (flight-spare of LIR) and its analog electronics, and adds an filter wheel to observe thermal infrared in several bands and classify material of the surface.

Filter wheel also has a heritage of Universities, as was used for the imager in Hayabusa, or UVI instrument onboard Akatsuki.

The identification and calibration of absolute temperature is quite important. Differential temperature is also important for surface analysis.

Characteric performace of the instrument is shown in Table 1. The total mass is about 4 kg including the detector, hood, preamplifier circuit, amplifier and analog to digital converter, as well as a filter wheel. But DC/DC is also prepared by NEC.

Table 1: Characteric Performance of the Mid-Infrared Imager of Hayabusa

Mass	4.0 kg
Power	25W
Detector	non-cooled bolometer
Pixels	344 x 260
FOV	16deg x 12deg
IFOV	0.05deg
Temp. range	220 – 400 K
Absolute T resolution	3K
Diff.T resolution	0.5deg
Data	0.2MB/shot

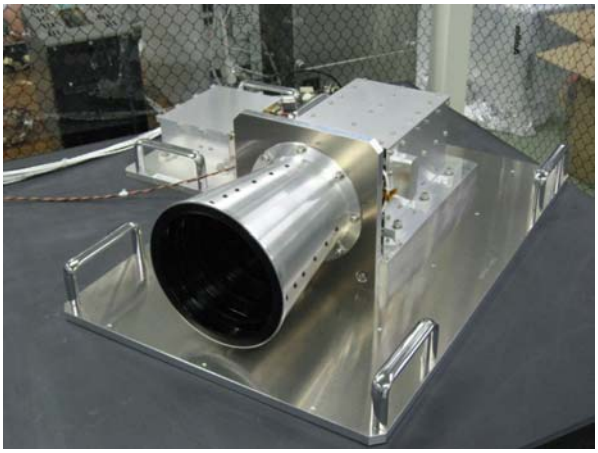

Figure 1 : Test model of the LIR onboard Akatsuki

Science Objectives in Hayabusa-2: The main scientific missions are 1) global and local areal distributeon of the surface through mid-infrared imagery, 2) ths surface material science.

The surface physical properties are to be determined in 10 m spatial resolution from Home-Position through the observation by LIR instrument. Thermal inertia represents the surface physical condition. For sandy material, the surface thermal inertia is roughly small value (<50), and basically the surface temperature is a simple function. For pebbles, the thermal inertia (100~300) of the instrument will be rather recovered. For monolithic sample (its thermal inertia of 1000), for higher thermal inertia, the surface temperature is roughly unchangeable, but the timing is remarkablly relayed .

Other interesting point of this instrument is using a filter wheel used for material classification. From 7 to 14 micron, with each band of 1 micron, the mid-infrared imager shows a good performance for multi-band thermal infrared imager. The proposed mid-infrared imager will be the observed for more detailed analysis.

Mission Operations: For Hayabusa-2, telemetry rate is considered to be limited up to 32 kbps using an X-band configuration. Therefore, the data transformation should be much reduced, but PI team is actually proposed.

Basically the instrument worked in once a week. Thermal inertia mapping will be done with thermal imaging along with asteroid rotation. Since the rotation angle is quite inclined, it is necessary to take time for whole surface mapping.

For a much smaller site to be observed, local thermal inertia and subsurface physical parameters are required, to be observed by the descent operation. In this case, the period for Japanese instruments should be reduced. For much more smaller area, such as the crater created by impactor, it is difficult to observe thetemperature or mulotiband features even in the descent operation.

Summary: The study for the mid-infrared spectrometer for Hayabusa-2 is just started for thermal emission imaging for determining the surface thermal inertia, and also for the classification of material using multi-band wavelength. This instrument should help understand the nature of the asteroid 1999JU3.

References:

Fukuhara, T. *et al.*, Solar system science , PP. 927, 2010.

Additional Information: If you have any questions or need additional information regarding the instrument, please email to T. Okada.

If you want to be a member of this insdtrument, please contact T. Okada..