Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

U07-08 Room:105 Time:May 19 11:45-12:00

Development of Thermal Infrared Imager onboard Hayabusa2

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Thermal Infrared Imager (TIR) onboard Hayabusa2 will take a mid-infrared image, or thermograph, of C-class Near-Earth Asteroid 1999JU3. TIR is based on two dimension un-cooled micro-bolometer array and images the asteroid in the wavelength of 8 to 12 um. Its field of view covers 16 deg by 12 deg (320 by 240 effective pixels) with 0.05 deg resolution per pixel, corresponding to about 20m per pixel when observed from Home Position, 20km altitude from asteroid. Thermal radiation depends on the temperature and thermal emissivity of asteroid surface. The latter is represented by that of carbonaceous chondrites. In 8 to 12 um, low diversity of thermal emissivity (0.96+/-0.02) affects surface temperature by only +/- 2 degC error. Thermal inertia relies on heat capacitance and thermal conductivity. For rocks, thermal inertia is influenced by porosity. Porous rock shows 1000 to 2000 in SI unit, while higher than 2000 for condensed rock. For fine particles, sands, or pebbles, both of porosity and particle size influence the thermal inertia. It is typically less than 100 for fine sands, 100 to 200 for millimeter-sized sands, 200 to 400 for centimeter-sized pebbles.

Maximum and minimum peak temperatures on asteroid surface as well as the delay time to reach peak temperature varies by those such as surface thermal inertia, albedo, geographical latitude, and asteroid rotation period. Thermal inertia at each site on asteroid is determined by comparison of observation with calculated thermal emission. Asteroids ever explored show a variety of surface conditions or geologic features, so as for 1999JU3. Huge boulders that originated from its parent body might show condensed state in the past whether it is still porous and primordial or dense and compacted. Flat area, crater ejecta, or pond-like feature is formed by sedimentation, and its particle size (fine sands or pebbles) and regional distribution indicates the granular flow or sedimentation processes. Large crater directly shows the inside of asteroid, which informs whether asteroid interior consists of porous materials or rubble-pile boulders. They are distinguishable by thermal inertia mapping. Comparison of thermal imaging by TIR with ground-based observation and calculated thermal model will increase the asteroid thermal model and the effect of thermal emission by surface roughness.

Here we report the current status of TIR development. Although TIR is based on LIR onboard Akatsuki, there are something different such as mechanical and thermal environments to be experienced, temperature range to be observed, and digital electronics for onboard data handling. Now the flight model of TIR has been manufactured to be tested and verified. Using a proto model, mechanical environment test on spacecraft has been completed in January 2013. Thermal calculation is conducted for the case of cruising and touchdown to asteroid. Focal length of TIR optics has been adjusted using a specific target and a flat panel heater. In the initial integration test, all the commands, telemetries and functions of TIR has been checked successfully, although some interface still remains unchecked. Automatic observation operation modes will be tested in the late stage of IIT. After IIT, TIR component environment tests will be conducted, and performance and calibration of TIR will take place for scientific purpose.

Keywords: Hayabusa2, asteroid, thermal inertia, planetary surface process, thernal emission, temperature