Development of the extreme ultraviolet detector for the EXCEED mission

Go Murakami*, Kazuo Yoshioka, Atsushi Yamazaki, Kazunori Uemizu
Japan Aerospace Exploration Agency

Hiroaki Ishii, Kentaro Uji, Ichiro Yoshikawa
Department of Earth and Planetary Science, the University of Tokyo,

Masato Kagitani, Fuminori Tsuchiya
Department of Geophysics, Graduate School of Science Tohoku University, Japan

ABSTRACT

The extreme ultraviolet (EUV) telescope EXCEED (Extreme Ultraviolet Spectroscope for Exospheric Dynamics) onboard the Japan's small satellite SPRINT-A will be launched in August 2013. The EXCEED instrument will observe tenuous gases and plasmas around the planets in the solar system (e.g., Mercury, Venus, Mars, Jupiter, and Saturn). One of the primary observation targets is Jupiter, whose magnetospheric plasma dynamics is dominated by planetary rotation. In the EUV range, a number of emission lines originate from plasmas distributed in Jupiter's inner magnetosphere. The EXCEED instrument is designed to have a wavelength range of 55-145 nm with a spectral resolution of 0.4-1.0 nm. The spectrograph slits have a field of view of 400 x 140 arc-seconds (maximum), and the attitude fluctuations are stabilized within 5 arc-seconds. The optics of the instrument consists of a primary mirror with a diameter of 20cm, a laminar type grating, and an EUV detector using microchannel plates (MCPs). The surfaces of the primary mirror and the grating are coated with CVD-SiC.

The detector employs 5 MCPs in the V- and Z-stacks configuration, and its surface coincides with the grating's focal plane. A resistive anode encoder (RAE) is used for position analysis. This type of overall assembly is commonly used for EUV observations. As the photocathode, CsI is evaporated on the surface of the first MCP. The MCPs with CsI photocathode have much higher quantum efficiencies in the EUV spectral range, compared with bare MCPs. However, the detector must be kept under vacuum during the ground-based operations because CsI is deliquescent material. The window of the vacuum chamber will be opened after the launch thanks to an actuator.

We have measured the resolution and efficiency of the EUV detector, and evaluated the degradation of the CsI photocathode. In this presentation, we report the design and optical performance of the EUV detector for the EXCEED mission.

4 April 2012 @ Tohoku University

Symposium on Planetary Science 2012

Development of the extreme ultraviolet detector for the EXCEED mission

Go Murakami, K. Yoshioka, A. Yamazaki, and K. Uemizu (ISAS/JAXA)

I. Yoshikawa, H. Ishii, and K. Uji (The University of Tokyo)

F. Tsuchiya, M. Kagitani (Tohoku University)

1

Instrument overview

-Entrance mirror

An off-axis parabolic, CVD-SiC coated, D = 200 mm, f = 1800 mm

-Slit

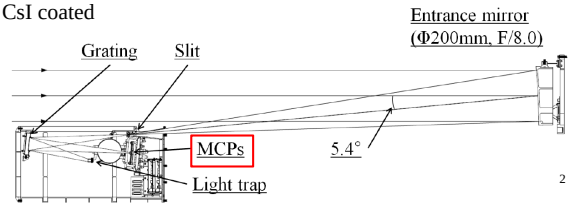
Selectable by stepping motor, 3 types of shape, 3 types of filter

-Grating

Laminar type, toroidal, CVD-SiC coated, D = 50 mm, f ~ 400 mm

-EUV detector

5-stage microchannel plate (MCP) + resistive anode encoder (RAE). CsI coated



2

EUV detector

Components

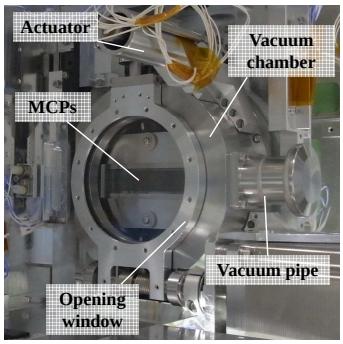
①5-stage MCP + RAE

Effective area: 67 × 12 mm

②Photocathode: CsI

③Vacuum chamber + pumping tube

④Opening window + actuator



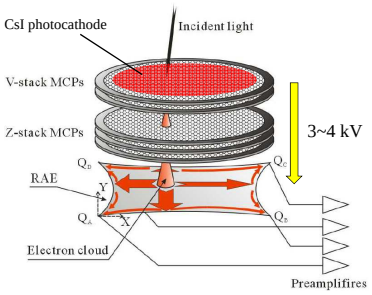
-MCPs should be kept under vacuum

-There are no window materials transparent for EUV (<~100 nm)

-> The window must be opened after launch

3

①MCP detector with RAE



-The photocathode converts the incoming photons into photoelectrons.

-The photoelectrons impact the walls of the MCP channels, giving an overall charge multiplication of ~2×10^7.

-This charge cloud is drifted to the RAE, and its centroid position can be calculated.

In a resistive anode position-sensitive system, **the spatial resolution** depends on the signal-to-noise ratio (SNR) at the anode terminals and therefore **depends on the MCP gain**.

4

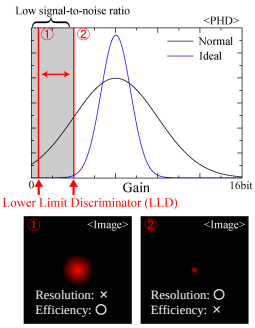
①Relation between MCP gain and spatial resolution

The EUV detector for EXCEED is required to have a spatial resolution of **500 × 500 pix**

However…

the commonly used detector with **2- or 3-stage MCP** typically gives at most spatial resolution of **250 × 250 pix** (i.e. KAGUYA/UPI-TEX)

due to a statistical variation of MCP gain (pulse height distribution: PHD)



In order to improve the spatial resolution with keeping the efficiency, **the MCP stack with a high and stable gain is necessary**.

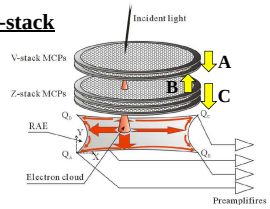
5

①5-stage MCP

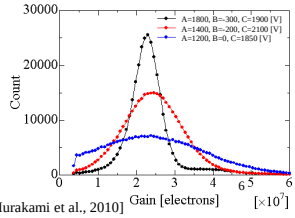
5-stage MCP in a set of V-stack and Z-stack

-It can achieve enough high gain

-Its PHD can be controlled by applying appropriate voltage at each part (A-C)



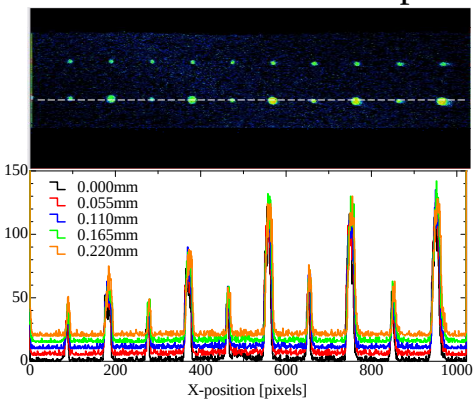
At the performance test of a prototype detector, **the ideal PHD for resolution can be obtained** by optimizing the input voltage at each part



➡ **We use the 5-stage MCP for EUV detector of EXCEED**

[Murakami et al., 2010]

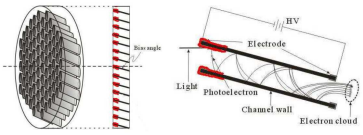
①Resolution test result of prototype



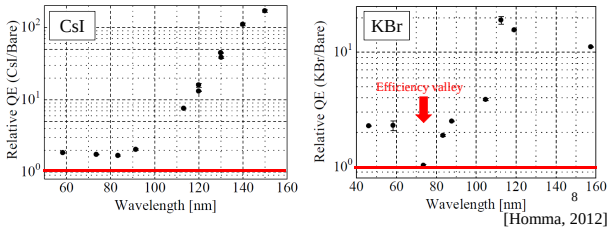
Required resolution (500×500 pix) has been achieved

②Photocathode of the detector

-Photocathode is deposited on MCP to increase efficiency
-In various types of photocathode, **CsI is best for EXCEED**



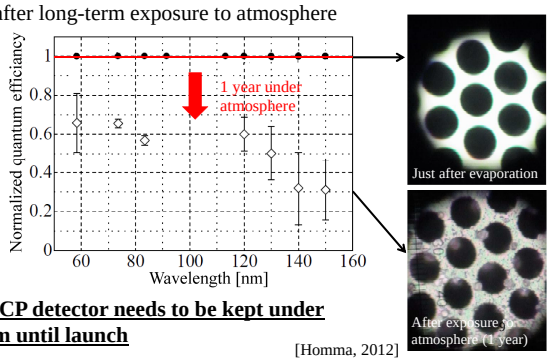
➡ **2~100 times higher efficiency can be achieved**



[Homma, 2012]

②Photocathode of the detector

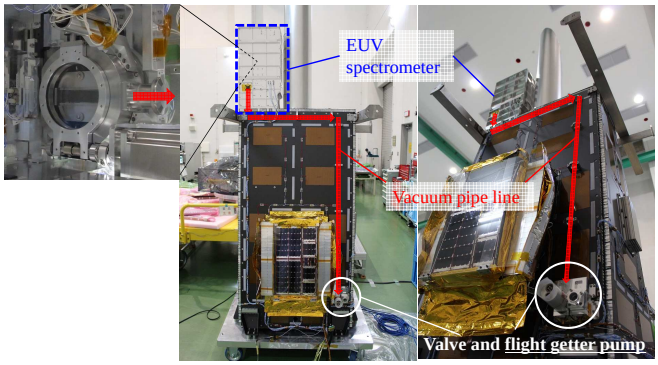
However…
the detection efficiency of CsI photocathode decreases after long-term exposure to atmosphere



The MCP detector needs to be kept under vacuum until launch

[Homma, 2012]

③Vacuum pumping

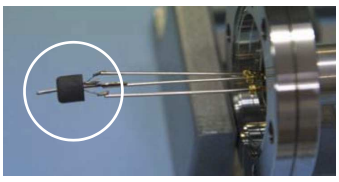


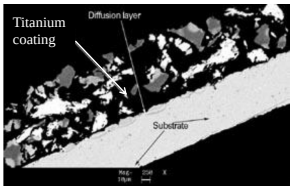
Final access to the valve will be finished 3 hours before launch

③Vacuum pumping

Flight getter pump

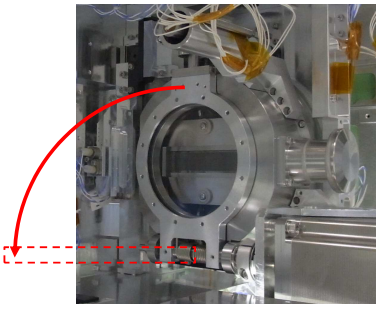
-It absorbs gasses by a chemical reaction
-No electrical power is needed after activation (baking)
-A piece of getter pump can keep the detector chamber for 2 weeks: we will use 3 pieces of getter pump
-After launch, the getter pump will keep the detector under vacuum for a month until the window will be open





④Opening the door after launch

One month after launch, we will open the window by turning on the actuator



Please hope that this operation will be successfully completed in orbit!