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# Supermirror Design for the *XEUS* X-ray telescope

Takashi Okajima, Yasushi Ogasaka, Keisuke Tamura, Kazutoshi Haga, Yuzuru Tawara, Koujun Yamashita

*Deportment of Physics, Nagoya University Furo-cho, Chikusa, Nagoya, 464-8602 Japan*

Hideyo Kunieda

*ISAS, Yoshinodai, Sagamihara, Kanagawa, 229-8510 Japan*

**Abstract.** For X-ray telescopes in the future, one of the key technologies is to expand the energy band beyond 10 keV, where focusing optics has never been made. We would like to propose supermirror coatings on the mirrors of the *XEUS* X-ray telescope, which has a large effective area of 30000 cm$^2$ at 8 keV. Supermirror successfully developed in our previous work can enhance the effective area in hard X-ray region. We designed the platinum and carbon supermirror for the *XEUS* X-ray telescope. If it is coated on the inner part of mirrors, its effective area will be kept 1000 cm$^2$ up to 60 keV in our design. The limiting sensitivity will be $2.4 \times 10^{-15}$ erg cm$^{-2}$ sec$^{-1}$ in 20–80 keV band (100 ksec).

## 1. Introduction

In X-ray astronomy, hard X-ray observations above 10 keV are important to find out many X-ray emitting objects obscured by thick absorbing material. They have crucial importance in the investigation of star forming region, active galaxies and the cosmic X-ray background. Mapping observations in such energy range also make clear the distribution of non-thermal components of extended objects, such as supernova remnants and clusters of galaxies.

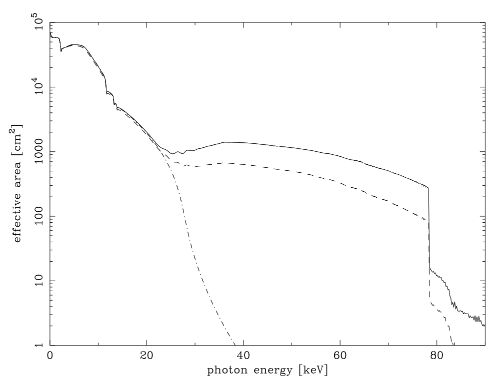
Recently the powerful X-ray satellites, XMM-Newton and Chandra were launched, and they achieved to have a large effective area of about 3000 cm$^2$ at 8 keV and a high angular resolution of about 0.5 arcsec, respectively. For the investigation of above sciences, it is required to extend the sensitivity over 10 keV and to take over those high performance. For this purposes, supermirror is one of the key technologies. InFOC$\mu$S balloon-borne experiment will be carried out by cooperating between Nagoya University and NASA Goddard Space Flight Center in 2001. In this experiment, the performance and capability of the supermirror hard X-ray telescope will be shown. The detailed discussion is described in Tawara et al. and Nomoto et al. in this proceedings. We would like to propose a coating supermirrors on the mirrors of the *XEUS* X-ray telescope which has a especially large geometrical area.

## 2. Supermirror Design

The *XEUS* X-ray telescope has a focal length of 50 m and a outermost diameter of 4.5 m for the initial mirror assembly (MSC1). On axis incident angles for 300 nested mirrors are from 0.17 to 0.65 degrees in the initial mirror configuration. (*XEUS* web page) Suermirror have changing periodic length of bilayer, which give us wide energy band for hard X-ray corresponding Bragg reflection peak. For the supermirrors design, we selected the combination of platinum and carbon, and the same design method as InFOC$\mu$S (Yamashita et al. 1998). The periodic length ranges from 40 Å to 26 Å. Total number of layer pairs is 221. An average of the peak reflectivity is about 40 % . The wide bandwidth of supermirror consist of 1st Bragg peak and 2nd Bragg peak. For simple supermirror, the reflectivity around a critical energy is lower than the mono-layer mirrors, due to low density of the mirror surface. We added Pt top coating of 100 Å on the top of the supermirror to avoid the reduction of reflectivity. Applying this type of supermirror to the part of *XEUS* mirrors having incident angles of 0.4 degrees or less, the effective area in high energy region is enhanced.

## 3. The Effective Area of The *XEUS* Hard X-ray Telescope

Finally we obtained the effective area shown in the figure. The solid, dashed and dot-dashed lines show the effective area of *XEUS* telescope with supermirror assuming an interfacial roughness of 0 Å and 3 Å, and original *XEUS* X-ray telescope (MSC1), respectively. In the hard X-ray region, while the effective area of the *XEUS* telescope decreses for X-rays above 20 keV, the *XEUS* hard X-ray telescope equipped the supermirror has a large effective area. Its effective area is kept to be 1000 cm$^2$ below 60 keV, and about 200 cm$^2$ at 78 keV. A sharp edge around 78 keV is caused by platinum K-edge absorption. In the fabrication, the interfacial roughness of 3 Å is realistic. In this case, it has over 100 cm$^2$ up to 78 keV. In the hard X-ray region 20–80 keV, a limiting sensitivity is $2.4 \times 10^{-15}$ erg cm$^{-2}$ sec$^{-1}$ at 100 ksec observation, assuming that a detector background is same as that of InFOC$\mu$S. This sensitivity has been never achieved in the previous missions and any other future missions.




## References

*XEUS* web page, http://astro.estec.esa.nl/SA-general/Projects/XEUS/

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Nomoto, K. et al., in this proceedings

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