SOFT X-RAY IMAGER USING MULTILAYER MIRROR OPTICS FOR MARTIAN EXOSPHERIC STUDIES. S. Panini[1], S. Narendranath[2], P. Sreekumar[1], P. S. Athiray[3], M. Nayak [4]. [1]Indian Institute of Astrophysics (panini@iiap.res.in), ISRO Satellite Centre (kcshyama@isac.gov.in) , [3]Manipal Centre for Natural Sciences, [4]Raja Ramanna Centre for Advanced Technology.

Introduction: Planetary X ray measurements in the past have yielded valuable science in several areas such as the surface chemistry, polar auroras, magnetospheres and solar wind interaction with the exosphere. X-ray spectrometers have been flown in several missions primarily to map the surface elemental abundances. We are developing a soft X-ray imager where multilayer mirrors are used to selectively image the energies of interest onto the focal plane detector. This would be thus capable of doing imaging spectroscopy of the Martian exosphere.

Motivation: Planetary exospheric studies on its density structure, temperature profile and composition, enable calculation of escape flux from the planet's atmosphere. This provides important constraints to models on long term atmospheric evolution and volatile inventory. The characteristics of this region of the planetary atmosphere are heavily driven by its interaction with the solar wind. The exosphere also exhibits short term variations that are driven by seasonal changes, dust storms and are strongly coupled to the physical and chemical processes in the thermosphere and ionosphere.

The extended exosphere consists of several species such as H, C, N and O. The exobase altitude and extent is different for the different species. In addition to the thermal population, there is an important non-thermal population of hot atomic species in the Martian exosphere. The current understanding of the density distribution of these atoms is largely based on 3D models rather than direct measurements especially in the extended exosphere.

XMM Newton observations of Mars [1] from Earth's orbit show solar wind charge exchange X-ray emission in the exosphere up to ~ 8 Martian radii. Mapping SWCX emission from an orbit around Mars can provide through forward modeling, a global picture of the neutral atom density profiles and quantify the contribution of this non-thermal escape mechanism.

X-ray imaging spectroscopy is one of the best ways to remotely sample the exospheric species and its dynamic interactions with the solar wind. A compact light weight design is crucial on a planetary mission where resources are limited. This work therefore is targeted towards a design where single reflection optics using multilayer coated mirrors, acts as a telescope with a short focal length for a mission to Mars.

Design: The optics design consists of 24 shells of single reflection grazing incidence mirrors that are Ni coated which will concentrate the X- rays onto a set of multilayer mirrors placed at an angle of 35° from the optical axis (Figure 1). The multilayer mirrors act as monochromators to image specific lines of interest to a detector at the Nasmyth focus. Design parameters of the soft X-ray concentrator and multilayer mirrors are optimized to primarily observe six lines from the Martian exosphere. Sequential operation of each of five multilayer mirrors gives excellent spectral response. Monochromatic multilayers also suppress the background counts. Figure 2 shows the effective area of the optics. Conventional semiconductors (Si) or wide band-bap semiconductors will be considered as focal plane detectors.

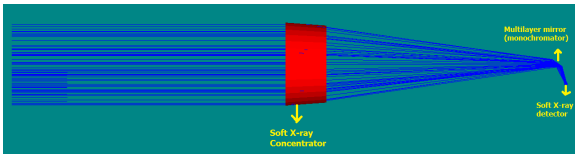

Figure 1: Optical layout of the telescope design

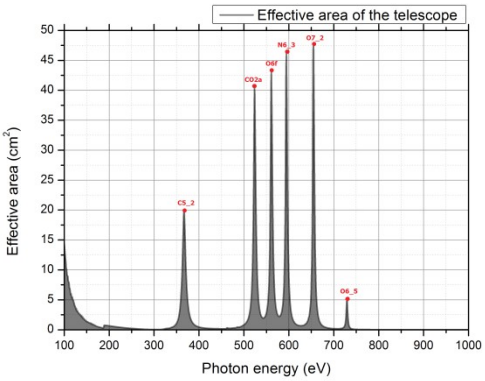

Figure 2: Effective area of the optics

Developments: We have coated silicon substrates with multilayers of W/B_4C (of a range in the number of bilayers from a few to 170 layers) with magnetron sputtering system at the Raja Ramanna Centre for

Advanced Technology (RRCAT), India (Figure 3). These mirrors have been tested for X-ray reflectivity and have gone through thermal cycling for stability checks.

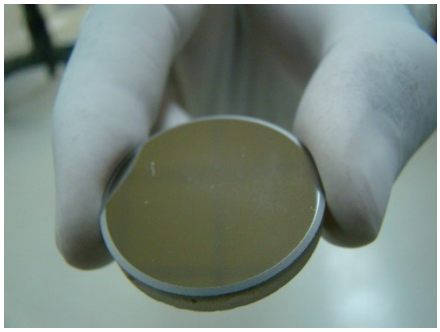

Figure 3: W/B_4C mirror developed using a magnetron sputtering system at RRCAT

Summary: We are developing a soft X-ray imager for Mars that would be capable of coarse imaging of the Martian exosphere at specific lines of interest in the 0.3 to 2 keV energy range. Multilayer mirror coatings have been developed and tested for X-ray reflectivity and thermal stability. The design yields a compact payload with a 100 cm focal length that can fly on a mission to Mars.

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References: [1] Dennerl, K., et al. (2006) A&A, 451, 709-722