Development of Multilayer Coatings for Hard X-ray Optics at NASA Marshall Space Flight Center

Motivation

Broadband X-ray multilayer coatings are under development at NASA MSFC for use on future astronomical X-ray telescopes. Multilayer coatings deposited onto the reflecting surfaces of X-ray optics can provide a large bandpass enabling observations of higher energy astrophysical objects and phenomena.

STATUS - Calibration and optimization of the new multilayer coating system at MSFC has been completed. Initial periodic multilayers have been deposited with plans to begin regular depth-graded coating runs within the next month.

Deposition Chamber

- DC magnetron sputtering system – planetary geometry
- Accommodates 1 - 4 inch flat substrates
- 2 cathodes provide single layer and multilayer coating capabilities (2 in diameter targets)
- Custom control software allows for precise and efficient deposition runs

Coating Uniformity

Coating uniformity is sensitive to several geometry-dependent parameters:

- Relative vertical and radial position of cathode and substrate
- Distribution of ejected atoms from the target (plume distribution)

Two inch diameter cathodes were selected for this system due to the reduction of operating cost while expanding material research capabilities

Coating Uniformity as a Function of Radial Cathode Position

![Coating Uniformity Graph](image)

Periodic W/Si Multilayers

Deposited three periodic W/Si multilayers with various d-spacings for system validation and deposition rate determination

D-spacings were selected within the d-spacing range of NuSTAR flight recipe 10 depth-graded W/Si multilayer

<table>
<thead>
<tr>
<th>Coating ID</th>
<th>D-spacing (Å)</th>
<th>N</th>
<th>T</th>
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<tr>
<td>XRO 032</td>
<td>75.4 - 25</td>
<td>291</td>
<td>0.38 (top)</td>
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<td>XRO 032</td>
<td>40</td>
<td>50</td>
<td>0.38</td>
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<td>XRO 035</td>
<td>25</td>
<td>50</td>
<td>0.38</td>
</tr>
</tbody>
</table>

NuSTAR Flight Recipe 10 is the target design that will be used for validation of the system’s depth-graded coating capabilities

Future Work

- In situ coating stress measurements – configured for rotating substrate holder
- System geometry can be changed to accommodate linear cathodes
- Ion mill implementation
- Inverse solution of deposited depth-graded multilayer structures

Target Material Plume Distributions

Used UniformityPro® software utility to model coating uniformity, calculate fitting parameter m

![Target Material Plume Distributions](image)

References