Fabrication of high precision, multilayer based polarimeter for a wide EUV energy range

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1. Introduction

- Polarmeters using multilayer EUV (extreme ultra-violet) optical elements are used to characterize the state of polarization of synchrotron radiation in the EUV region and the reflection and transmission properties of EUV optical devices.
- A high precision five-rotational axes EUV polarimeter using transmission multilayers as polarizers and reflection multilayers as analyzers has been designed and fabricated. Mo/Si, Cr/C, Sc/Cr and W/B/C reflection and transmission multilayers have been designed and fabricated. The reflection multilayers were fabricated using magnetron sputtering, and the transmission multilayers were fabricated using CVD deposition, magnetron sputtering and chemical etching processes.
- The polarimeter is supported on a hexapod to simplify the alignment, and the equipment can be moved easily between different beamlines.

2. Fabrication of the multilayers

- Reflection multilayers were fabricated using magnetron sputtering
- Fabrication process of the transmission multilayers
  1. SiN layer deposition - by CVD
  2. Formation of back surface mask - photolithography is used to pattern a window in the photo resist
  3. Removal of SiN layer - dry etching is used to form a window in the SiN layer
  4. Formation of window area - SiN is etched from the back to form a SiN membrane
  5. Multilayer deposition - by magnetron sputtering
  6. Removal of SiN membrane - SiN is removed from the back leaving the multilayer supported by a Si3N4 frame

- Examples of measured reflectivity and transmittance of free-standing multilayers for an incident angle of 80 deg. vs. wavelength

3. Polarizer & Analyzer

- This polarimeter was designed to cover the energy range up to 1200 eV.
- To cover this energy range, four pairs of multilayers are needed.
- The parameters for these multilayers are given in this Table.

<table>
<thead>
<tr>
<th>Material</th>
<th>Mo/Si</th>
<th>Cr/C</th>
<th>Sc/Cr</th>
<th>W/B/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periodic length (nm)</td>
<td>0.4</td>
<td>3.13</td>
<td>2.57</td>
<td>1.75</td>
</tr>
<tr>
<td>1st element thickness / d</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.24</td>
</tr>
<tr>
<td>No. of layer pairs</td>
<td>100</td>
<td>280</td>
<td>400</td>
<td>350</td>
</tr>
<tr>
<td>Interface and surface roughness</td>
<td>~0.4 nm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- For each material composition, two types of multilayer were fabricated: one unsupported multilayer for the polarizer and one back supported multilayer for the analyzer

4. Polarimeter instrument

- Schematics of the polarimeter
  - Polarizer & Analyzer
  - Multilayer cassettes
  - Analyzer (reflection multilayer)
  - Polarisers (transmission multilayer)

- Fabricated polarimeter

- Accuracy of rotational axes

- Multi-axis polarimeter with angular resolution of 0.001 deg

5. Summary

- A high precision five-rotational axes EUV polarimeter using transmission multilayers as polarizers and reflection multilayers as analyzers was designed and fabricated.
- To cover a wide energy range, around 100 eV ~ 1200 eV, Mo/Si, Cr/C, Sc/Cr and W/B/C reflection and transmission multilayers were designed and fabricated.
- The polarimeter is supported on a hexapod to simplify the alignment.
- This equipment can be moved easily between different beamlines.