A new linear polarizer design for application in the far-ultraviolet spectral range

Goddard Space Flight Center

Collaborators: Manuel Quijada(GSFC 551), Paul Scowen(GSFC 667), Mateo Batkis (GSFC 551), Johnathan Gamaunt (ASU), Javier Del Hoyo (GSFC 551), Luis De Marcos (CUA/GSFC/CRESTT2), Bob Woodruff

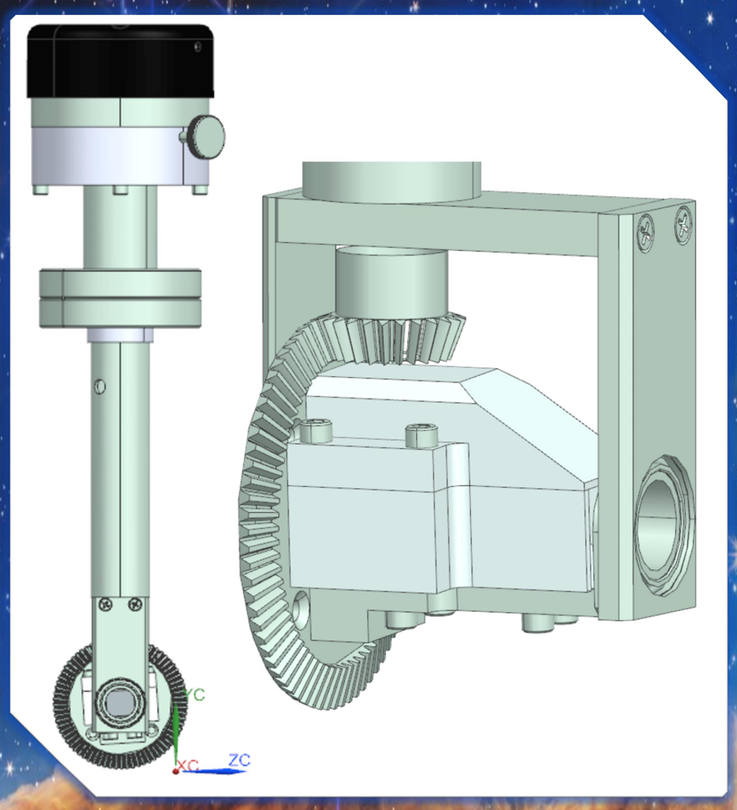
The Catholic University of America

Optics Branch Code 551

Arizona State University

I. Project Goals

- GSFC produces world-class far-ultraviolet (FUV) coatings
- Current instrument limitations make examining the polarization properties of these coatings impossible in the 100-200nm range
- With the creation of a polarizer that will be fitted into our existing McPherson Model 225 Vacuum Ultraviolet (VUV) Spectrometer we will be able to fill in the gaps in our measurement ranges in the FUV spectra
- This polarizer will enable direct measurements of the complex refractive index (n and k) values of a variety of coating materials after deposition process is complete

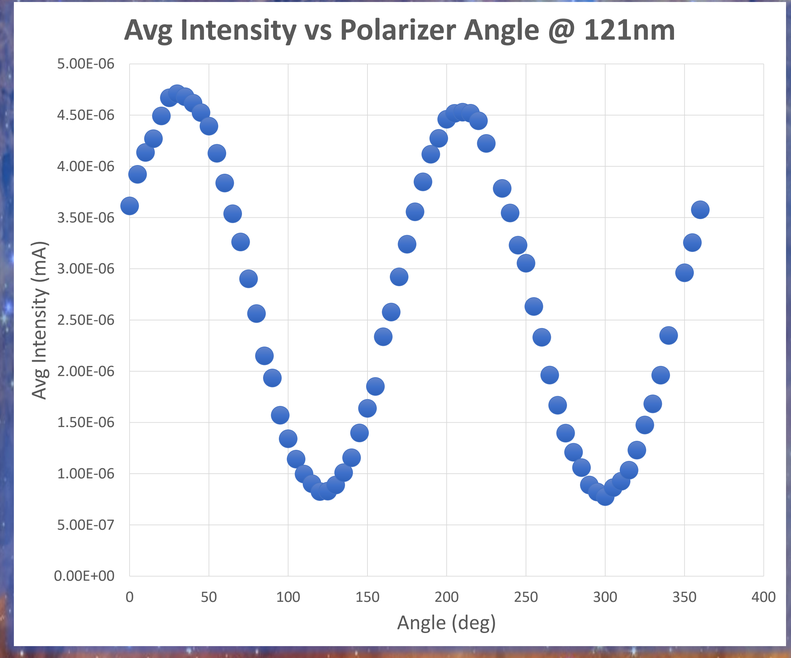


II. Polarizer Design

- Optical Design:
  - The polarizer is an arrangement of
    - 2x silicon carbide (SiC)
    - 2x lithium floride (LiF) crystals
  - The crystals are arranged in a U-Shape configuration
  - Incoming light is reflected off each surface at an incident angle of 56.75° before passing out of the polarizer
  - The result is that outgoing light is highly linearly polarized
- Mechanical Design:
  - The polarizer mount must be able to rotate about the optical axis through a full rotation of 360° with a desired precision of 0.25-0.1°

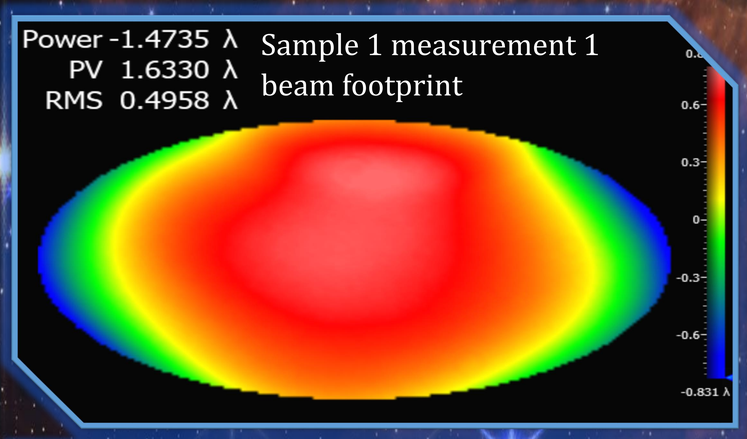
III. Materials Characterization

- Initial order contained 8x SiC and 8x LiF crystals
- In order to determine which ones in each batch to select for our polarizer we characterized several optical properties
- Properties included:
  - Roughness (measured on Park Systems NX20 AFM)
  - Flatness (measured on Zygo VeriFire MST+)
  - Spectral Reflectance (measured on Perkin Elmer with the TAMS accessory)
- Initial characterization work proved that SiC samples 1, 4 were to be selected for their superior optical performance
- All LiF Samples proved to have similar properties however sample 1's front and sample 4's back surface had the best roughness values and thus were selected for their stray light suppression properties



IV. Assembly & Alignment

- With all optical characterization complete and the mount / assembly in hand we were able to proceed with the assembly / alignment
- As per our mechanical design we were able to place the LiF and SiC samples in its mount without issue
- The assembled was first tested in our PE 3Detector Accessory, it was then mounted and placed into its rotation stage and was tested in our McPherson 225
- Initial test show that as the polarizer was rotated it performed as expected and properly polarized light on our test MgF2 sample (shown left)



SiC AFM Data Sample 1

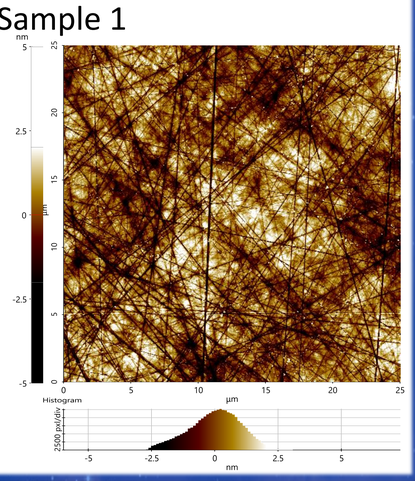
Region size: 25x25µm

Image Resolution: 556x556px

Lateral Resolution: ~45nm/px

Roughness: RQ=1.0nm





V. Results

- Initial Results:
- Crystal Characterization
  - Roughness: All SiC and LiF samples showed similar values with RQ:1-2nm
  - Flatness:
    - SiC Samples 1, 4 showed the best PV, Power, and RMS values
    - All LiF Samples showed Similar PV, Power, and RMS values
  - Spectral Reflectance:
    - Spectral Reflectance of both SiC Sample 1, 4 and LiF spare sample agreed with theoretical data gathered from published refraction data when measured at 56.75°
- Polarizer efficiency:
  - Measurements in the 200-800nm spectra showed a relatively constant Ts and Tp of about 1% and 0.012%, respectively
  - Extinction ratios of about 60-100. Note that the extinction ratio decreases as the wavelength approached 200 nm since the commercial polarizer in the spectrometer becomes less efficient.

