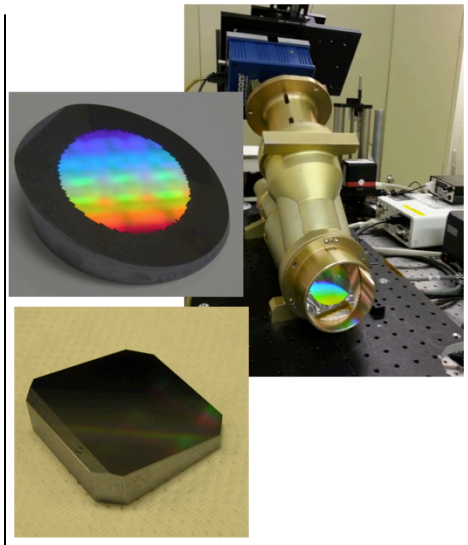
Immersion Grating for Compact Greenhouse Gas Monitoring Instrument

PI: Daniel Jaffe, The University of Texas at Austin

Objective

- Fabricate silicon (Si) immersion gratings for IR (1150 – 8500 nm) spectroscopy to support ground-based, airborne, and space-based infrared spectrometers.
  - These gratings offer substantial advantages in compactness, formatting, and efficiency over other dispersive devices and have 3.44 times the resolving power of a conventional front-surface device for a grating of a given size.



- In an immersion grating, the light is incident on the grating surface from the inside, where the wavelength is shortened by a factor equal to its refractive index (3.44 for Si)
- Immersion grating built using grayscale lithography (top left)
- Immersion grating built using contact lithography (bottom left)
- Immersion grating placed in the JPL Spectrometer Testbed (near left)

Accomplishments

- Developed the optical layout for several IR spectrometers at 1.598-1.659 μm, 2.045-2.080 μm, 2.305-2.385 μm, and 7.634-8.333 μm that are suitable for Earth science applications
- Explored three methods of direct e-beam writing of gratings: negative photoresist, two-pass with positive photoresist, and Cr liftoff, in which Cr liftoff was identified as the most effective method for patterning small groove constant immersion gratings
- Patterned a grating surface with λ/20 phase uniformity (measured on the front surface at 633 nm) with no spectral ghosts to the level of $I_0/I_g < 10^{-4}$ via contact printing and machined it into an immersion grating prism suitable for the 1.598-1.659 μm band
- Fabricated a grating surface with λ/17 phase uniformity (measured on the front surface at 633 nm) with no spectral ghosts to the level of $I_0/I_g < 10^{-4}$ on a blazed silicon substrate suitable for cutting into an immersion grating prism for the 1.598-1.659 μm band using e-beam patterning with chromium liftoff
- Fabricated an immersion grating suitable for the 2.045-2.080 μm band with the grayscale E-beam patterning and plasma transfer etch method directly into a silicon prism that was placed into the JPL Spectrometer Testbed to demonstrate the modular immersion grating spectrometer design

Co-Is/Partners: Daniel Wilson, Christian Frankenberg, Victor White, Andy Kuhnert, JPL; Cindy Brooks, University of Texas

$TRL_{in} = 3$ $TRL_{out} = 4$