National Aeronautics and Space Administration

Improved Black Silicon Nitride Slits for Imaging Spectrometers

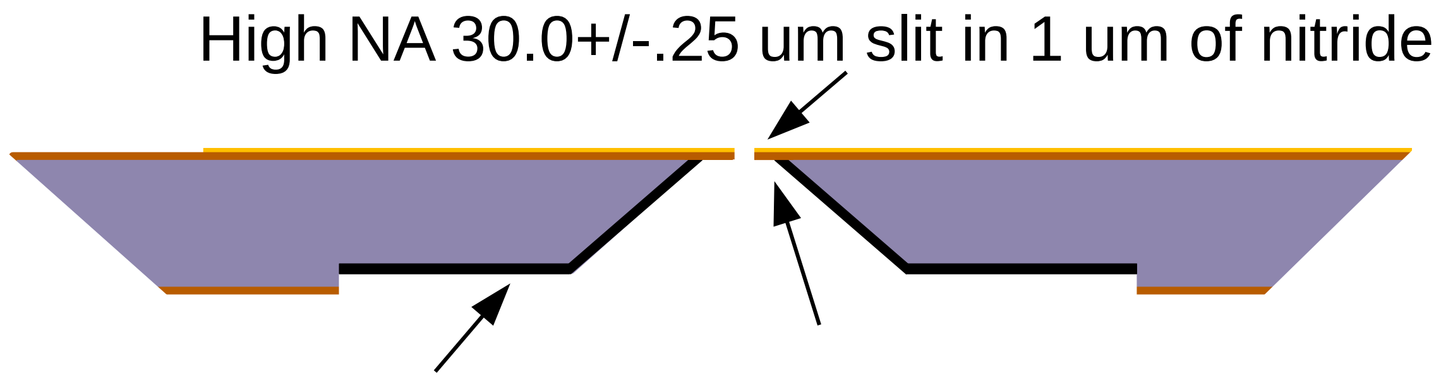
Principal Investigator: Victor White (389); Co-Investigators: Karl Yee (389)

Program: FY22 R&TD Innovative Spontaneous Concepts

Objective:
The objective of this research is to create highly accurate, high numerical aperture (NA), ultra-black slits for hyperspectral imaging spectrometers. We want the black go all the way to the edge of the slit itself, and to have the membrane where the slit is to be as thin and accurate as possible. If we could do this, we could further increase the sensitivity, signal to noise ratio, and accuracy of JPL's imaging spectrometers.

Background: Black silicon is one of the blackest materials in existence. Researchers at JPL have incorporated it into making slits for imaging spectrometers which can absorb almost all of the light at the point of rejection. JPL Black silicon slits have become a standard component of JPL's Hyperspectral imagers, each whith their own weakness. These black silicon slits were previously based on 2 slightly different techniques, the **Silicon Nitride Slits (SiN)** and the **Silicon on insulator (SOI)** slits.

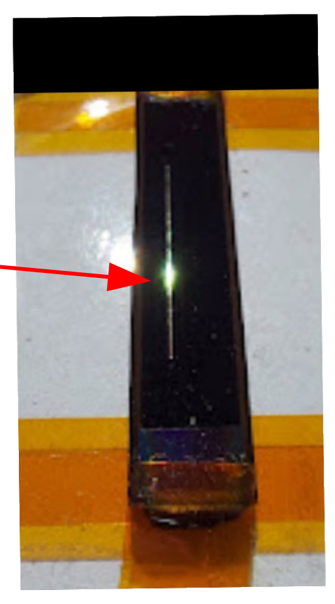
The **Silicon nitride (SiN)** slits, can have a slit width accuracy better than ¼ um, and with a membrane of ~ 1 um, have a very high aperture. But the black does not go to the edge of the slits, and they backscatter some light.



High NA 30.0+/-.25 um slit in 1 um of nitride

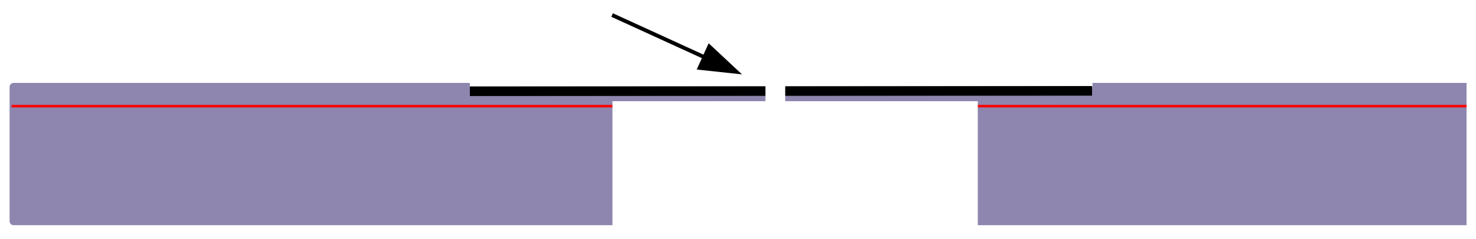
Black silicon

10-15 um nitride cantalever



Silicon nitride slit showing reflected light off of exposed membrane

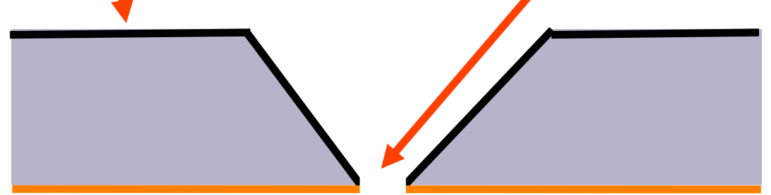
The **SOI (Silicon On Insulator)** slits have a black that goes to the edge the slit, but has relatively poor linewidth control of ~0.5-1.0 um, and it's membrane thickness is ~30-35 um. Thus it has a more limited NA and less overall accuracy.



30.0+1. um slit in 35 um of silicon.

The slit is black to the edge

Approach and Results: We proposed a technique to make the slits black to the edge, but of a high aperture.



Note that the black silicon is so black, the "V-Groove" topology is basically invisible.

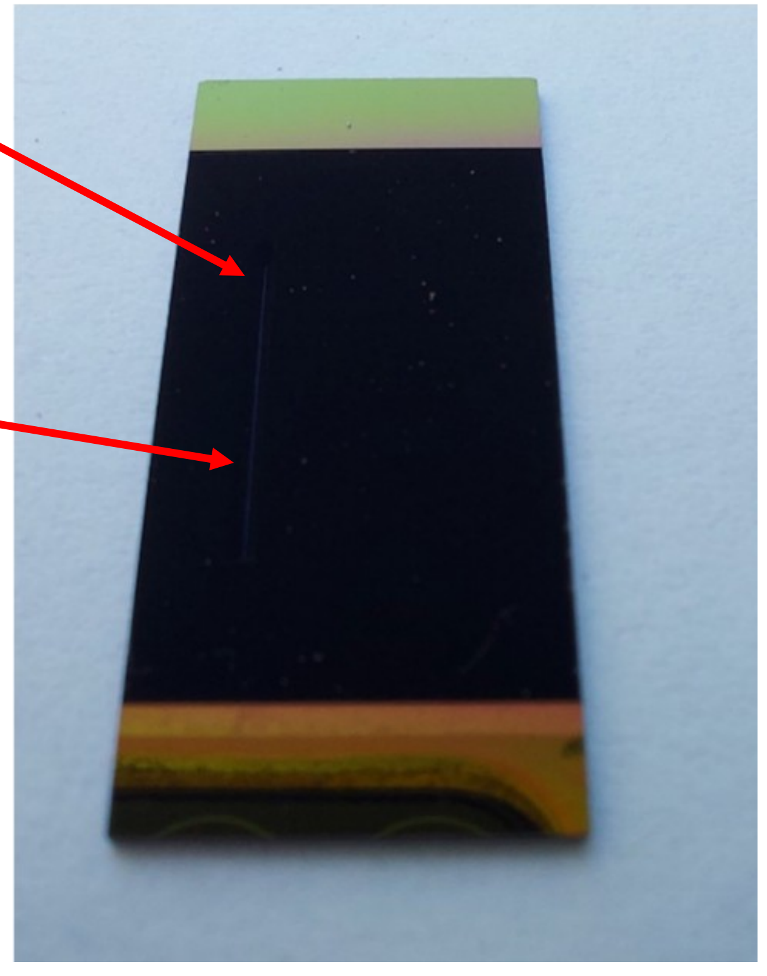
Black Silicon

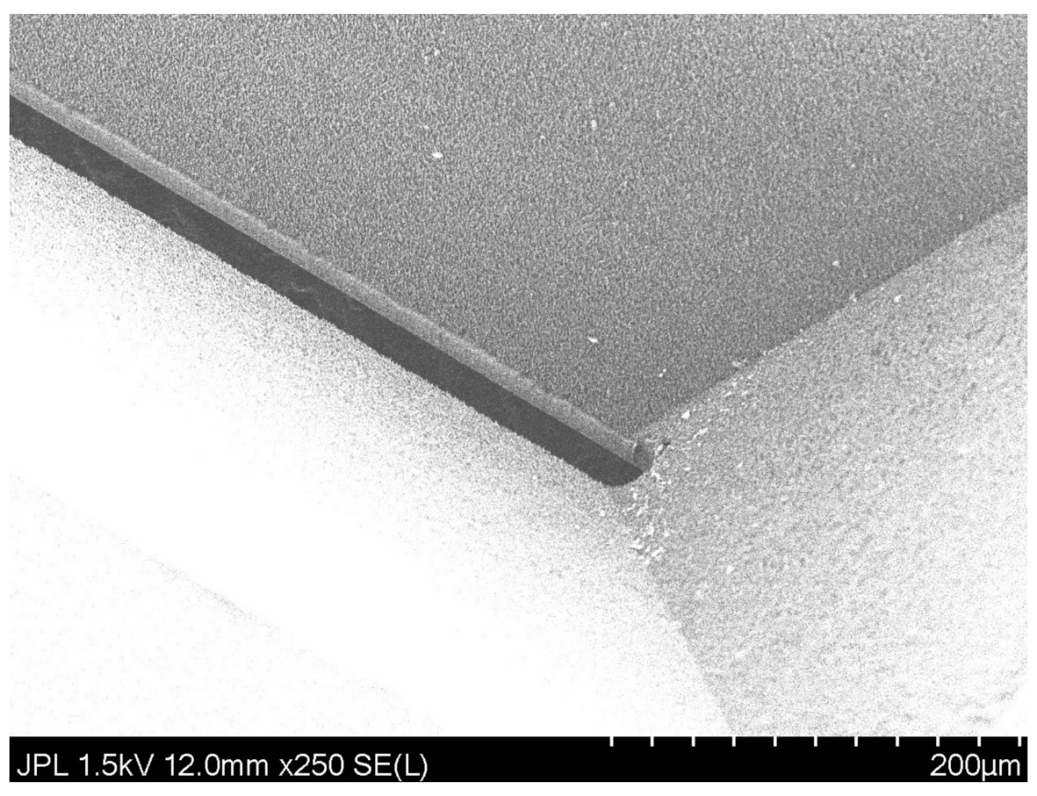
Slit at the bottom Of the V-Groove

1 um of SiN

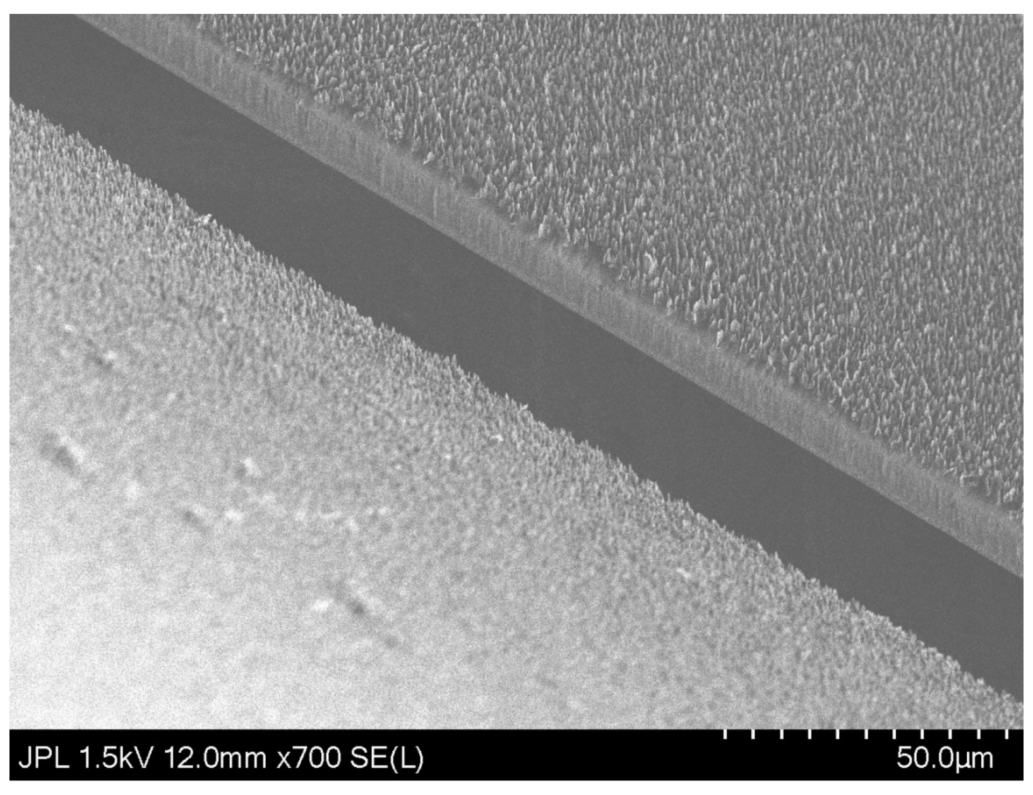
Sidewall ~ 5-10 um

Slit Linewidth control is determined by direct E-beam write on the nitride.





SEM of the end of the slit



A closeup of the slit itself.
The sidewall thickness at the slit itself is on the order of 7.5 um, and the 1 um of nitride is visible.

Significance/Benefits to JPL and NASA: This technology combines the accuracy and high NA of the nitride slit with the blackness of the SOI slits. This may shortly supercede both types of JPL's black silicon slits.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Clearance Number: CL#
Poster Number: RPC#

PI/Task Mgr. Contact Information:
Email: vewhite@jpl.nasa.gov