Current Status of Novel Gratings for Next Generation Astronomical Instruments VII

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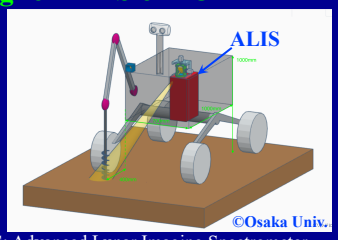
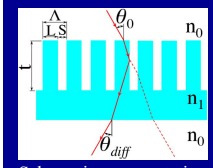
Volume binary (VB) grating for ALIS of LUPEX

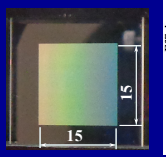


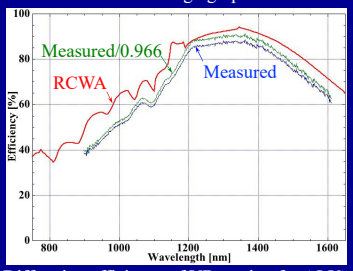
LUPEX: Lunar Polar Exploration Mission, ALIS: Advanced Lunar Imaging Spectrometer.



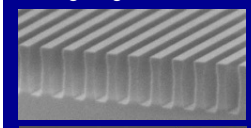
Schematic representation of VB grating.

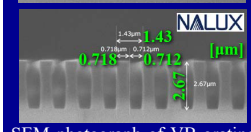
Λ=1.43 μm, t=2.65 μm, L&S=1:1, θ_0=24.8°, n_1=1.0, n_2=1.45.



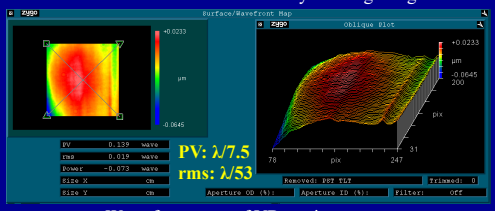


Diffraction efficiency of VB grating for ALIS.





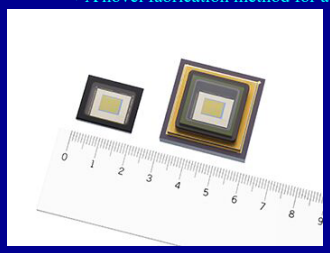
SEM photograph of VB grating fabricated by anisotropic plasma etching on silica substrate.

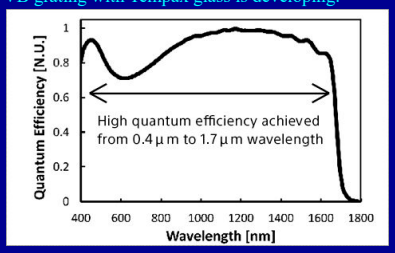


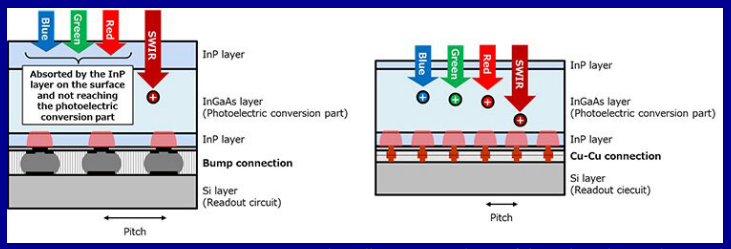
Wave front error of VB grating.

InGaAs detector for ALIS is changed!

Xenics (20×20 [μm], 640×512 pix) →Sony (5×5 [μm], 1280×1024 pix)
→Design and fabrication of lens became difficult.
Λ=1.43μm (700g/mm) →2.0μm (500g/mm)
→ A novel fabrication method for a VB grating with Tempax glass is developing.

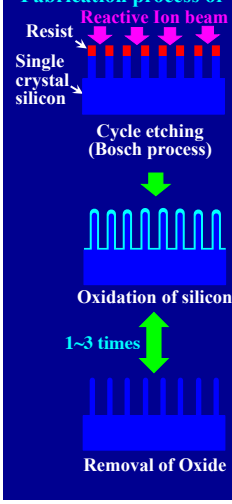




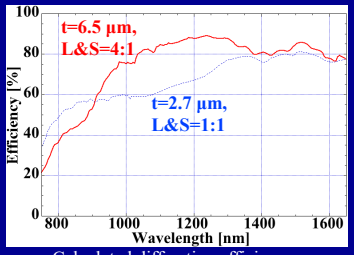


[https://www.sony.net/SonyInfo/News/Press/202005/20-036E/]

Fabrication process of VB grating 2



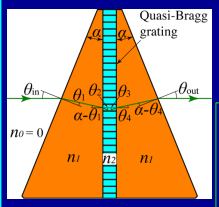
Λ=2.0 μm, t=6.5 μm, L&S=4:1, θ_0=19.2°, n_1=1.0, n_2=1.45.



Calculated diffraction efficiency (RCWA) of VB grating for ALIS.

VB grating for MOIRCS echelle grism

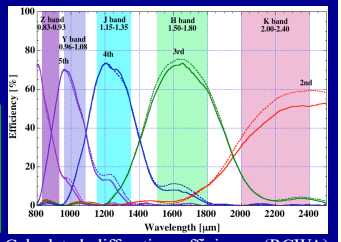
MOIRCS: Multi-Object InfraRed Camera and Spectrograph of 8.2m Subaru Telescope



Schematic representation of echelle grism.

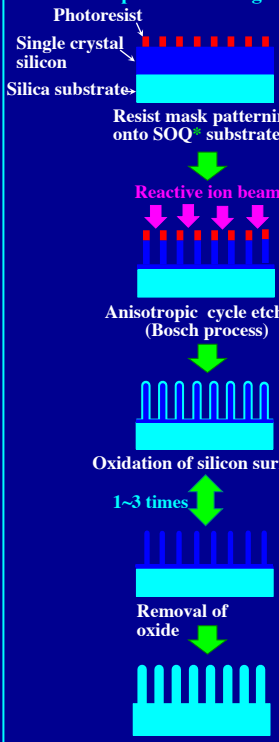
Λ=5.1 μm, t=16 μm, L&S=4.6:0.5 [μm], θ_0=28.4°, n_{2a}=1.45, n_{2b}=1.74.

MOIRCS echelle grism
Slit width: 0.3"
5th, R= 4,630@1.02 μm
4th, R= 4,420@1.25 μm
3rd, R= 4,270@1.65 μm



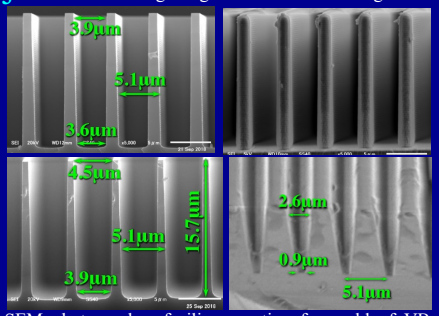
Calculated diffraction efficiency (RCWA) of VB grating for MOIRCS echelle grism.

Fabrication process of VB grating 3



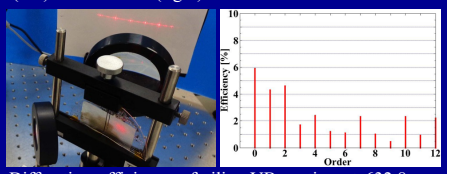
* SOQ: Silicon on Quartz

[N. Ebizuka, *CEAS Space journal* (2020)]



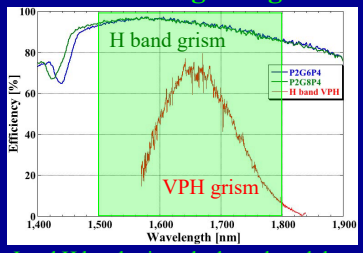
SEM photographs of silicon grating for mold of VB grating fabricated by cycle etching of silicon (upper left), oxidation of silicon (upper right), and removal of the silicon oxide layer (lower left), totaly oxidized silica VB grating tilted with 45° (lower right), t is evaluated about 10.5 μm, although designed t is 16 μm.

Silica VB grating fabricated in a SOQ substrate,12 hours (left) and 40 hours (right) oxidization.

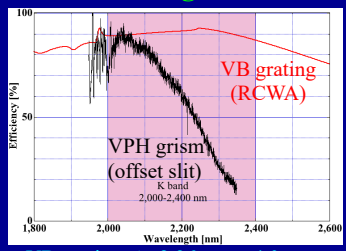


Diffraction efficiency of silica VB grating at 632.8 nm (θ_0=45°). Diffraction efficiency concentrates around 11th order at 632.8nm if t and L&S is ideal.

VB grating for MOIRCS K band grism



J and H band grisms had employed the LightSmyth grating instead of the VPH grating. [I. Tanaka, *Proc. SPIE* 11451 (2020)]



VB grating: Λ=2.36μm, t=4.0μm, L&S=1:1, θ_0=27.8°, n_{2a}=1.435, n_{2b}=1.0.

Summary

- The VB grating achieves very high efficiency and wide bandwidth of wavelength.
- A prototype VB grating with quartz glass for ALIS have fabricated.
- A novel fabrication method for a VB grating of ALIS with Tempax glass is developing by using a Si mold.
- We performed test fabrications of a silicon mold for a VB grating of the MOIRCS echelle grism by anisotropic plasma etching and a silica VB grating on a SoQ substrate by using MEMS technologies.
- Instead of the VPH grism of MOIRCS K-band, we propose a VB grism.