Blazed Gratings on Convex Substrates for High Throughput Spectrographs

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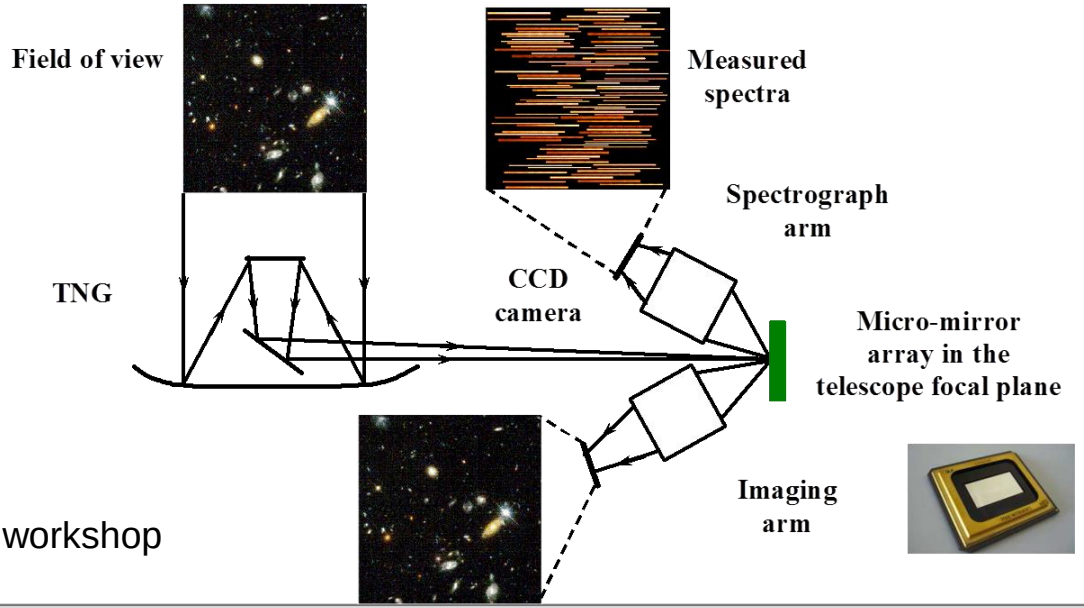
BATMAN for Galileo Telescope

- Next-generation infrared astronomical instrumentation for ground-based and space telescopes will be presumably based on MOEMS programmable slit masks for multi-object spectroscopy (MOS)
- This astronomical technique is used extensively to investigate the formation and evolution of galaxies as well as stellar physics

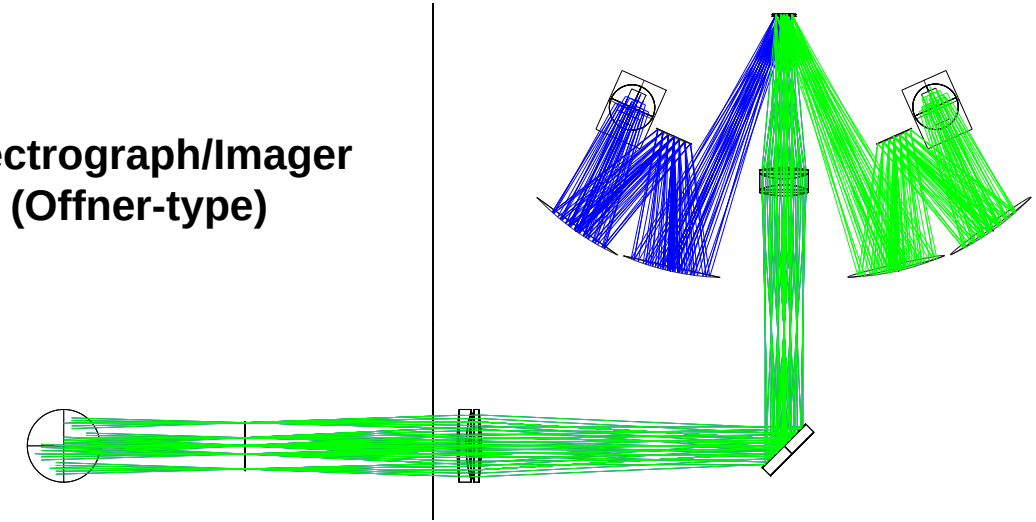


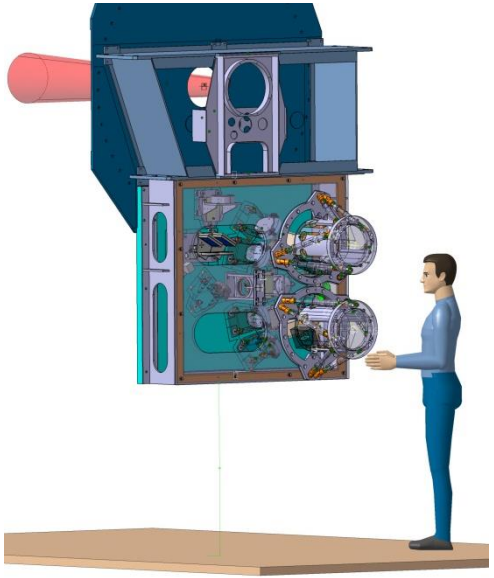
F. Zamkotsian et al., 2016
F. Zamkotsian et al., 2017, poster in this workshop

BATMAN for Galileo Telescope

- A multi-object spectroscopy instrument called BATMAN using a Digital-Micromirror-Device will be mounted on the Galileo telescope
- A two-arm instrument has been designed for providing simultaneous imaging and spectroscopic capabilities.

Spectrograph/Imager (Offner-type)

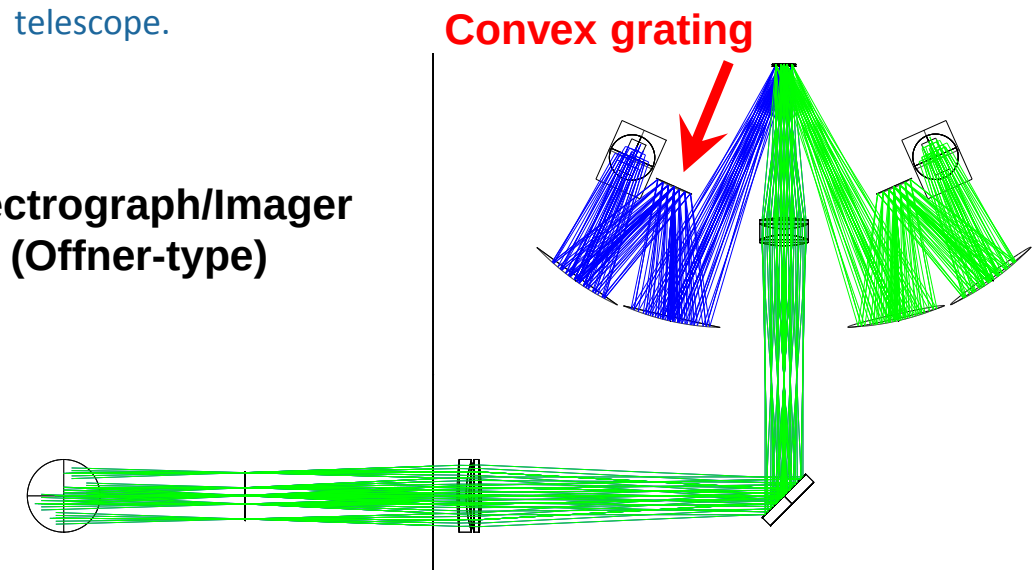


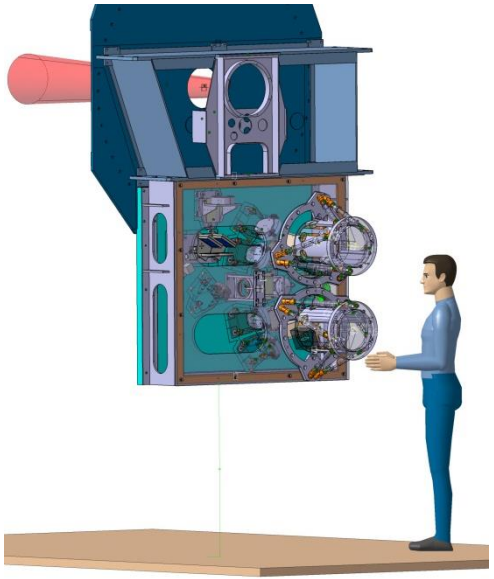


Grating Application

- A **convex grating** is a key element in the compact spectrograph
- Blazing of the grating is performed to maximize the light intensity in **1st order of diffraction**
- The spectrograph is a part of the MOS instrument under development, which will be mounted on the Galileo telescope.

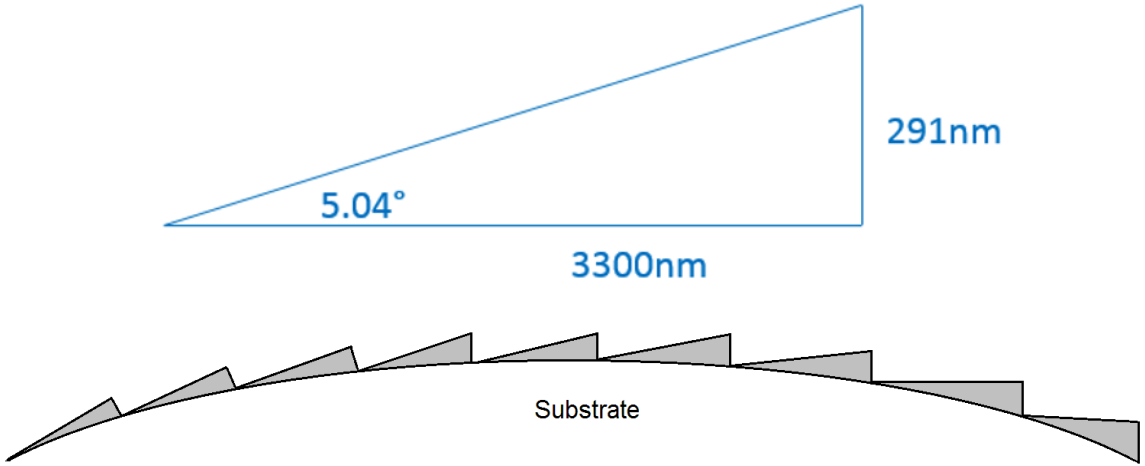
Spectrograph/Imager (Offner-type)





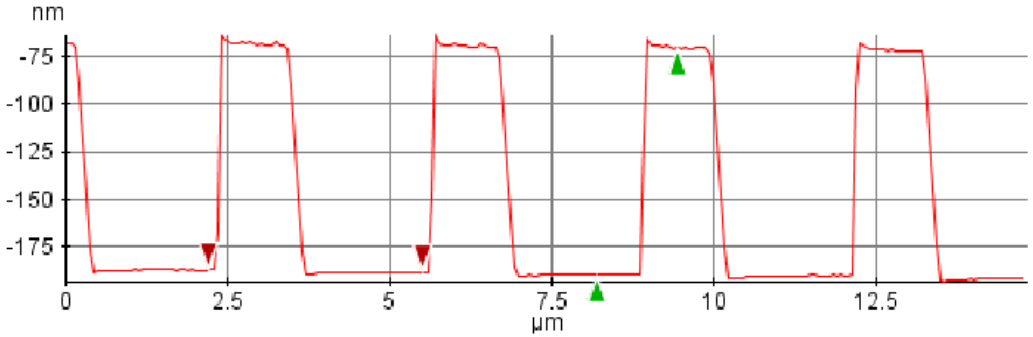
Grating Specification

- Reflective grating blazed in the 1st order of diffraction (p = 3300 nm, α = 5.04°) on a convex substrate
- Radius of curvature = 225 mm; footprint diameter = 63.5 mm
- The blaze is optimized at λ = 580 nm within the spectral range of 400 – 800 nm

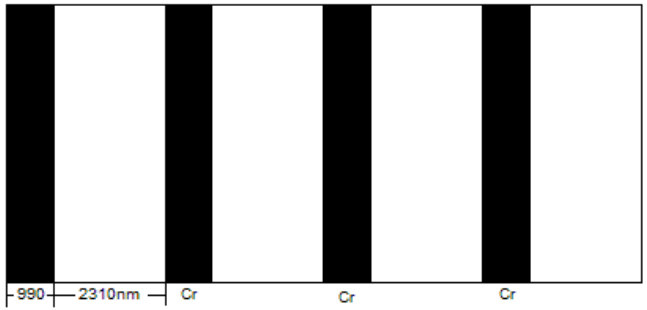


Rectangular Grating on Flat Surface

- Chromium mask with a 3300 nm period grating on a Quartz substrate was used as a master for further UV replications:
  - 120nm Cr thickness
  - Duty Cycle: 30(Cr)/70(Quartz).



Cursor	ΔX(µm)	ΔY(nm)	Angle(deg)
Red	3.301	-1.053	-0.018
Green	1.245	119.058	5.463

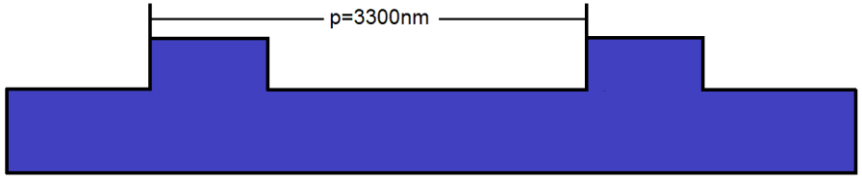


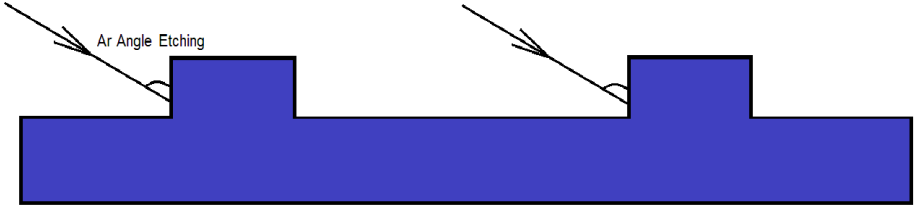
Blazed Grating on a Flat Substrate

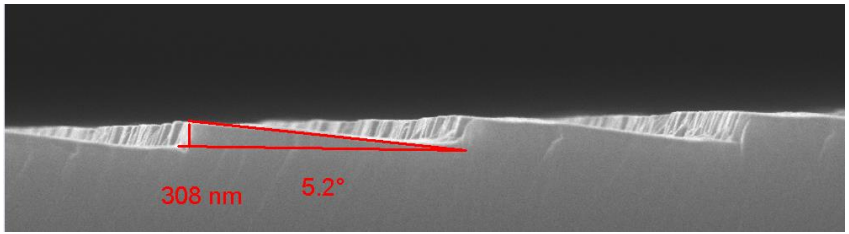
- The rectangular grating was UV replicated twice using Sol-Gel material to keep the respective profile polarity
- Conversion into a blazed shape has been reached by angular Ar ion etching of the Sol-Gel material
- The specified blazed grating parameters have been obtained by adjusting the initial grating depth in Sol-Gel as well as the Ar etching angle and duration.

Fabrication of Master Grating

- Origination of the **blazed master grating** on a flat substrate by **angular Ar ion etching** starting from a rectangular grating with a period of 3300 nm
- The designed blazed grating parameters (depth and blaze angle) was reached by adjusting the initial grating depth as well as the Ar etching angle and duration

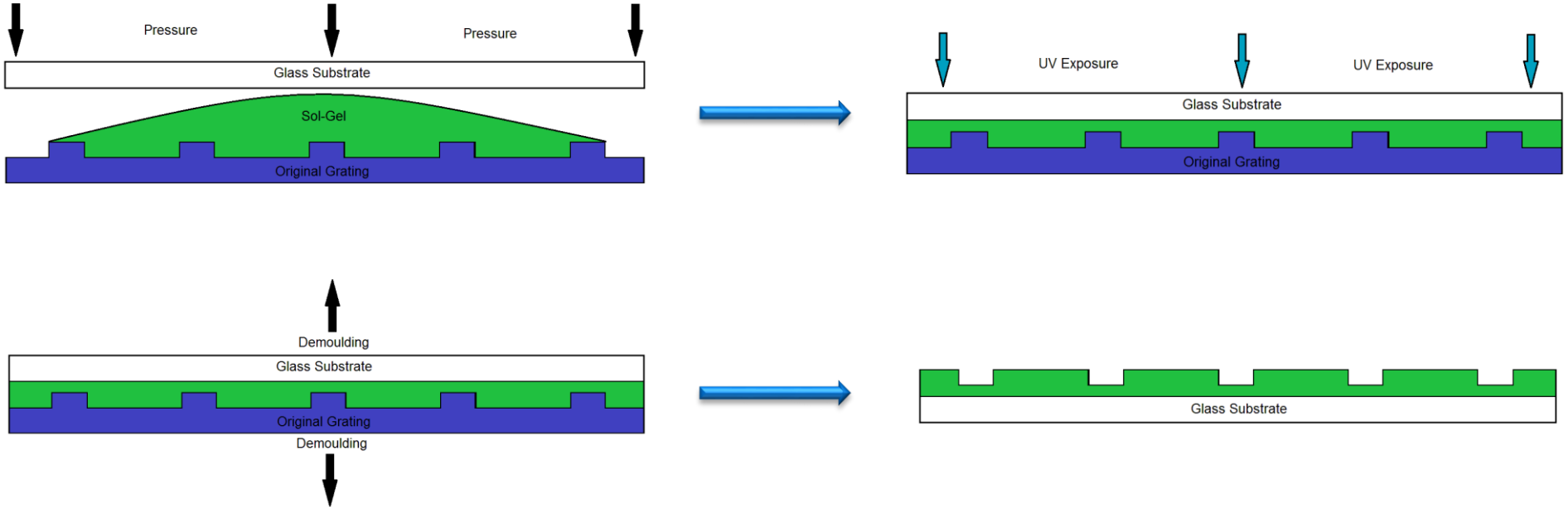






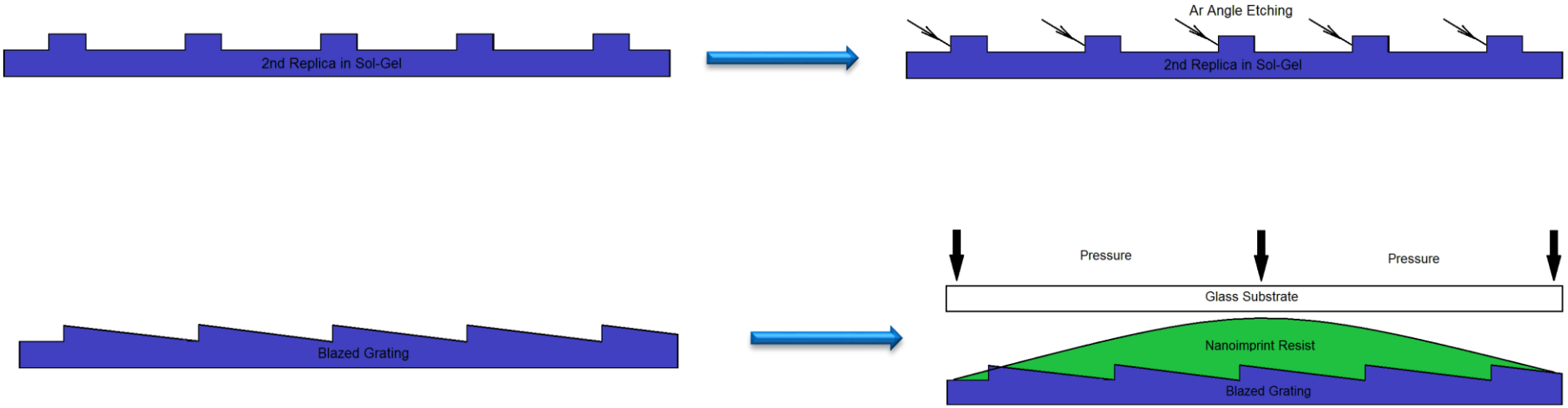
Blazed Grating Transfer: from Flat to Convex. Step 1.

- Step 1: 1st Replication.



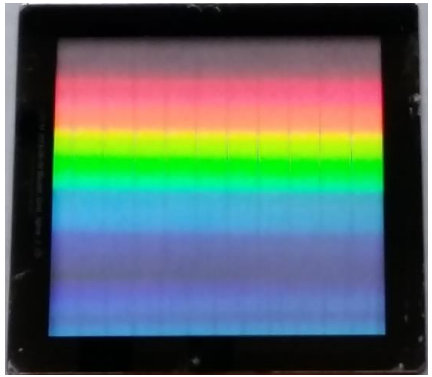
Blazed Grating Transfer: from Flat to Convex: Steps 2, 3, 4

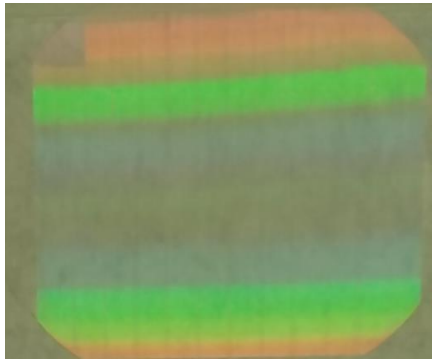
- Step 2: 2nd replication
- Step 3: Ar angle etching
- Step 4: Flexible stamp

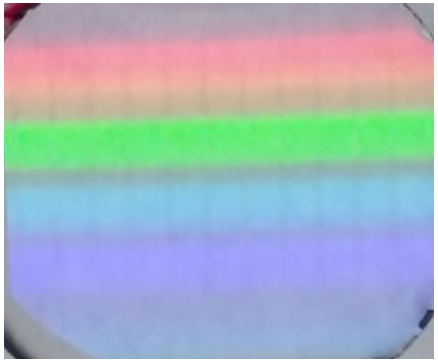


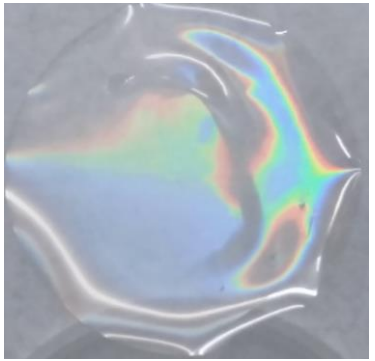
Blazed Grating Transfer: from Flat to Convex: Steps 1 - 4

- Start point: Cr mask
- Step 1, 2: replications of original grating
- Step 3: Ar angle etching
- Step 4: Flexible stamp



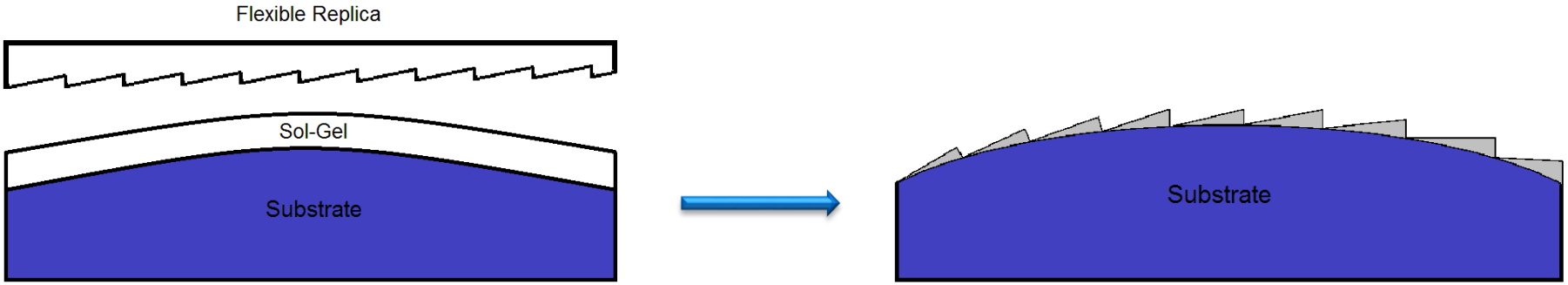






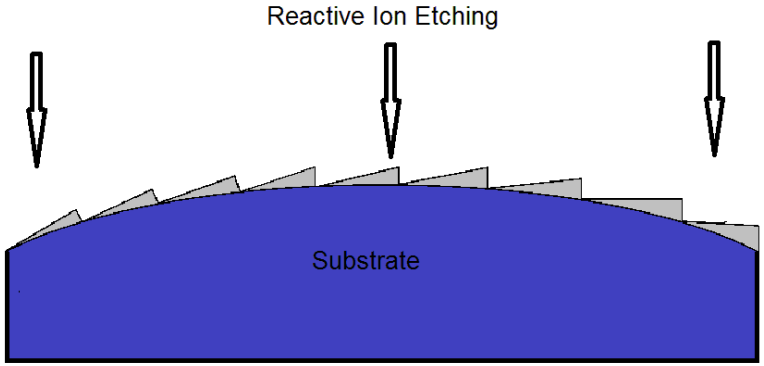
Blazed Grating Transfer onto a Convex Substrate

- Flexible stamp was generated by UV replication of the blazed grating from the flat surface, utilizing a flexible nanoimprint material
- Flexible stamp was used to emboss Sol-Gel preliminary spin-coated on the convex substrate
- The final component is a convex substrate with a Sol-Gel layer carrying the grating structure.

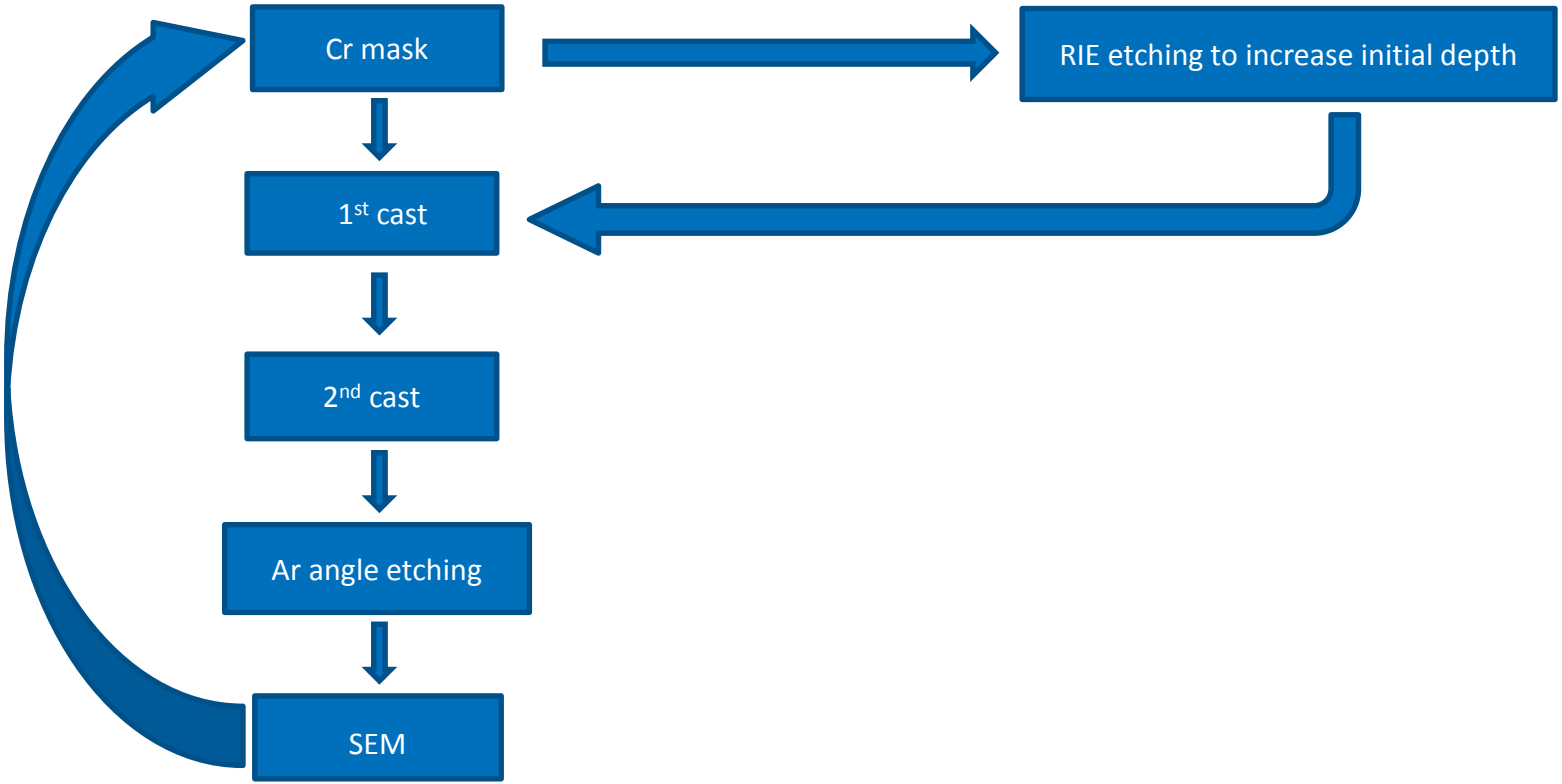


Blazed Grating Transfer into a Convex Substrate

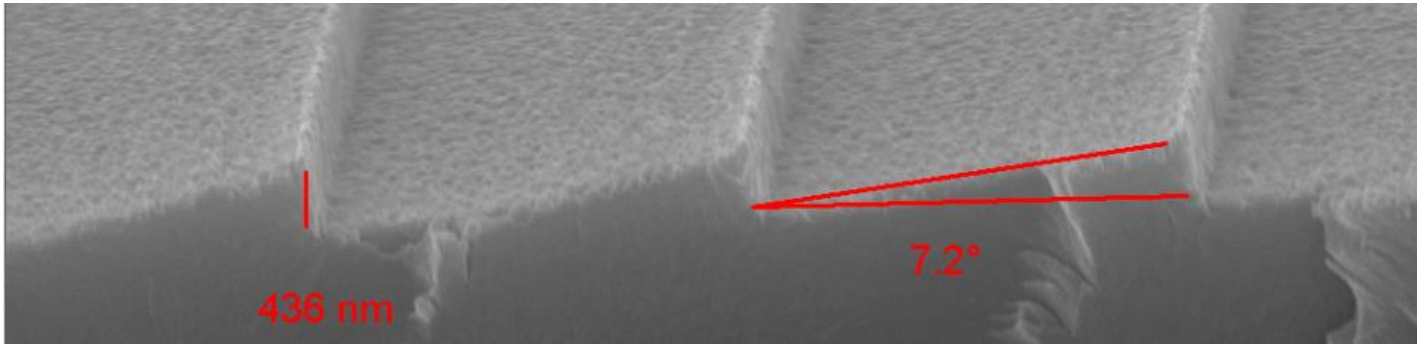
- Flexible stamp was used to emboss a thin layer of nanoimprint material spin-coated on the convex surface
- Nanoimprint material was used as a masking layer for Reactive Ion Etching of the convex substrate
- Replicated blazed grating was transferred into the volume of glass substrate by Reactive Ion Etching etching.

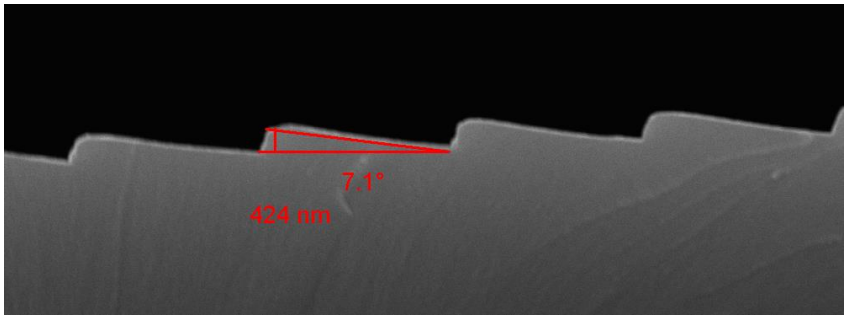


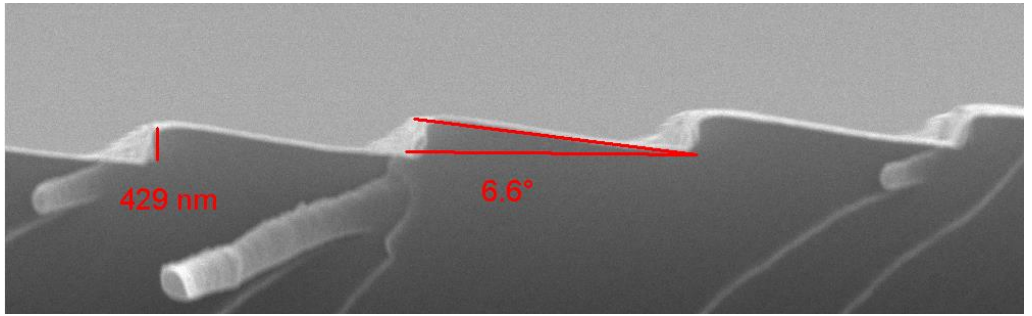
Blazed Grating on a Flat Substrate: Optimization cycle



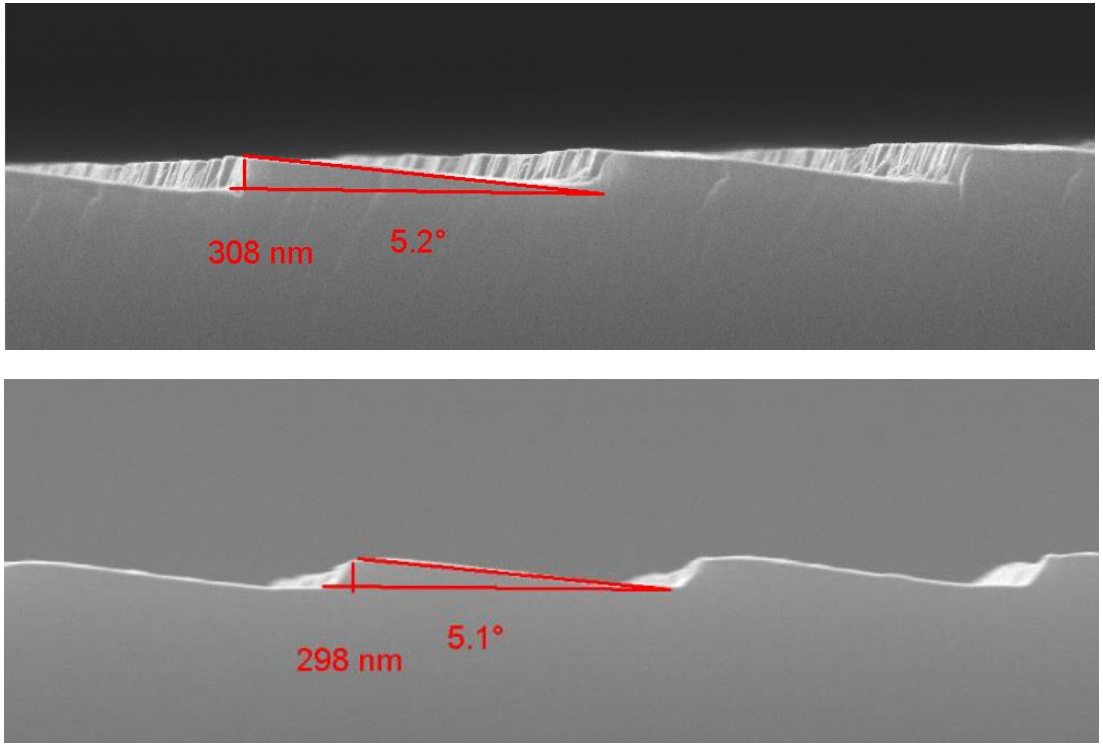
Blazed Grating on a Flat Substrate: parameters adaptation



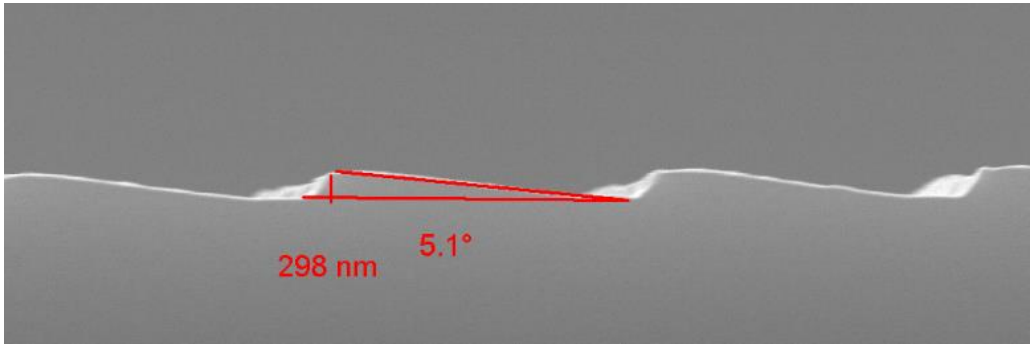


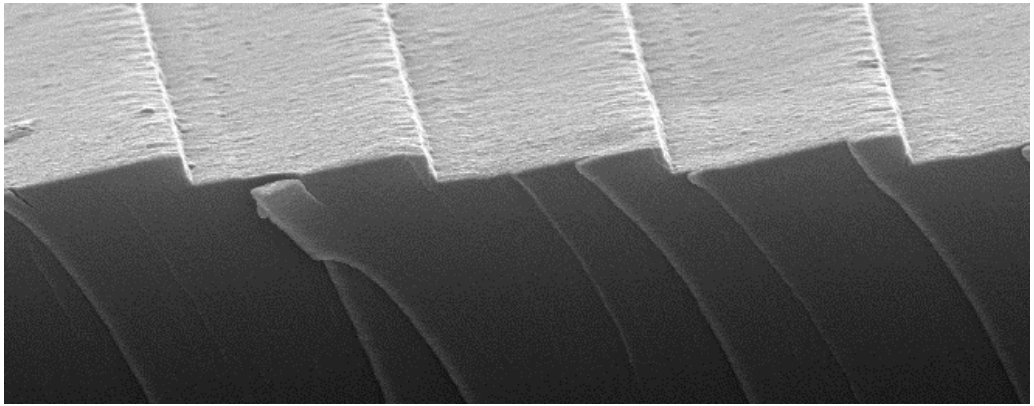


Blazed Grating from Flat to Convex Substrate



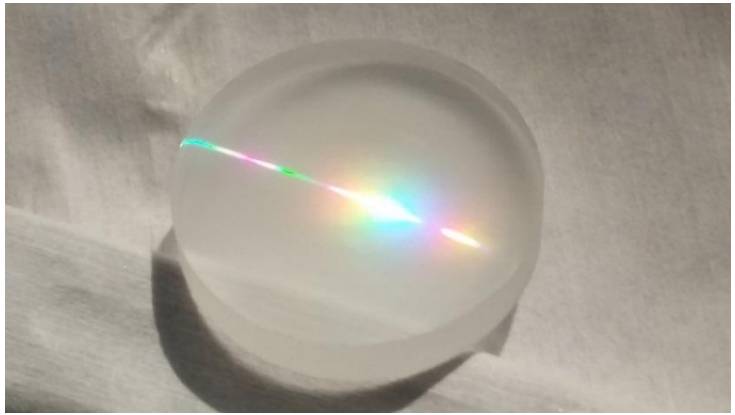
Blazed Grating on a Convex Substrate





Blazed Grating on a Convex Substrate

- Blazed grating on a convex surface has been successfully realized for next generation compact and highly efficient spectrographs
- Monolithic approach is considered more preferable due to the absence of a glass to Sol-Gel interface prone to fatigue
- Blazed grating on convex substrates has been sent for a silver and protective layer depositions. Upon receiving samples will be measured by SEM at CSEM and optical performance measured on specific bench at LAM



Thank you for your attention!