2° Forum della Ricerca Sperimentale e Tecnologica

VPHG@INAF-OABr: EFFICIENT DISPERSING ELEMENTS IN THE UV-VIS-NIR SPECTRAL RANGE

Manuela Arnò, Michele Frangiamore, Andrea Bianco
INAF - Osservatorio Astronomico di Brera - Merate

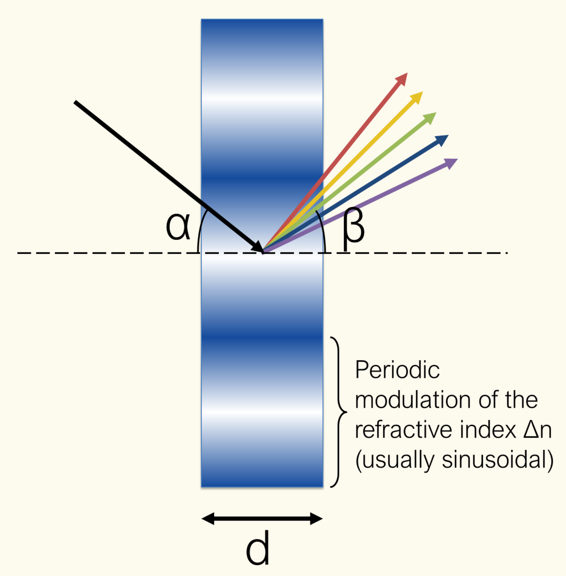
1 INTRODUCTION

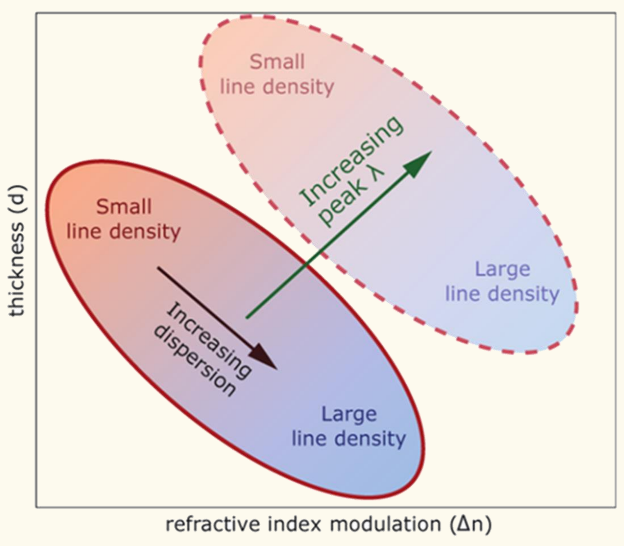
One of the key elements in modern spectrographs is the dispersing element, which basically defines the resolution. Moreover, the dispersing element is one of the less efficient component in the spectrograph; therefore, it is crucial to choose the correct technology to make such optical element. **Volume Phase Holographic Gratings (VPHGs)** are dispersing elements with interesting features. In particular, they show **diffraction efficiencies higher than 90%,** they can be tailored according to the requirements of the spectrographs[1].

We show here our manufacturing capabilities of VPHGs in the UV-Vis spectral region.

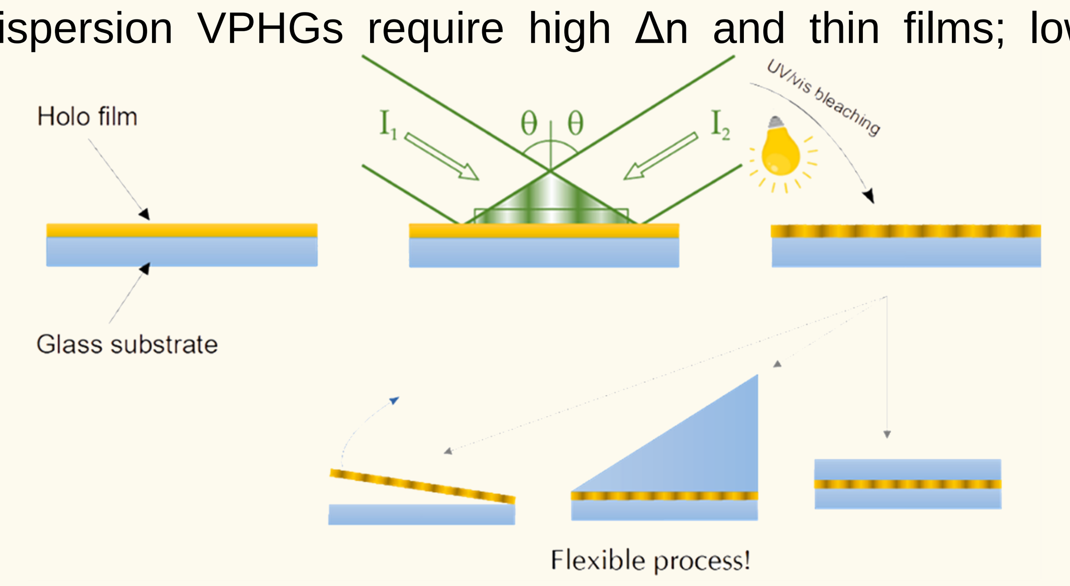
2 THEORETICAL BACKGROUND

VPHGs are diffraction gratings based on a periodic modulation of the refractive index (Δn), induced by the interference pattern of two-laser beams and stored in a holographic material with a defined thickness (d). Large efficiencies are possible matching the Bragg condition[2]: the angle of incidence α is equal to the angle of diffraction β. The values of d and the Δn to have both a large peak efficiency and large bandwidth, depends on the line density G, i.e. the dispersion. Large dispersion VPHGs require high Δn and thin films; low dispersion VPHGs requires thick films and small Δn[3].





An innovative and simple process has been developed to write VPHGs[4], minimizing manufacturing risks.



3 MANUFACTURING CAPABILITIES

At INAF-Osservatorio Astronomico di Brera we have the capabilities to produce a wide range of VPHGs according to the instrument requirements[4]. Moreover, we can characterize them in different conditions.

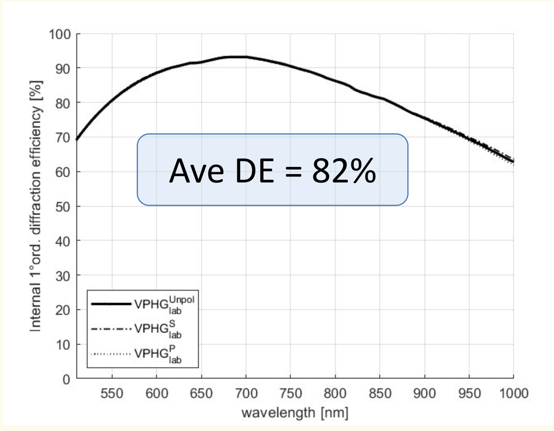
The **Diffracted Wavefront Error (DWE)** is becoming as important as the Diffraction Efficiency. It depends on:

- Aberration in the holo set-up;
- Deformation of the substrate during the gluing process.

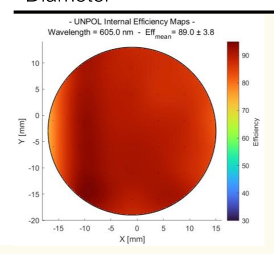
The following table contains a summary of the main properties we are able to achieve for our VPHGs.

Property	Value
Line density	150 – 3500 l/mm
Spectral range	330 – 2500 nm
Peak diffraction efficiency	>90%
Clear aperture	<190 mm in diameter
Diffracted Wavefront Error	< 1 λ
Characterization	• Diffraction efficiency curve • Diffraction efficiency map • Wavefront error • Thermal behaviour (-100°C – 200°C)

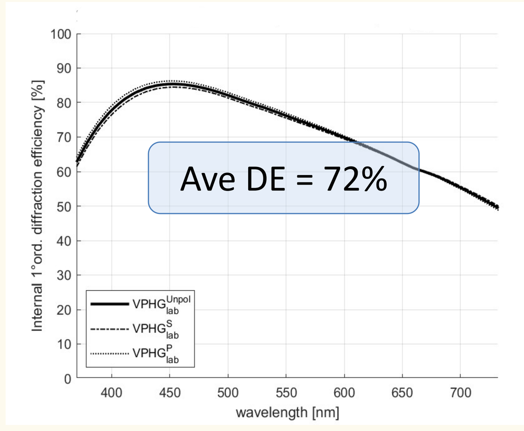
UV – VIS gratings



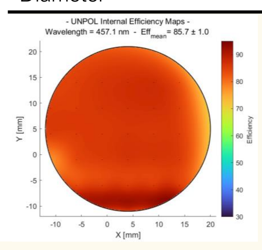
Property	Value
Line density	550 l/mm
Spectral range	500 - 1000 nm
Angle of incidence (α)	11.8°
Diameter	50 mm



Low dispersion blue VPHG: Symmetric efficiency, more than 60% at edges and 93% peak.

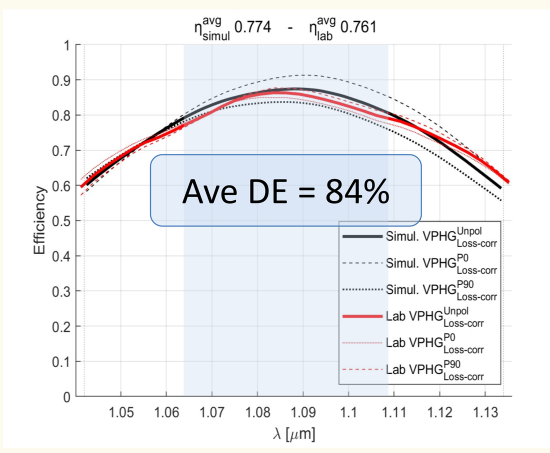


Property	Value
Line density	750 l/mm
Spectral range	370 - 720 nm
Angle of incidence (α)	11.6°
Diameter	50 mm

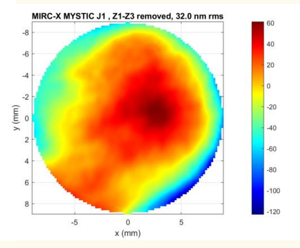


Low dispersion red VPHG: The curve is shifted towards shorter wavelengths to avoid excessive loss. The device achieves excellent efficiency with average value over 72%.

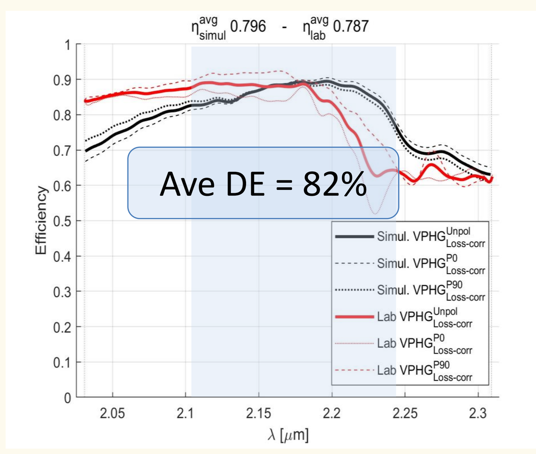
IR J and K band gratings



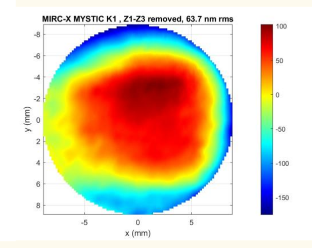
Property	Value
Line density	1074 l/mm
Spectral range	1065 - 1111 nm
Angle of incidence (α)	35.8°
Diameter	18 mm



MIRC-X J1[5]: Symmetric efficiency close to 80% at edges and 85% peak and excellent match with simulations.

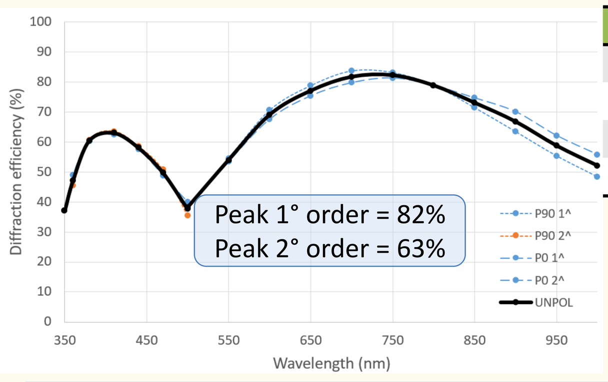


Property	Value
Line density	399 l/mm
Spectral range	2100 - 2239 nm
Angle of incidence (α)	25.6°
Diameter	18 mm

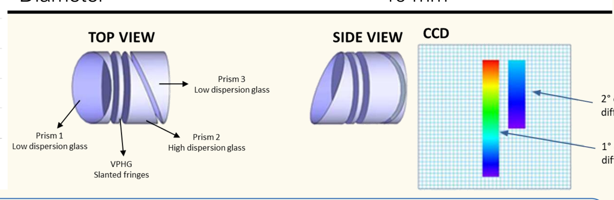


MYSTIC K1[6]: The efficiency curve is shifted towards shorter wavelengths to avoid excessive loss. The device achieves excellent efficiency with average value over 80%.

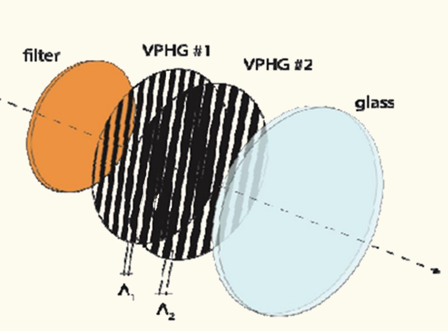
Unconventional configurations



Property	Value
Line density	341 l/mm
Spectral range	350 - 1000 nm
Angle of incidence (α)	15.1°
Diameter	40 mm



Dual Order GRISM: configuration based on three prisms as in the image in the bottom-right. The performance of AFOSC Dual order element is reported in the graph on the left. Another dual order GRISM in mounted in the Dolores spectrograph at TNG[7].



Multiplexed VPHG: stacked VPHGs configuration, with two layers having different line density and clock angle[8]

4 CONCLUSIONS

1. INAF OABr is the leading institution in the manufacturing of VPHGs
2. VPHGs are highly suitable for use as dispersing elements in spectrographs operating across UV, visible, and near-infrared (NIR) wavelengths.
3. Diffraction efficiencies between 80% and 90% can be achieved over a wide spectral range.
4. The diffracted wavefront error, a critical property, can be controlled during VPHG production, with RMS values of less than 100 nm achievable through precise focus adjustments.
5. Innovative approaches, such as dual-order and multiplexed VPHGs, are being developed to extend the spectral range of these elements..

5 REFERENCES

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2. Baldry, I. K., PASP, 2004, 116(819)
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CORRESPONDENCES

andrea.bianco@inaf.it
michele.frangiamore@inaf.it
manuela.arno@inaf.it

WEBSITE

http://www.brera.inaf.it/vphg-brera/index.html