

Highly Selective Optical Filtering Technology on 300 mm Glass Wafer for Advanced Spectroscopy Applications

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INTRODUCTION

KEYWORDS:

Photonic crystals
Dielectric metasurfaces
Multispectral filtering
CMOS integration
VIS & NIR ranges

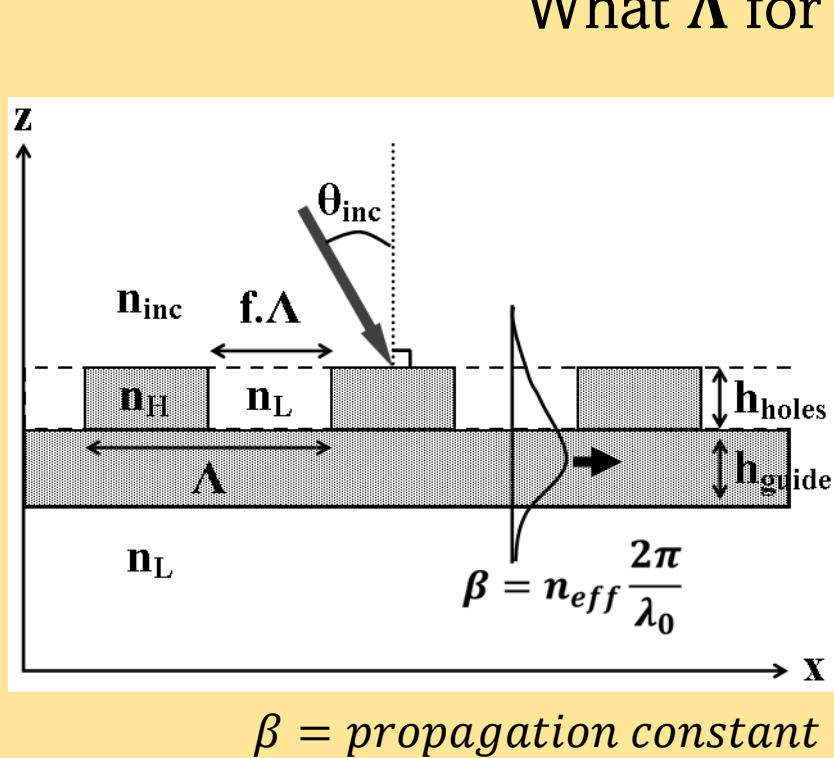
- General concerns about environment & health [1]
 - Main goal: bring sensing resources everyone can reach
- How ?
 - Retained principle: Spectral analysis over Visible – Near-Infrared ranges (spectrometer-like)

- What ?
 - Core solution: Resonant waveguide grating filters [2] made in Si₃N₄ and SiO₂ using CMOS compatible process. Filters are embedded on 300mm glass wafer (independent component)

Design : Resonance at λ_R

What Λ for a wanted λ_R ? [2,5]

1D - periodic

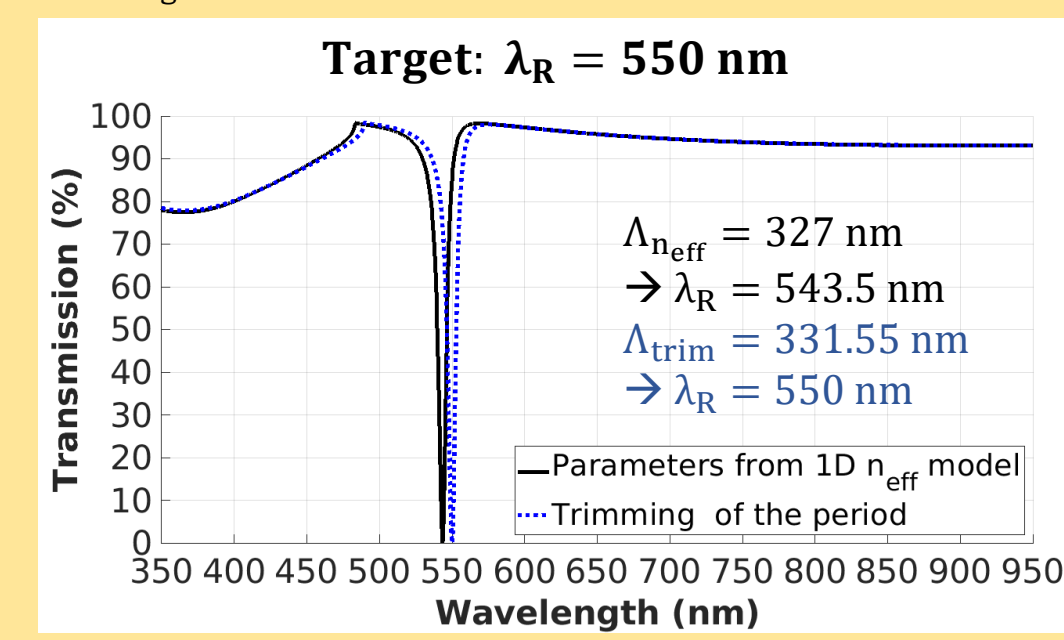


$$\Lambda = p \lambda_R \left[\frac{n_{\text{eff}} - n_{\text{inc}} \sin(\theta_{\text{inc}})}{n_{\text{eff}}} \right]^{-1}, p \in \mathbb{Z}$$

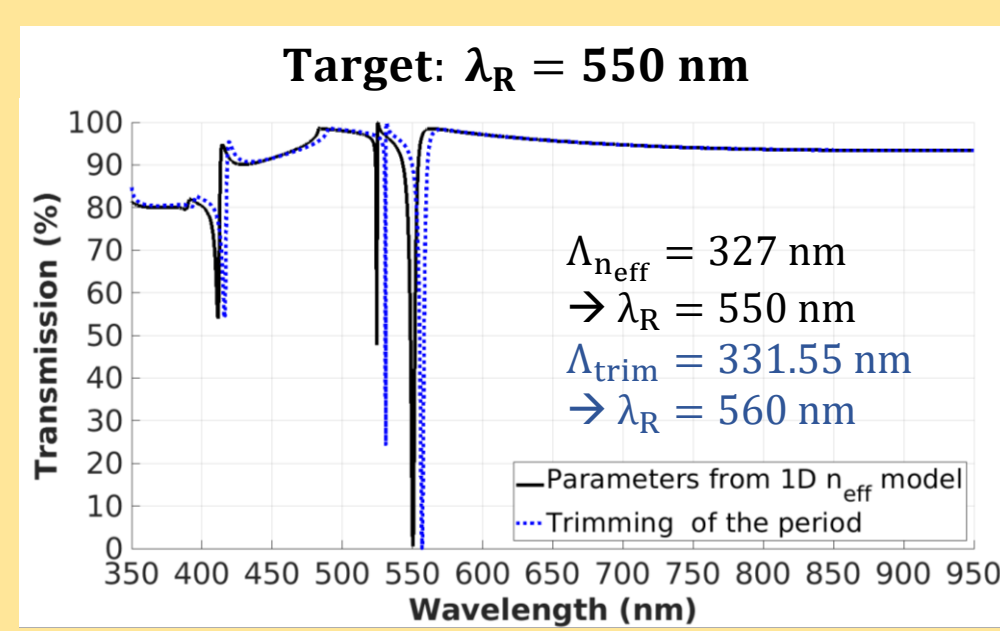
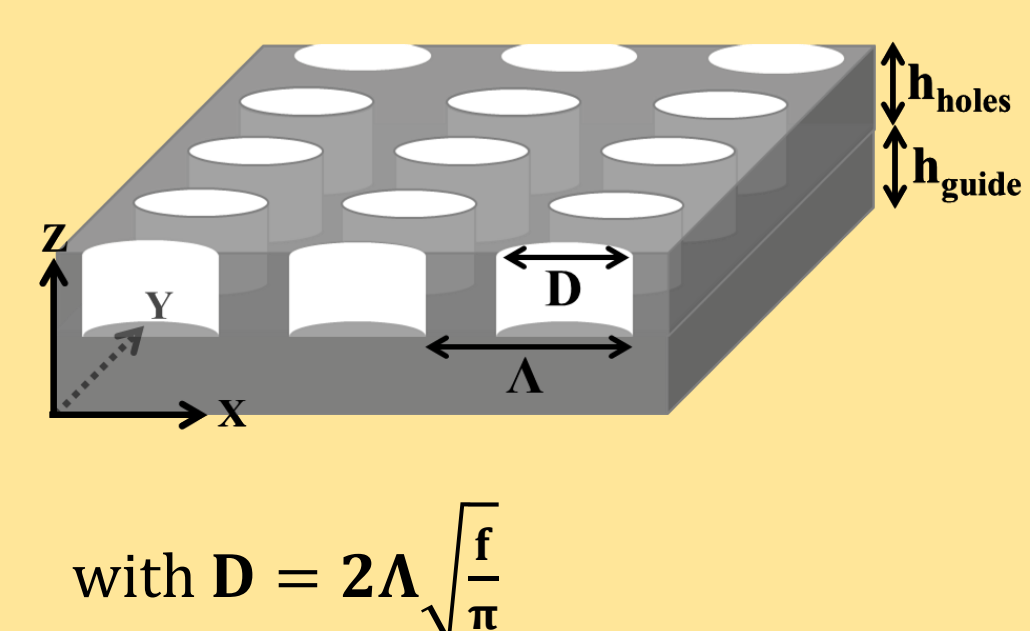
at normal incidence

Calculation of n_{eff} with a mode solver
 $n_{\text{eff}} = f(\lambda_0, n_{\text{avg}}, n_H, n_L, h_{\text{holes}}, h_{\text{guide}})$
 where $n_{\text{avg}} = \sqrt{f \cdot n_L^2 + (1-f) \cdot n_H^2}$
 (Homogenization in TE polarisation) [5]

Example: $n_{\text{inc}} = n_L = n_{\text{SiO}_2}$; $n_H = n_{\text{Si}_3\text{N}_4}$
 $h_{\text{guide}} = 55 \text{ nm}$; $h_{\text{holes}} = 70 \text{ nm}$; $f = 0.40$



2D - periodic

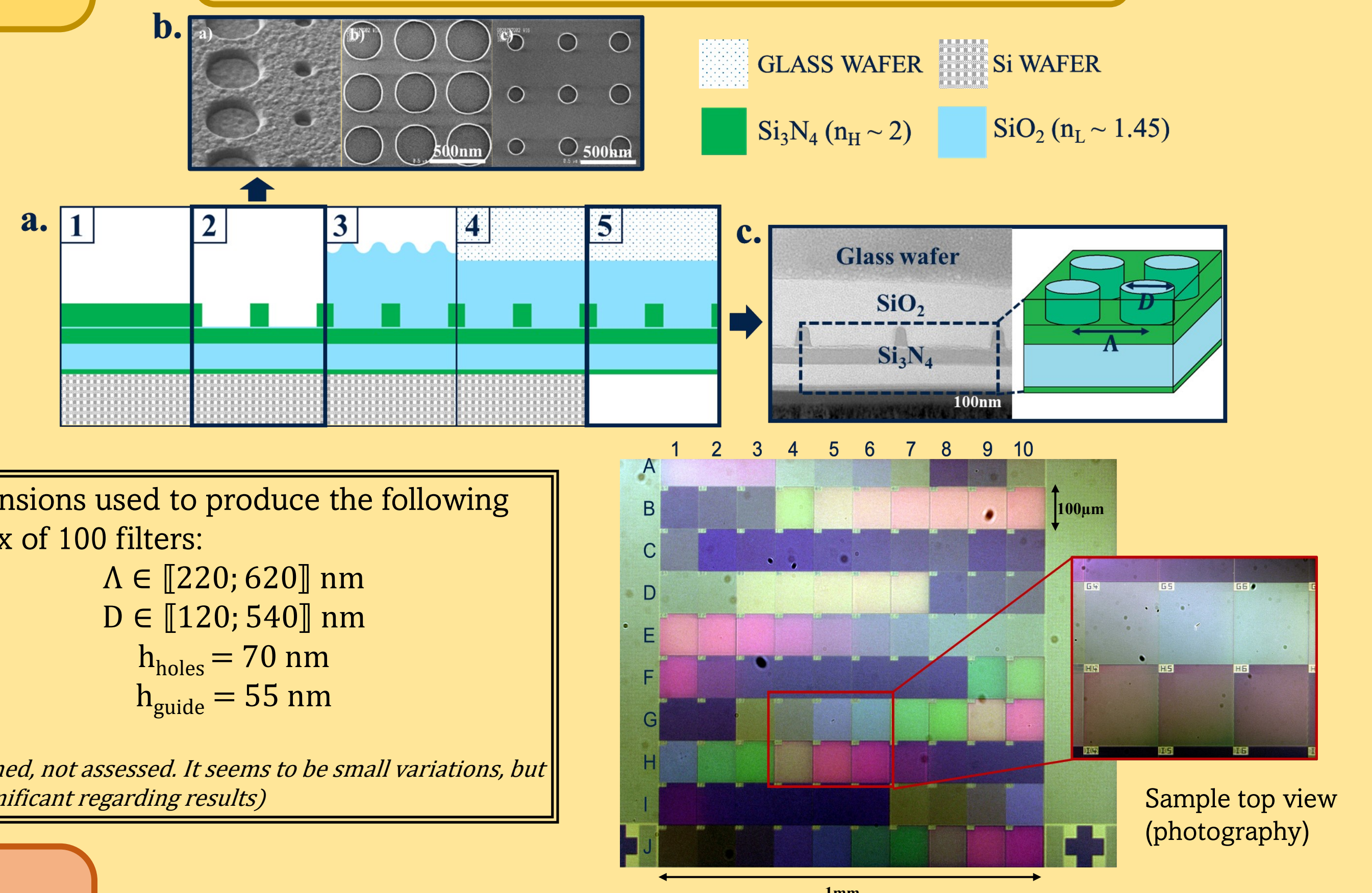


Some behaviors by varying parameters:

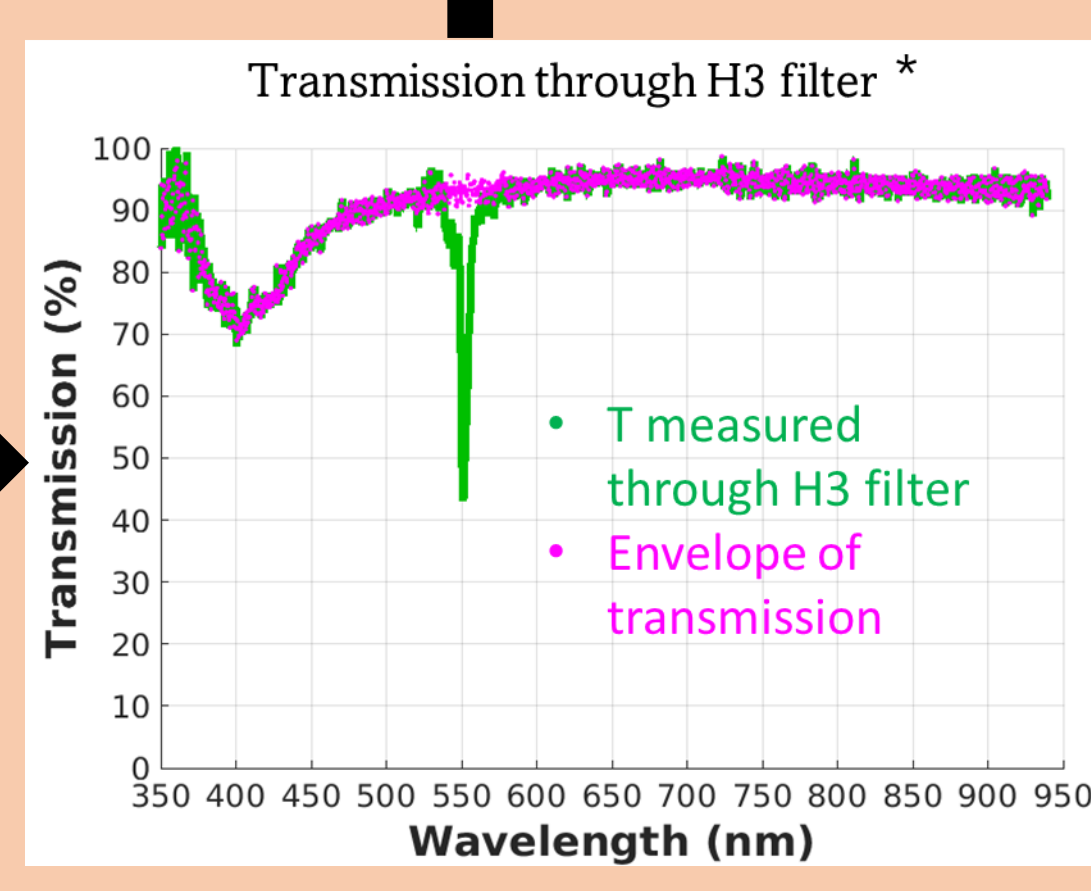
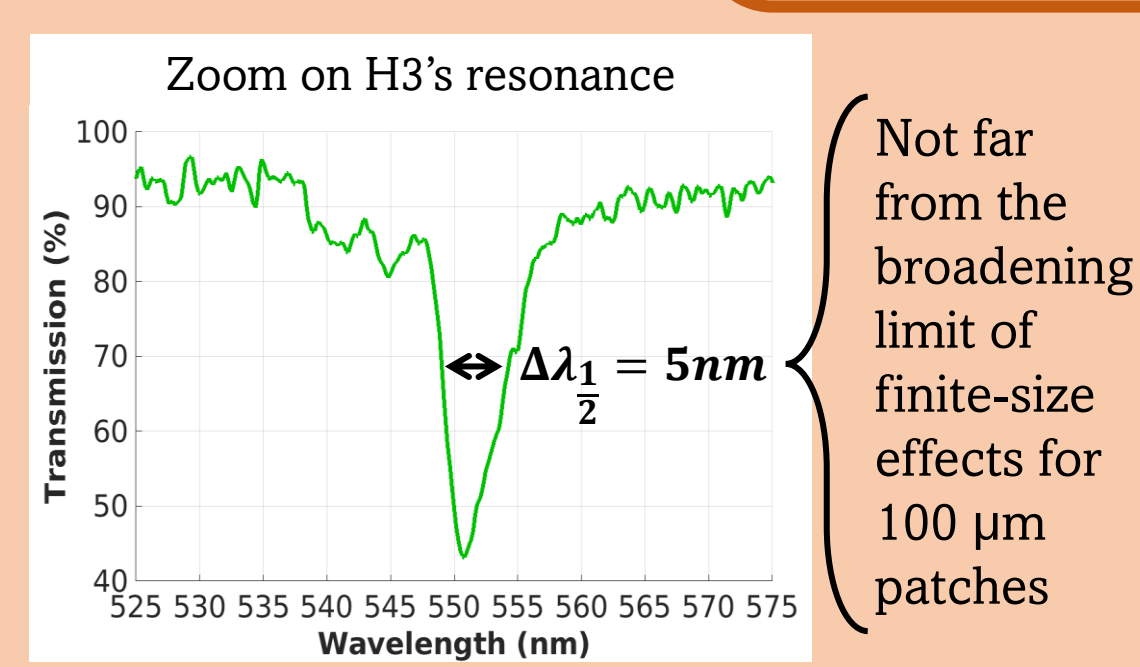
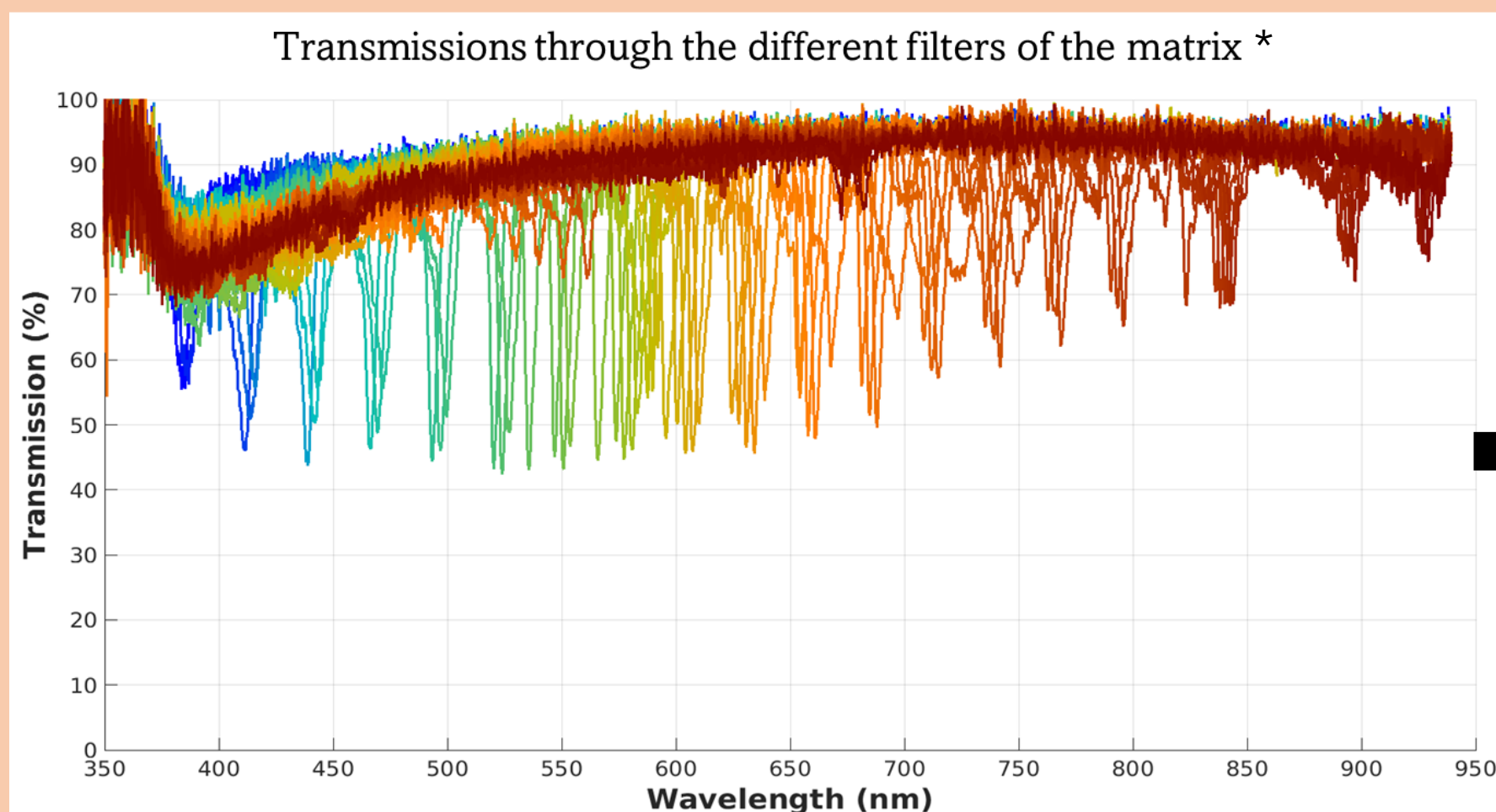
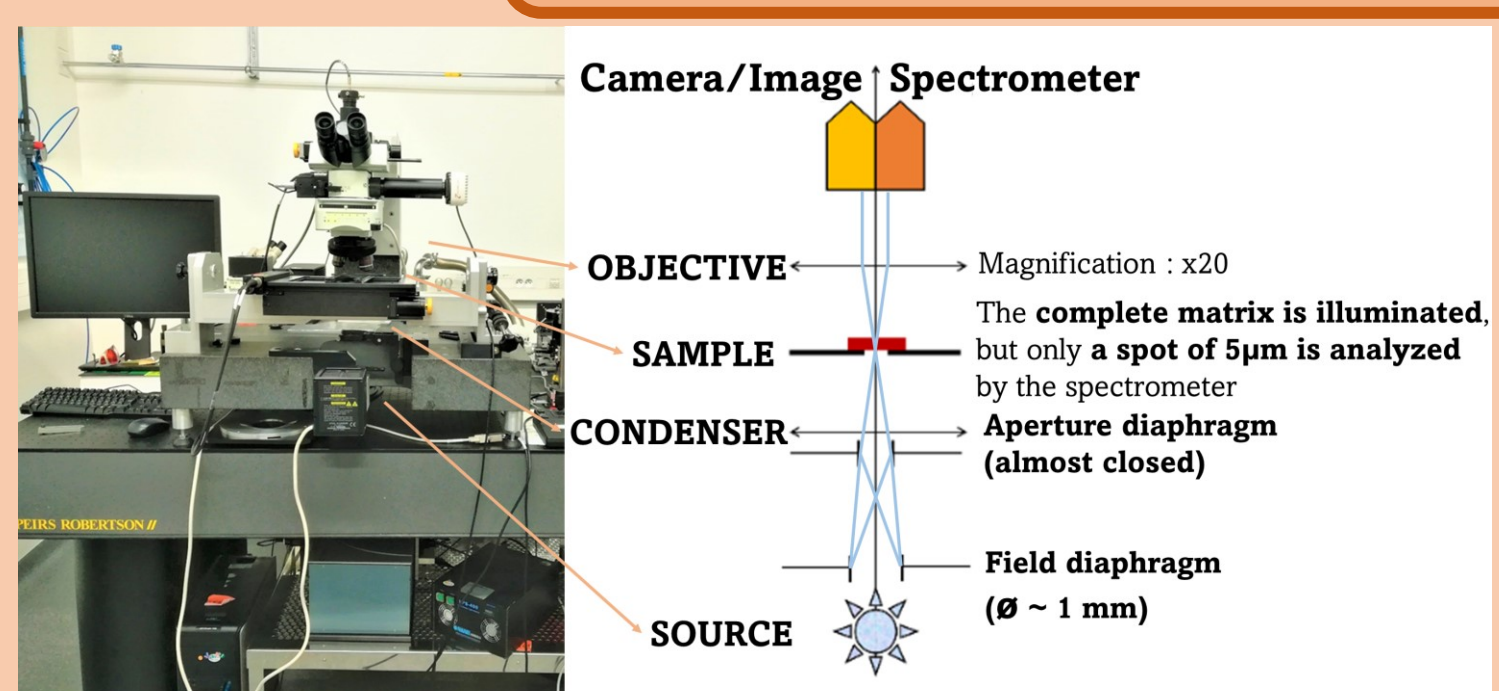
- λ_R decreases when h_{holes} and h_{guide} reduce, since they are correlated through n_{eff} (and vice-versa).
- The full width at relative half-maximum $\Delta\lambda_1$ increases with the grating height h_{holes} .

FILTERING STRUCTURES

Processing



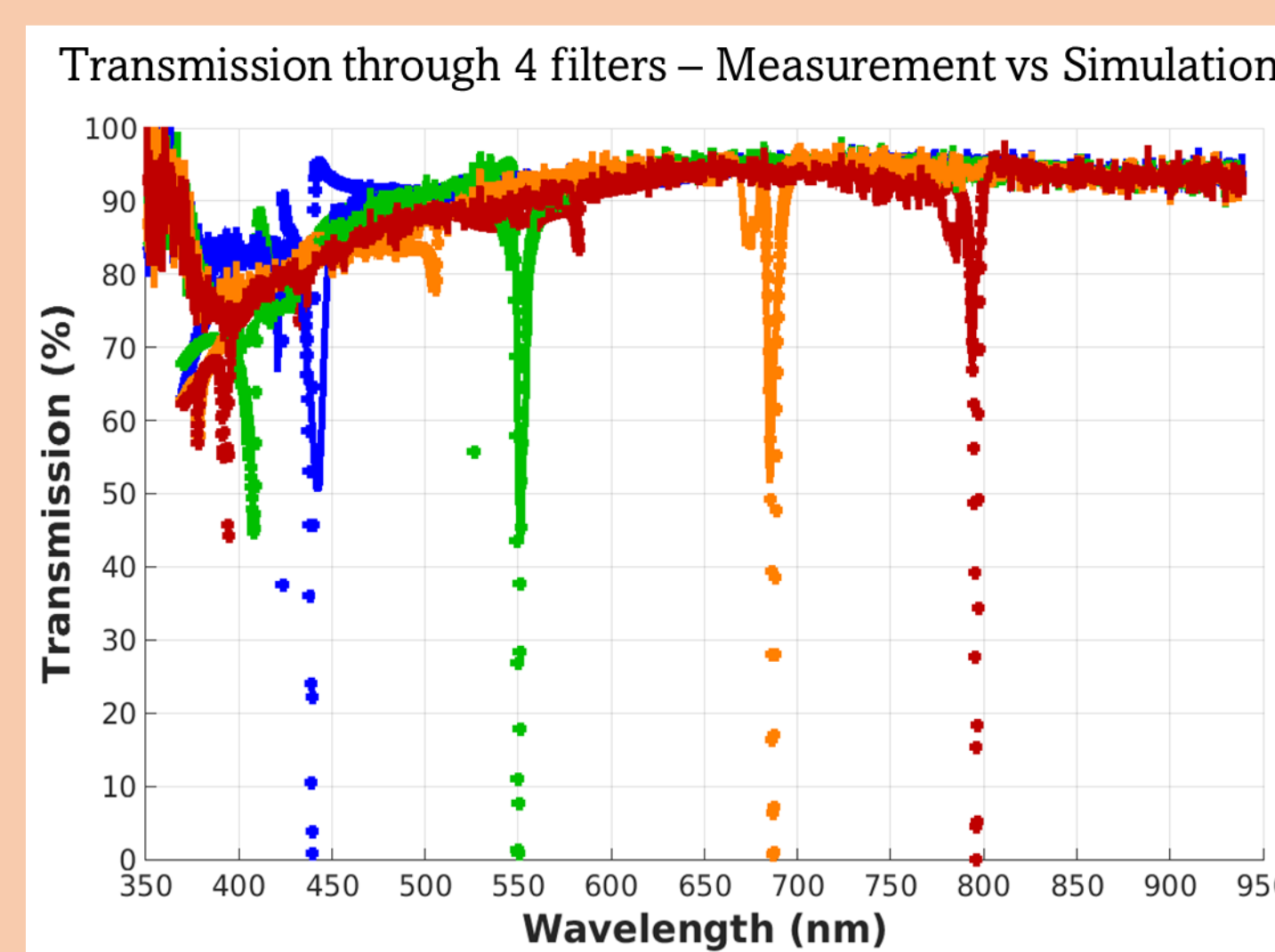
Measurements



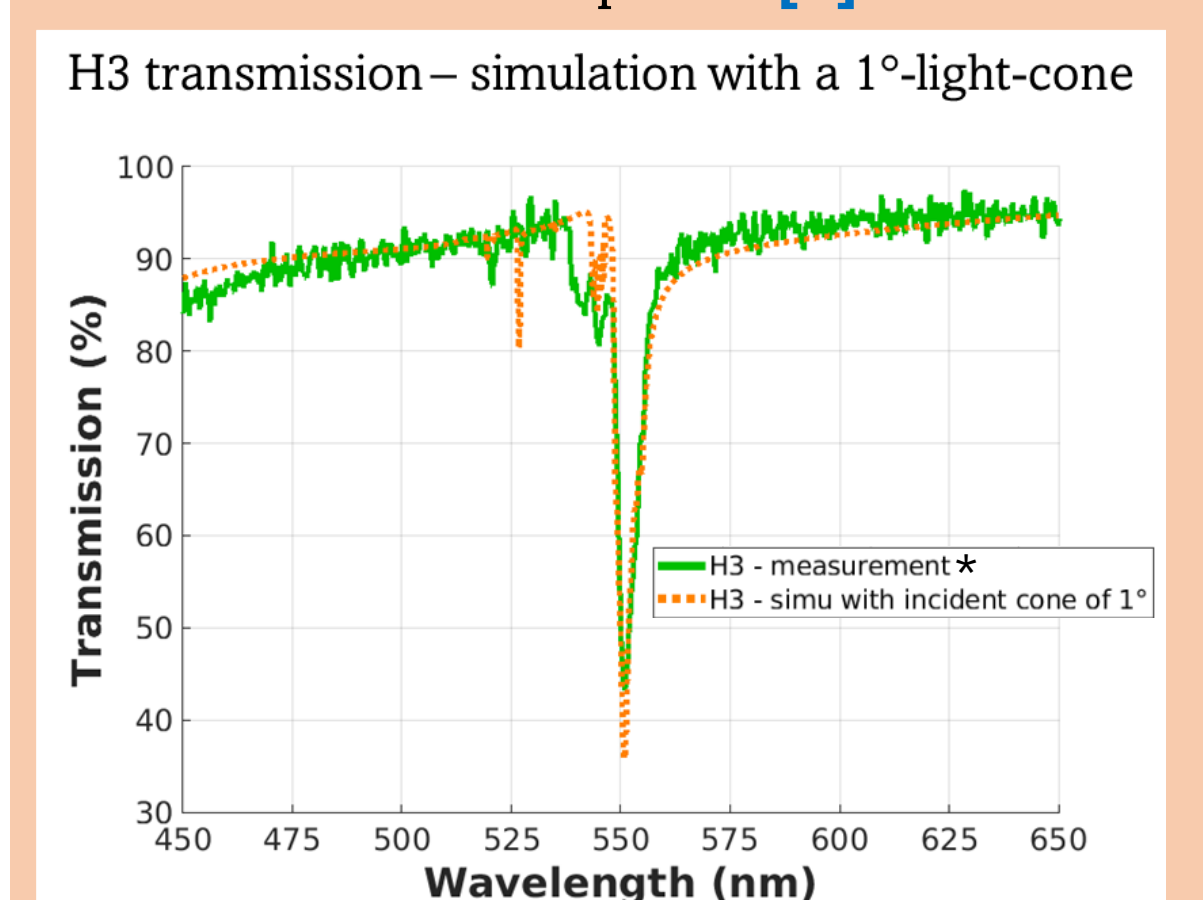
RESULTS

Comparison with simulation

Simulation tool: RCWA method with Reticolo [3]



Influence of a conical non-polarized incidence on the response [4]



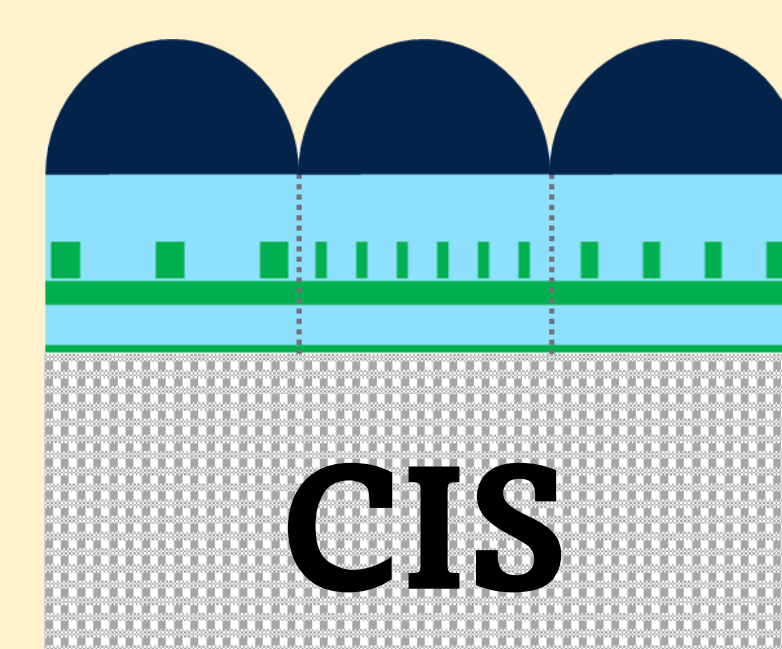
N° filter	I7	I8	I9	I10	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	G1	G2
$\lambda_{R, \text{simu}}$ (nm)	383.0	411.0	439.0	467.0	494.75	522.5	550.25	578.75	605.0	632.25	659.5	686.75	714.0	741.25	768.75	796.0
$\lambda_{R, \text{meas}}$ (nm)	386.7	413.6	442.0	469.5	496.9	524.0	550.8	577.4	604.3	630.8	657.9	684.8	711.8	739.2	765.9	793.4
$\Delta\lambda_R$ (%)	0.97	0.63	0.68	0.54	0.43	0.29	0.10	0.23	0.12	0.23	0.24	0.28	0.31	0.28	0.37	0.33

CONCLUSION

- ✓ Numerical and experimental demonstration of a filter matrix made of resonant waveguide gratings
 - Numerous narrowly filtered bands
 - Deterministic resonance properties (position & half-width) through geometrical parameters
 - Rejection mode
 - Visible to Near-Infrared spectral domains

- ✓ Production of grating filters with dielectric material, adapted to CMOS process, onto 300 mm ST platform
 - Access to industrial quality
 - Low-cost because usual dielectric materials and processes, and mass-production
 - Can be integrated onto CMOS image sensor

- Perspectives :
 - Pass-band filter (instead of stop-band like here)
 - Use of other CMOS compatible materials (amorphous Si)
 - Integration onto CMOS image sensor (CIS)



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