Direct transfer by plasma etching of 2.5D patterns obtained by grayscale lithography

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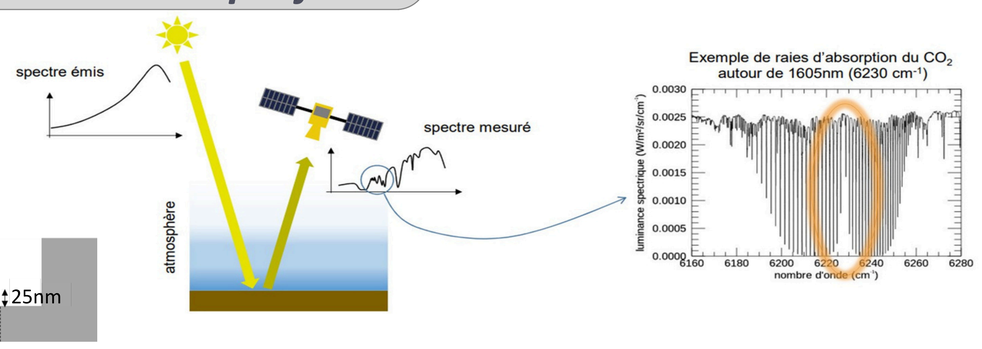
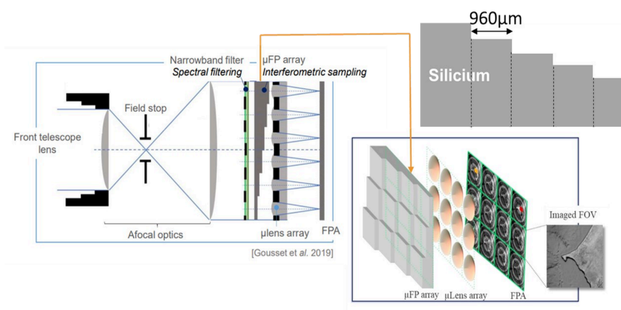
Context : SCARBOnproject

- The SCARBOn project aims to develop compact SWIR imaging spectrometers for greenhouse-gas monitoring



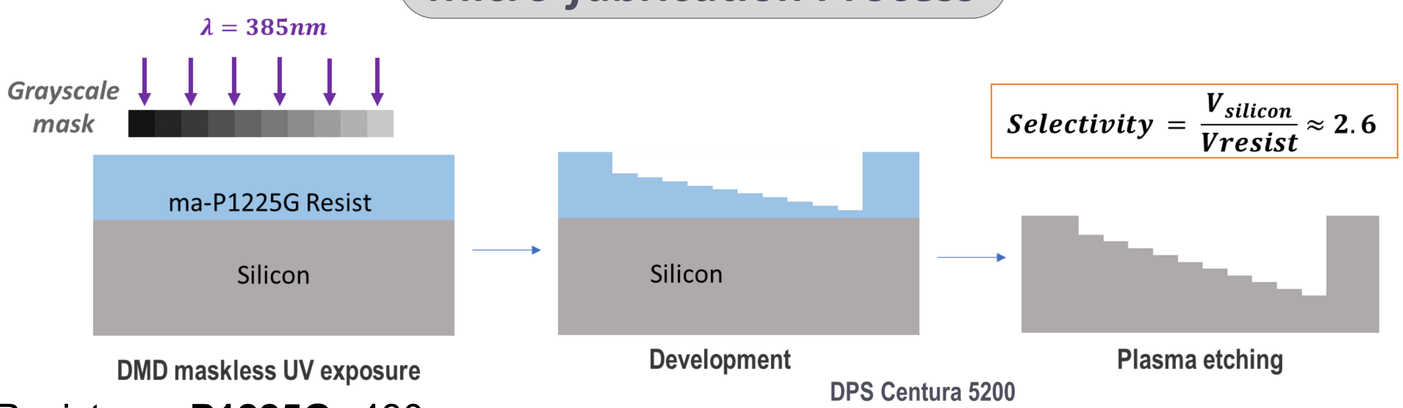


- NanoCarb is a miniaturized static SWIR spectrometer (based on arrays of Fabry–Perot cavities) that uses silicon interferometric plates to detect atmospheric CO_2 and CH_4 with high spectral accuracy

Objective

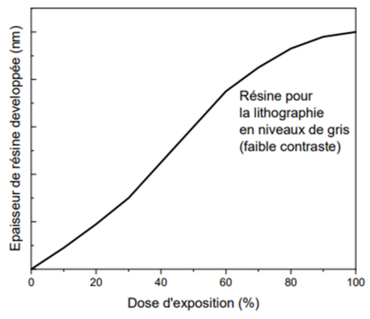
- ➢ Generation of 2.5D profiles in a single exposure step, enabling simultaneous control of geometry and surface roughness → Grayscale lithography
- ➢ Reproducible plasma etching process enabling direct transfer with reproducible resist/Si selectivity and low surface roughness

Micro-fabrication Process



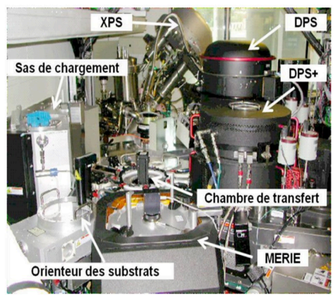
- Resist : **maP1225G** , 480 nm.
- Exposure : **385 nm** maskless

Low contrast resist



(Smart Print UV, Microlight3D)

DPS Centura 5200

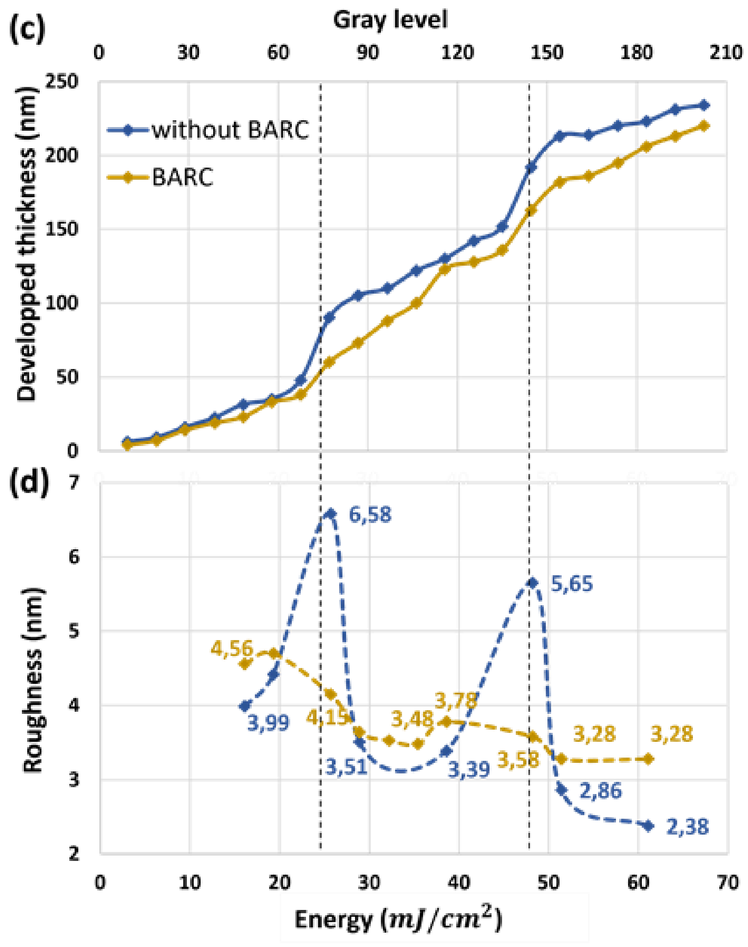


Gaz (sccm)

HB_r (120)
Cl_2 (40)
$He - O_2$ (5)

- ICP etching→ **HBr** (120 sccm) + **Cl_2** (40 sccm) +**He-O_2**(5 sccm)
- Obtainedslectivity:**2.6**(Si / resist)

The use of BARC Layer

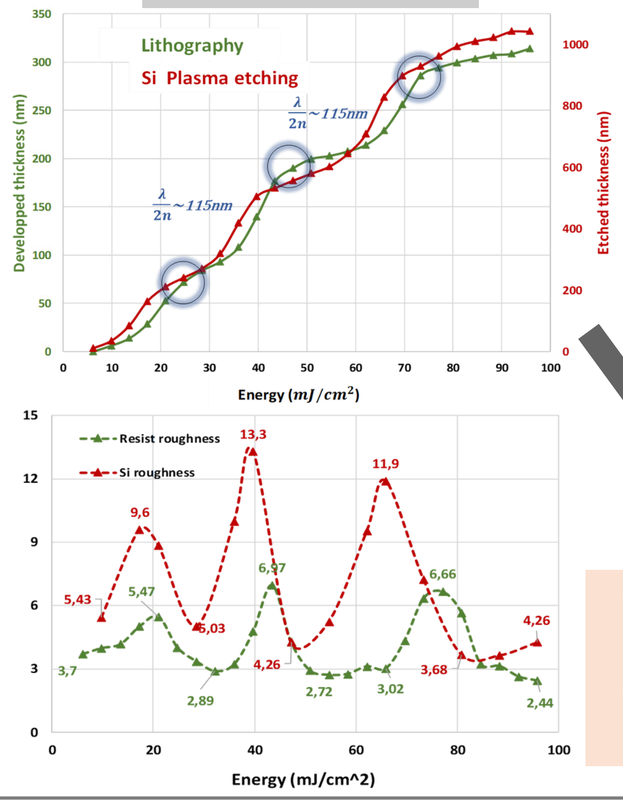


- Introducing a BARC layer suppresses standing waves and prevents the associated roughness peaks in the resist that are transferred in silicon

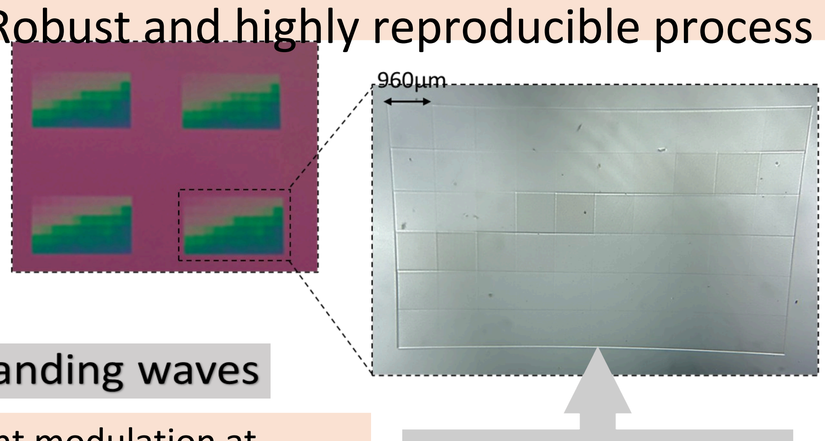
- The BARC layer is efficiently etched using the same plasma recipe, but with an etch rate about 1.3× higher than the resist

Results

Contrast curve



- ✓ Precisely controlled step heights
- ✓ Pattern faithfully reproduced into silicon
- ✓ Robust and highly reproducible process



Standing waves

- Height modulation at specific depths
- Periodic roughness peaks on few steps

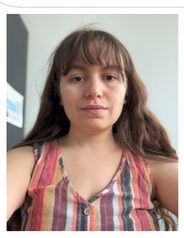
AftertransferintoSi (example interforemetric plate suppliedfor the SCARBOn project)

Conclusion

- Demonstration of a direct transfer of 2.5D profiles into silicon using a reproducible etching process with controlled resist-to-Si selectivity
- The BARC layer is compatible with our plasma chemistry, enabling its complete removal during etching and thus allowing a lower-roughness transfer into silicon.

Perspectives

- Extension to other substrates such as quartz, widely used in micro-optics, by developing an etching chemistry enabling simultaneous transfer of 2.5D grayscale patterns from the resist into quartz with controlled selectivity



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UGA Université Grenoble Alpes
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