Dpt MicroElec. MicroCapt.

Titre :

Sur l'utilisation de la résine UV210 se flashant en UV profond pour les circuits de photonique intégrée / optoélectroniques : processus de nano-lithographie, propriétés physiques et structures réalisées

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+ Plate forme NanoRennes : https://www.ietr.fr/plateforme-nr-nanorennes

*https://www.ietr.fr/bruno-beche
https://spm.univ-rennes1.fr/bruno-beche

Rennes Metropole area

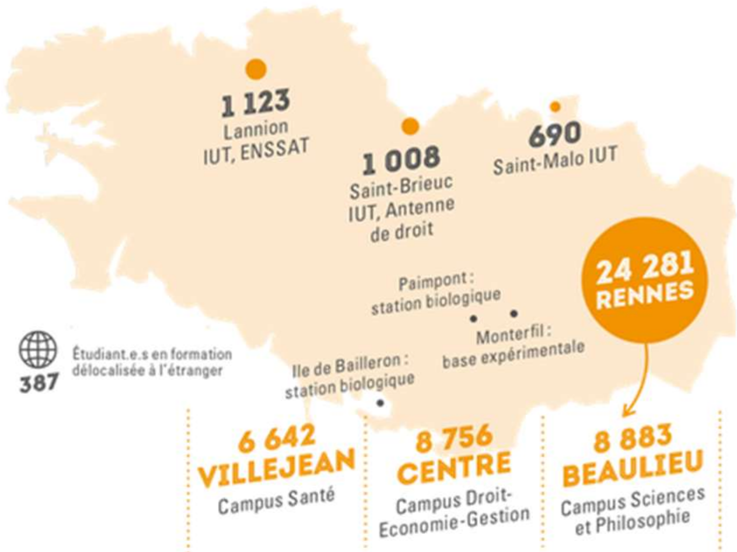
~ 450 000 inhabitants

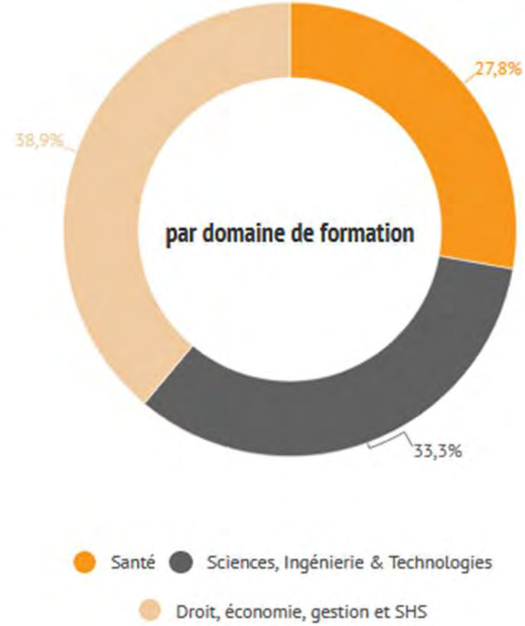
~ 68 000 persons in formations

Univ. Rennes 1
> 200 bilateral agreements with European universities
32 Institutes of Research (CNRS, INRA, INSERM…)
+ 4 Federative Structures in Research
10 UFRs + high schools

Plus de 600 diplômes

- 15 DUT
- 17 mentions de licence
- 37 licences professionnelles
- 45 mentions de Master
- 6 diplômes d'ingénieur
- Diplômes de santé
- Préparations aux concours (métiers de l'enseignement, de l'administration et carrières juridiques)
- 130 DU (diplômes d'université)





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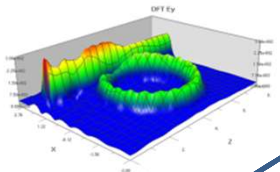
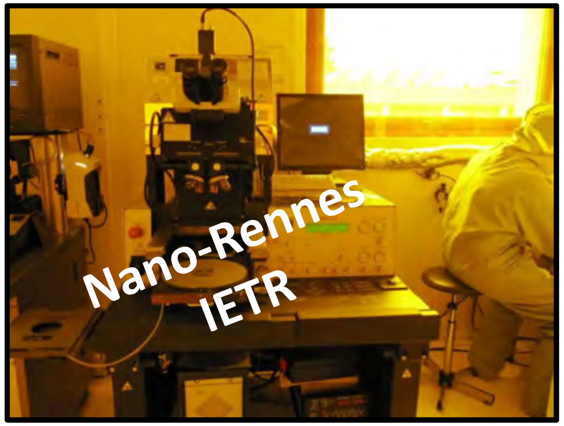
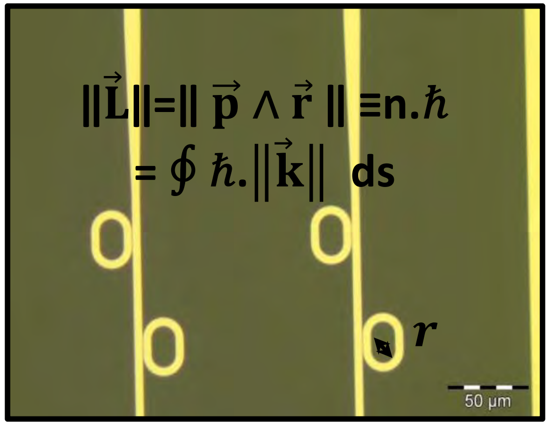
Context - Mastery of Technologies (NanoRennes_IETR CNRS)

i) **Theory Simulation**

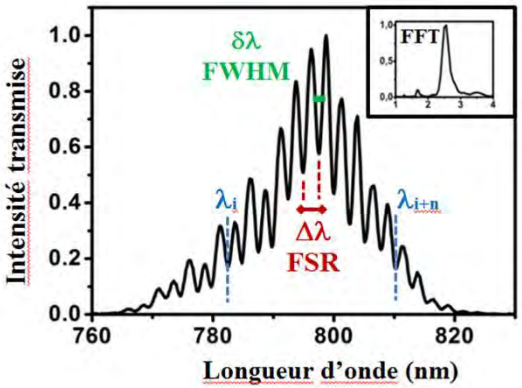


ii) **Organic material Processes ('cheaper') - Quality Control**

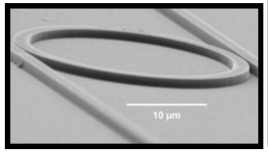


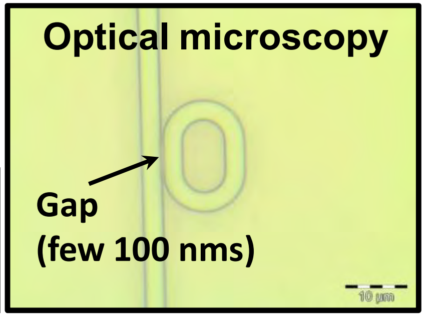


iii) **Platform of characterisation/ Opto-Electronics, Opto-Mechanics**



SEM

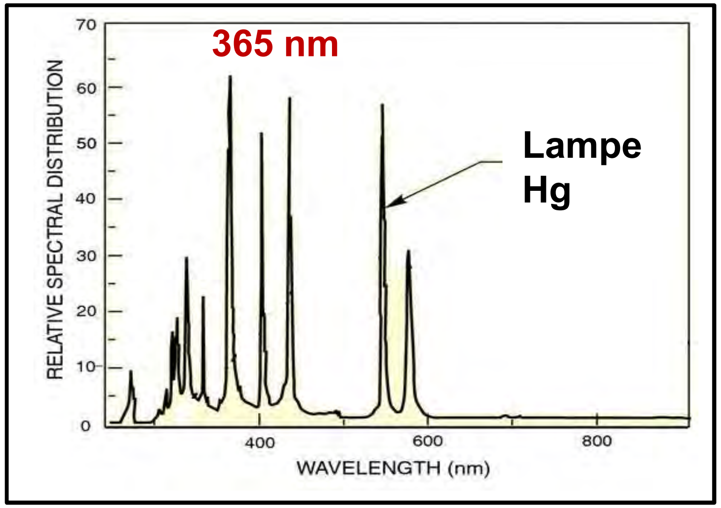




iv) Mathematic and **Signal treatment /** ***in live + in situ…***

Materials and Processes - *'past for us'*

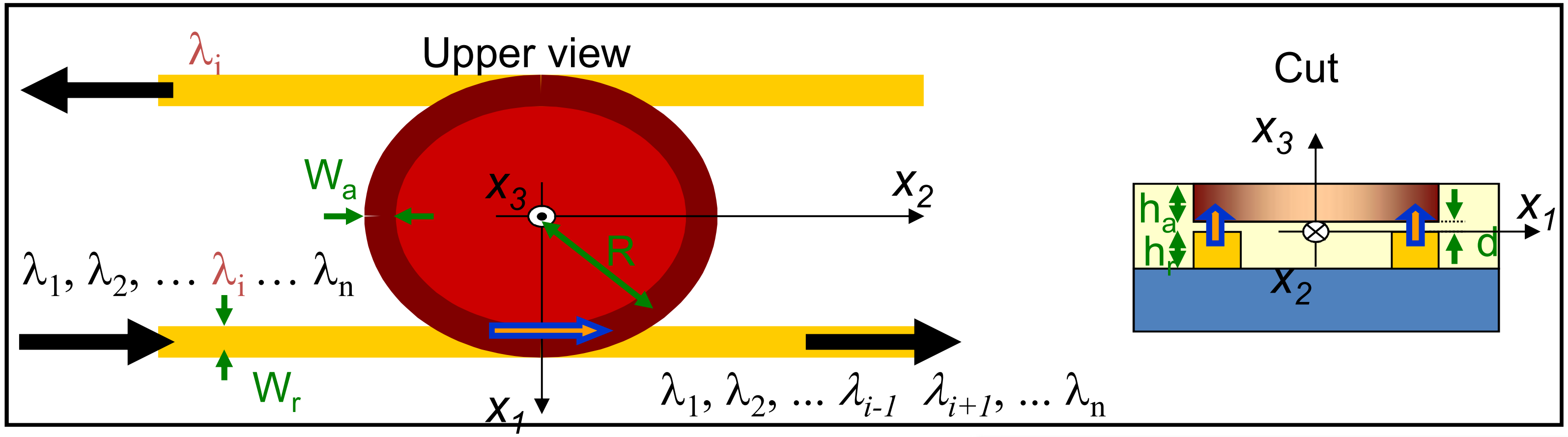
Choices and study of organic materials, many products and liquid photoresist exist for the realizations of integrated elements [PMMA, PS233, SU8, NOA stick, Kapton…] for *µ-fluidic, photonics, optoelectronics…*



- **Photolithography: limited by diffraction**
- **Usual lithography: insolation at λ = 365 nm**
- **Limit of 'clean' resolution *close to 1 µm***

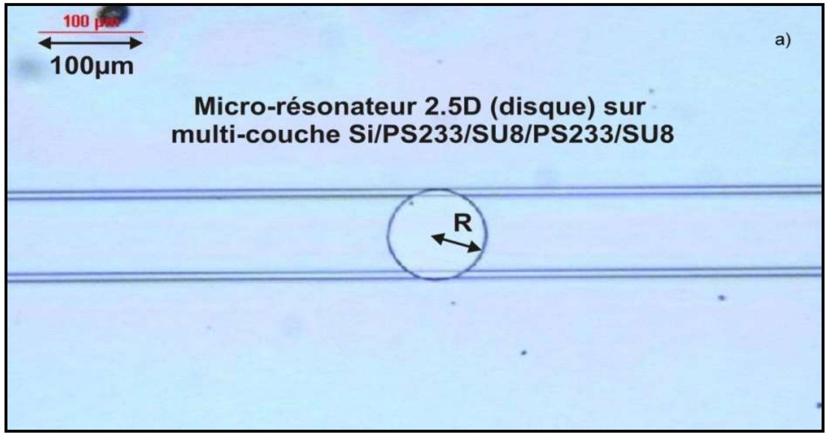
(difficult when thick resin !)

- **Example with resins flashing at 365 nm or *'non-simplicity'* to build a 2.5D micro-resonator**

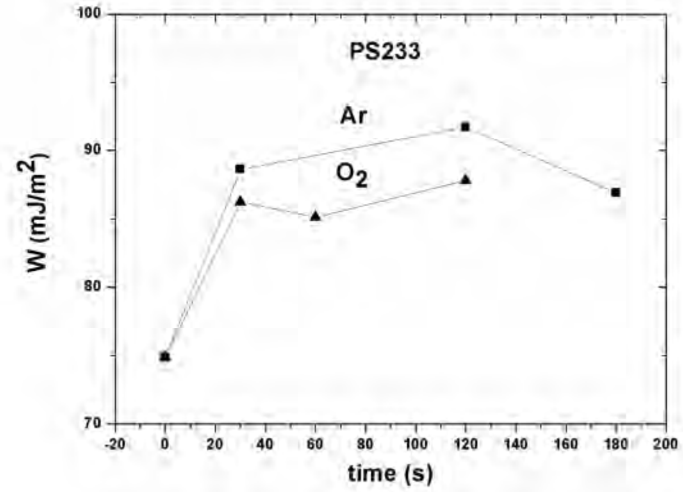


- For 2.5D structures, existence of a surface energy or surface tension γ which can make difficult all possible and unimaginable assemblies ➔ Surface energy modification and measurements ($J.m^{-2}$) : $[\gamma = (\partial G/\partial S)_{T,p,n}]$

Possibility of modifying it by plasma surface treatment, modifying the adhesion work $W_{material1/material2}$ which is *function of* γ



[$W_{SU8/PS233}$]

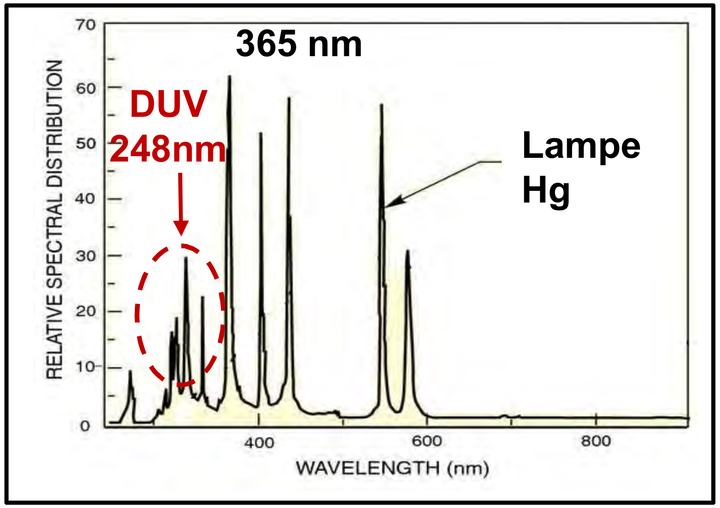


Not in one step and so simple !

▪ **The Deep UV lithography (DUV):**

▪ **Insolation at λ = 248 nm**
Organic material DUV 210 (positive photoresist)

▪ **High resolution: 200 nm ➔ quartz mask**



▪ **Chemical aspect :**

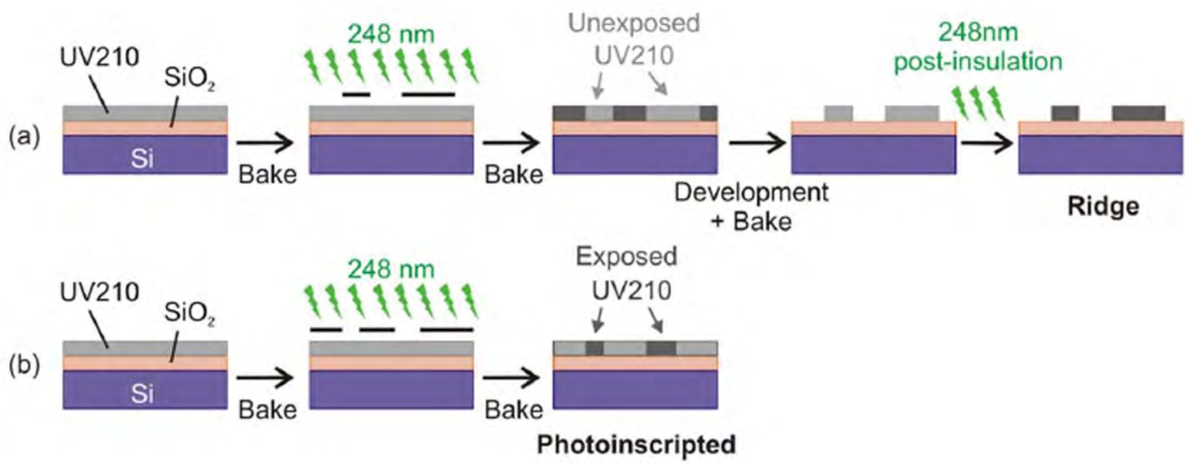
UV210 is a chemically amplified (CA) resin based on poly p-hydroxystyrene (PHS) in combination with poly t-butyl acrylate (PBA). Such a CA resin contains a photo-acid generator (PAG), added to the copolymer matrix. When exposed to deep-UV light (248 nm), *PAG produces a small amount of acid which acts as a catalyst* during post-baking exposure. *The cascade of chemical transformations* activated by the acid results in a change in polarity in the polymer from lipophilic to hydrophilic.

▪ **Judicious optical properties**
n=1.565 + lower optical losses (typically 3 dB.cm^{-1} at λ = 980nm)

Materials and Processes

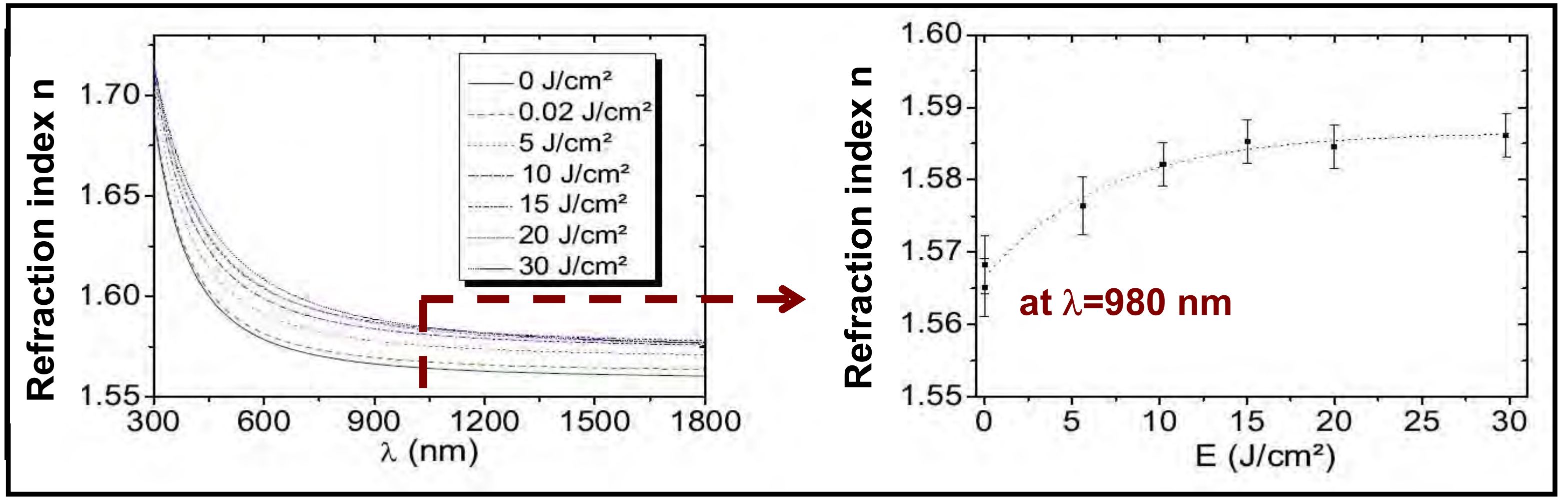
- **Photolithography: Deep_UV 210 (with development ridge, rib or not photo-inscripted)**

Steps	Parametres
Spin-coating (v,a,t), thickness, roughness	(900 rpm, 5000rpm/s, 30s), ~800-850 nm, <3 nm
Softbake	3 min at 140°C
Deep UV exposure	E = 20 mJ/cm² during 27 s
Post-exposure soft-bake	1 min at 120°C
Development	30 s, with Microposit MF CD-26
Final softbake	12 to 24 h at 120°C

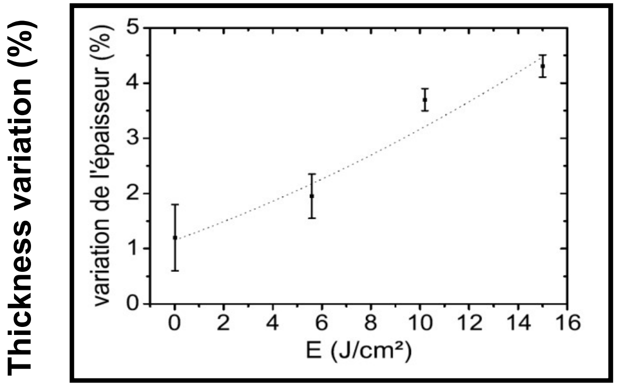


Materials and Processes

- The UV210 organic material
- Ellipsometric measurement & dispersion curves of UV210 (extinction k <10^{-3})

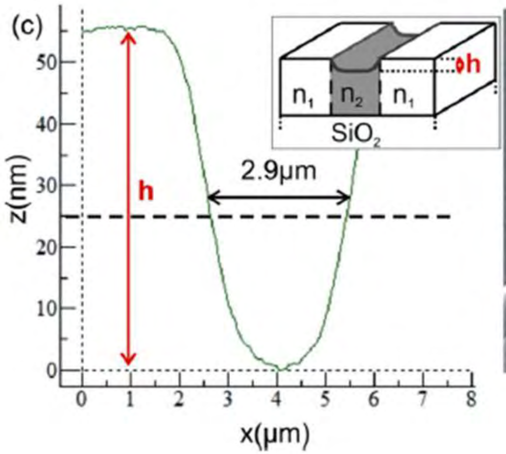


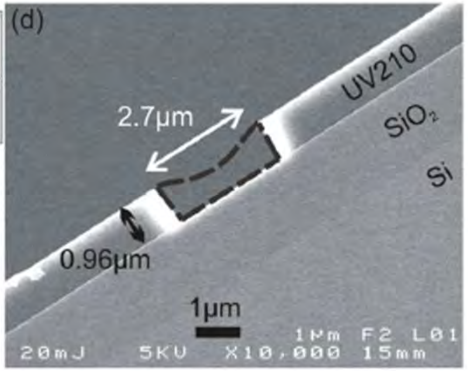
- Indices enough high for core waveguide applications on lower cladding
- Insolation dose increases : saturation of the value of index and diminution of film thickness, density increases (Gladstone empiric law)



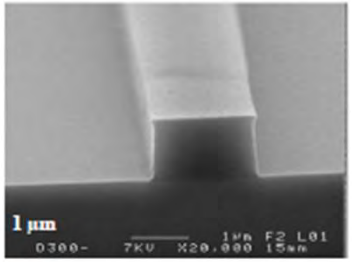
- **Insolation dose effect : diminution of film thickness, density increases**

AFM measurement



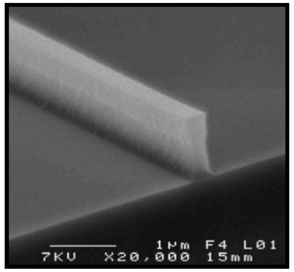


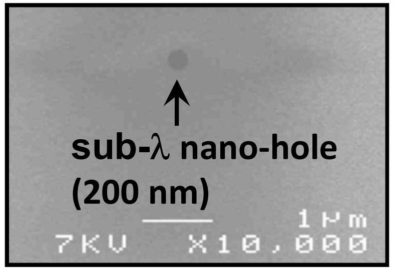
Dotted shape photo-inscripted (before development here)

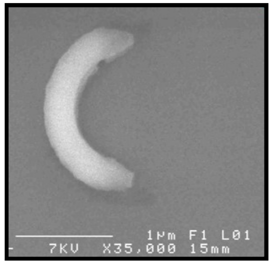


- **Possibility to develop sub-λ patterns of Deep UV210 for nanotechnology**

Width of waveguide 250/300 nm

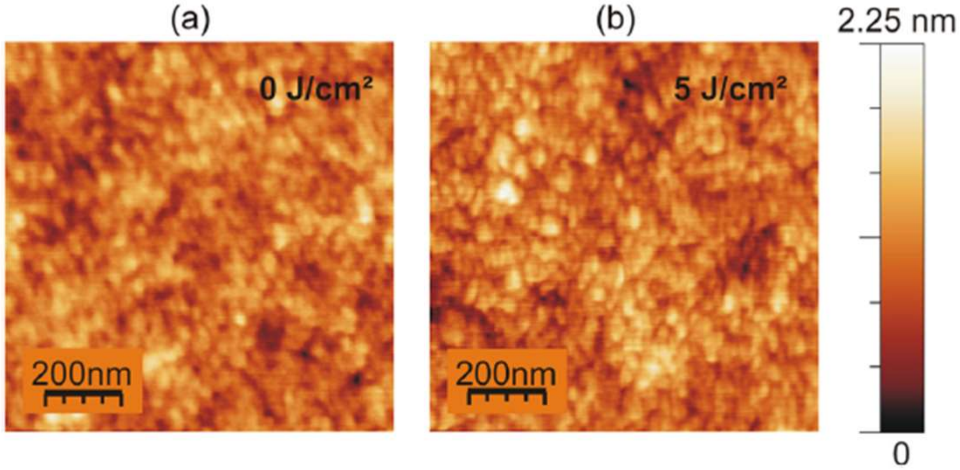


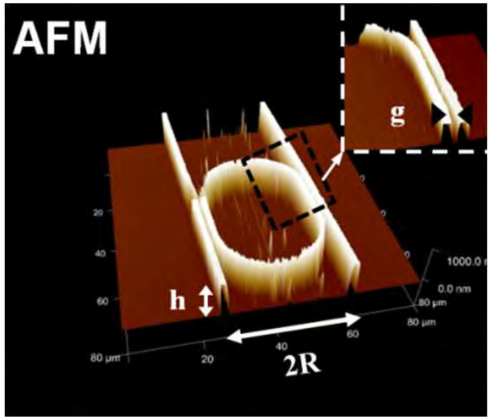




+ Good mechanical strength when hardened

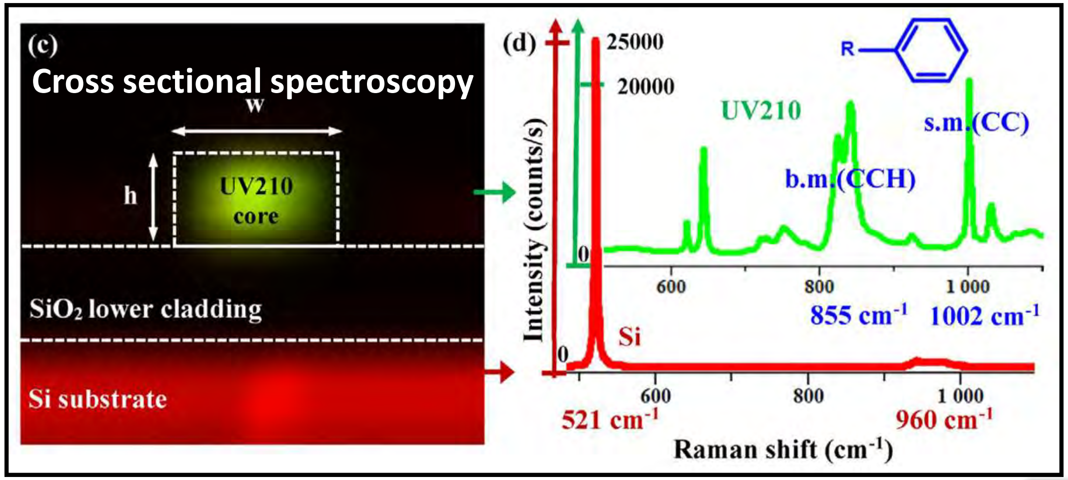
- **Quality control : AFM imaging**



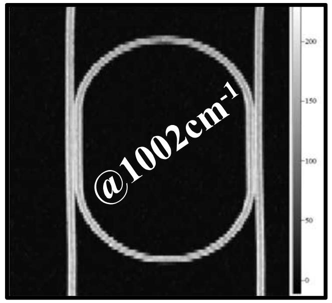


Roughness surface : 2 nm

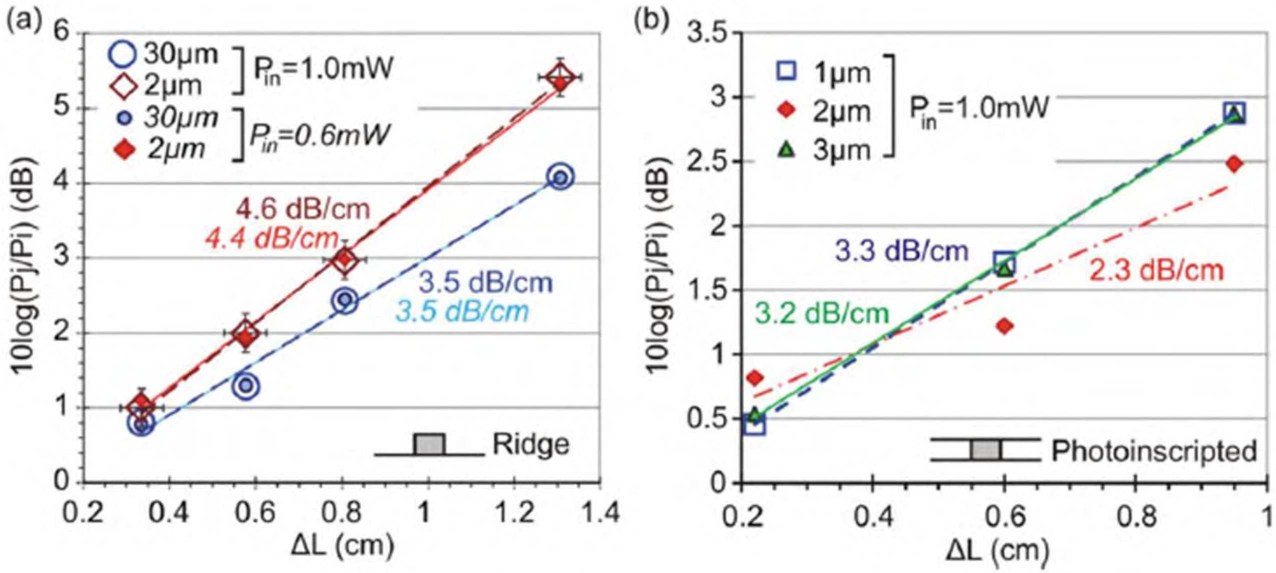
- **Quality control / Raman Spectroscopies analyses + Imaging**



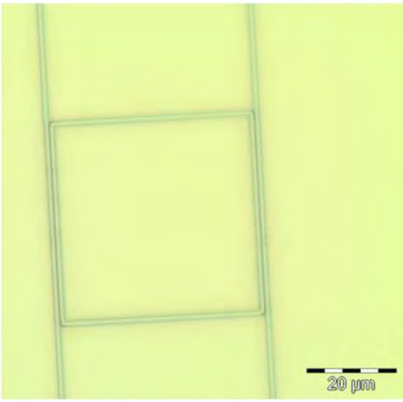
Raman spectroscopies *plus* Imaging reconstruction

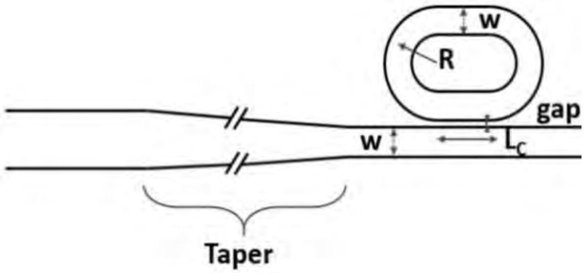


- **Optical transparency and single mode guiding**

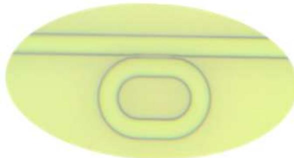


- **An example of schematic curved structure shaped/developed with only one layer/flash !**





DUV 210 MR
Optical microscopy



Thank you for your attention

Références

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[6] Castro Beltran R., Garnier L., St Jalmes A., Lhermite H., Gicquel E., Cormerais H., Fameau A.-L., Bêche B., “Microphotonics for monitoring the supramolecular thermoresponsive behavior of fatty acid surfactant solutions”, Opt. Comm., 468, 125773.1-7 (2020). https://doi.org/10.1016/j.optcom.2020.125773
[7] Garnier L. , Lhermite H., Vié V., Pin O., Liddell Q., Cormerais H., Gaviot E., Bêche B., “Monitoring the evaporation of a sessile droplet by means of integrated resonator”, IoP - J. Phys. D: Appl. Phys., 53, 125107.1-10 (2020). https://doi.org/10.1088/1361-6463/ab651d