study of nano-printing in a biomaterial and its use as a secondary polymer mold

JNIL 11-12/05/23 LYON

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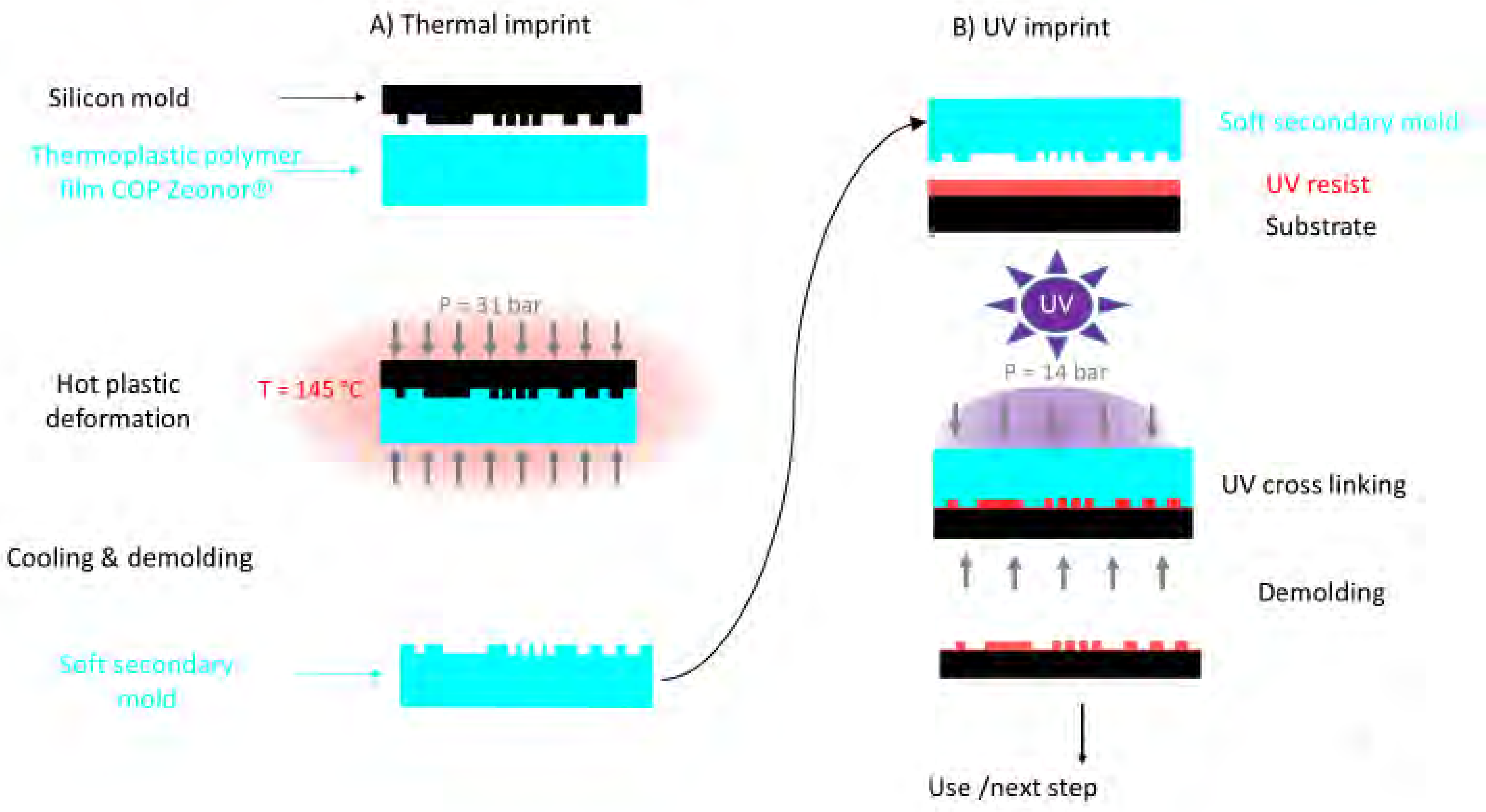
Presentation plan

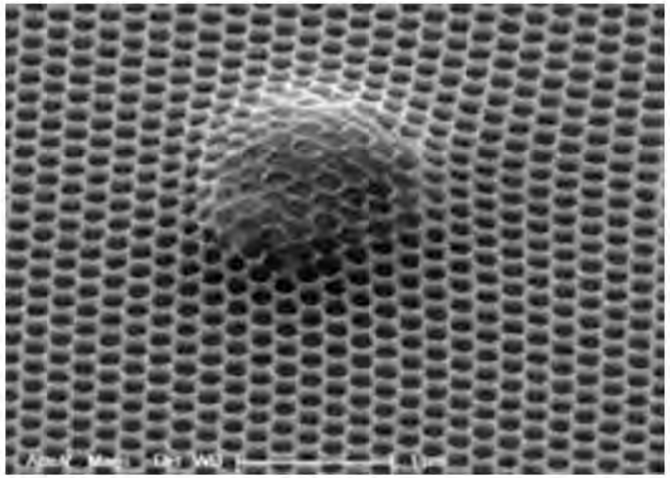
- Secondary polymer mold
  - Principle
  - Avantages
  - The environmental problem : cyclo olefin polymer versus polylactic acid
- Our results with polylactic acid
- Conclusions and perspectives

Secondary polymer mold principle



Advantages and a drawback of the secondary polymer mold process

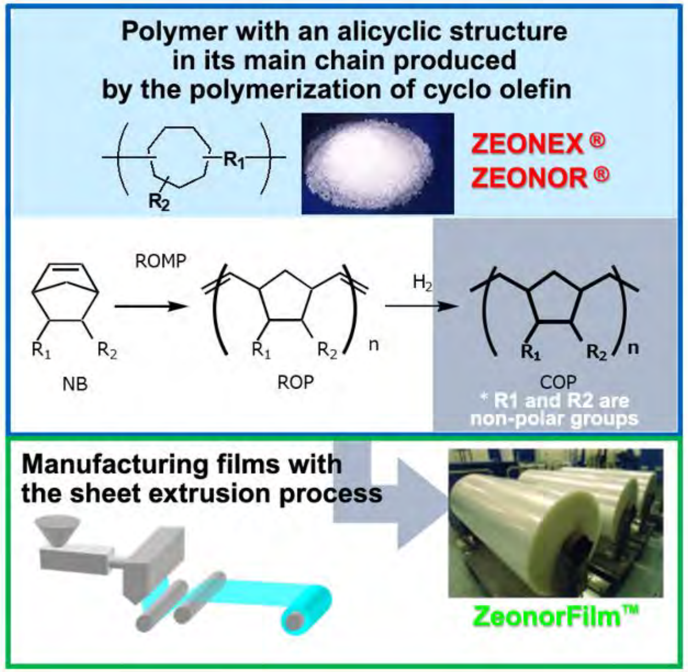
- ✓ Advantages
  - ✓ In UV imprint, the original mold does not need to be transparent (silicon OK)
  - ✓ The original mold is preserved (no hard/hard contact)
  - ✓ Fewer non-uniform print issues
  - ✓ Easier demolding
  - ✓ No polarity reversal (what was protruding remains protruding)

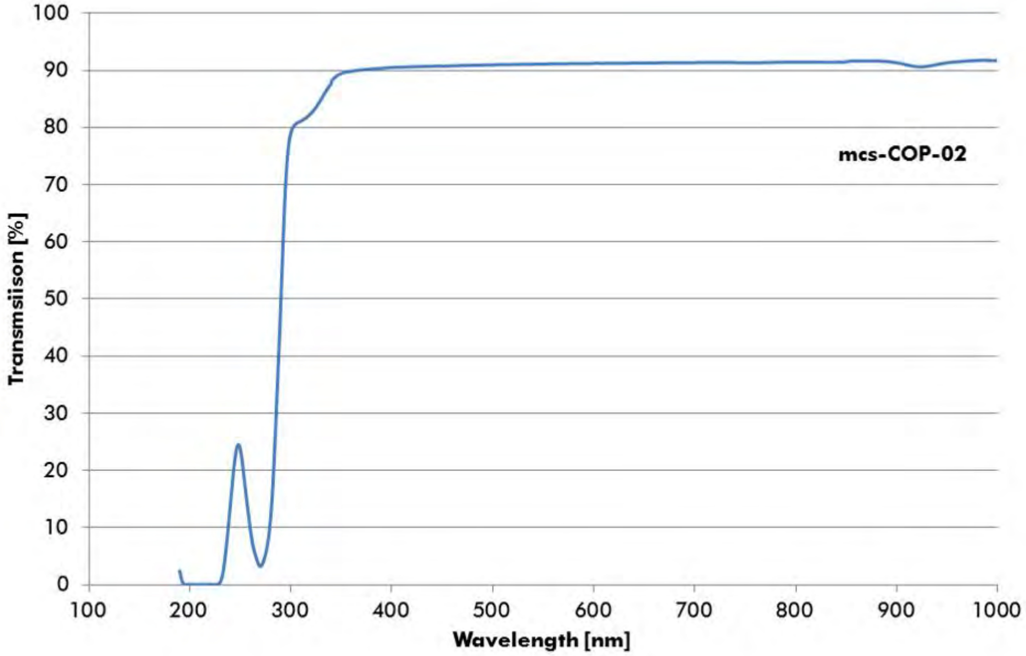


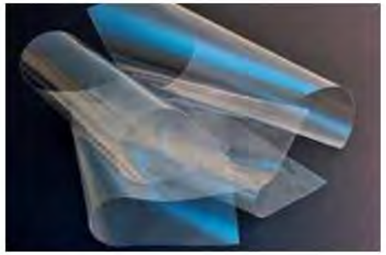
Pattern printed on a contaminating particle on the substrate

➢ But : with zeonor®, use of petro-based and non-degradable disposable polymer materials

Zeonor® petrosourced non biodegradable

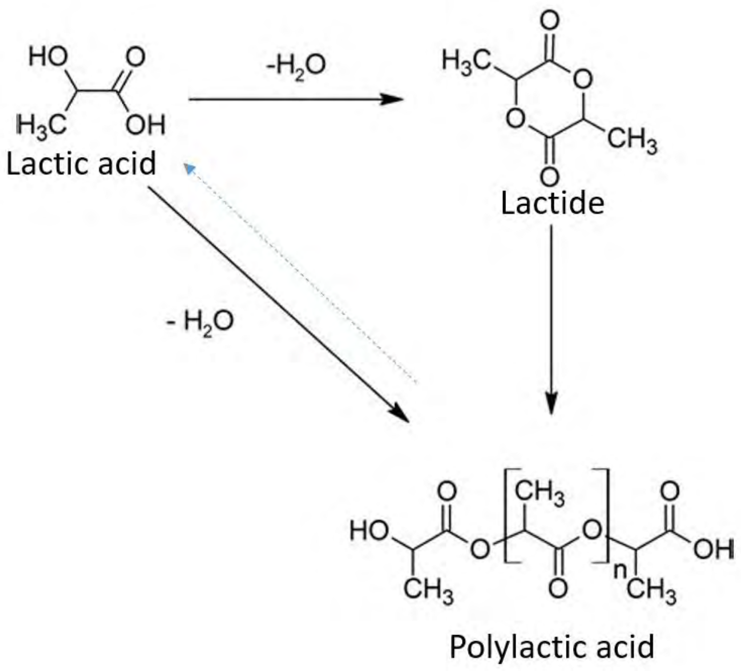






Polylactic acids : biosourced, biocompatible, biodegradable polymer

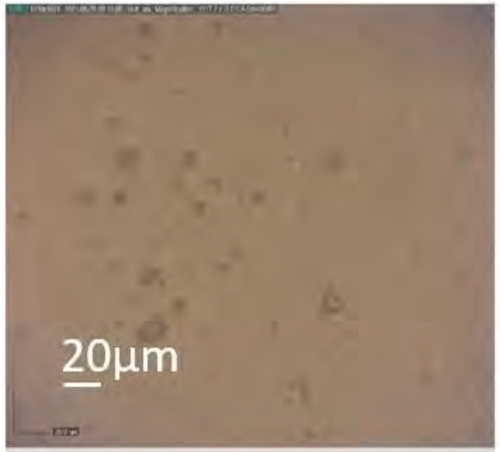
Lactic acid : endogenous molecule



Peer, A., Dhakal, R., Biswas, R., & Kim, J. (2015). Nanoscale patterning of poly (L-lactic acid) films with nanoimprinting methods. Nanoengineering: Fabrication, Properties, Optics, and Devices XII, Proc. of SPIE 2015 Vol 9556, doi.org/10.1117/12.2188888

Farahani, A., Zarei-Hanzaki, A., Abedi, H. R., Tayebi, L., & Mostafavi, E. (2021). Polylactic acid piezo-biopolymers: Chemistry, structural evolution, fabrication methods, and tissue engineering applications. Journal of Functional Biomaterials, 12(4). https://doi.org/10.3390/jfb12040071

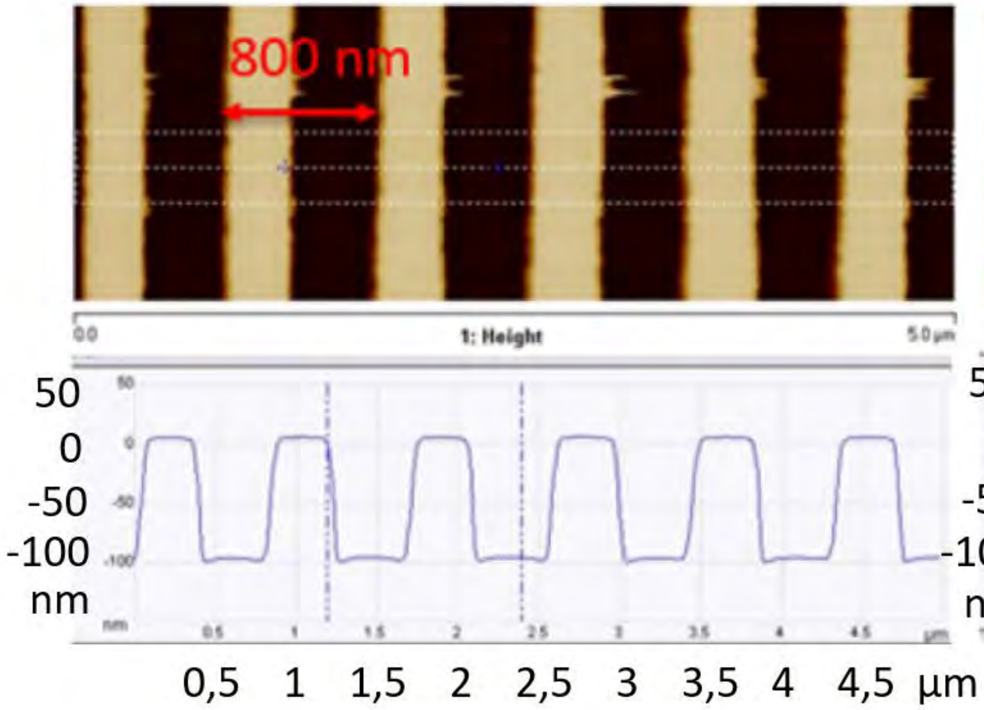
First tests on a commercial 50µm thick PLLA film



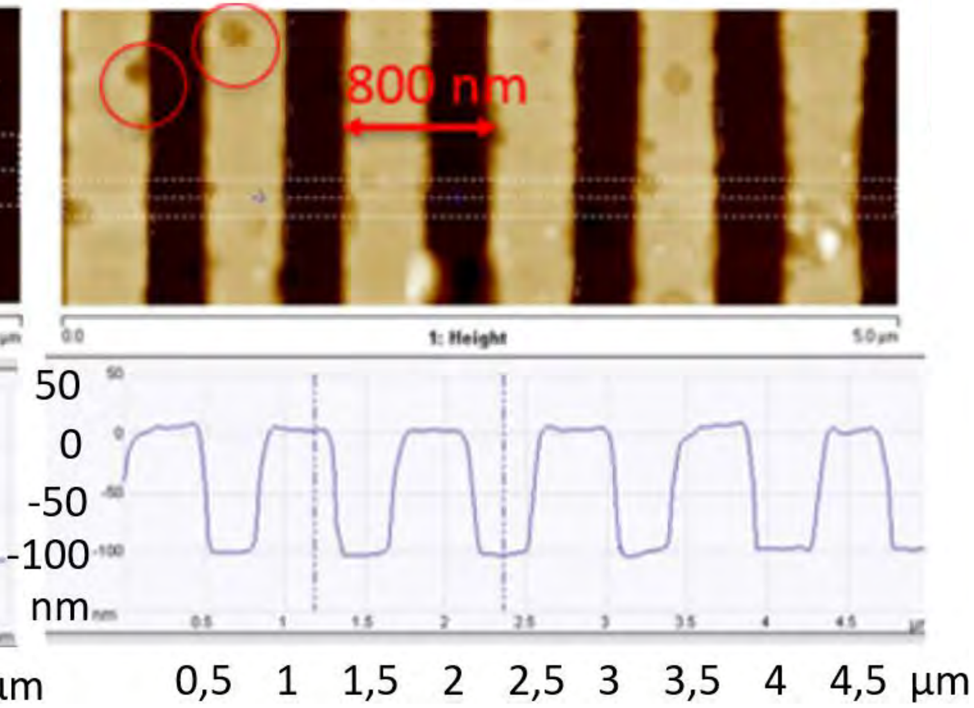
Optical micrograph of the PLLA commercial Goodfelowfilm, thickness 0.05 mm

- Numerous microscale round shape defects on the commercial film before imprint
- Numerous ~100 nm defects on the secondary mold after imprint

AFM of silicon mold



AFM of replica in PLLA film

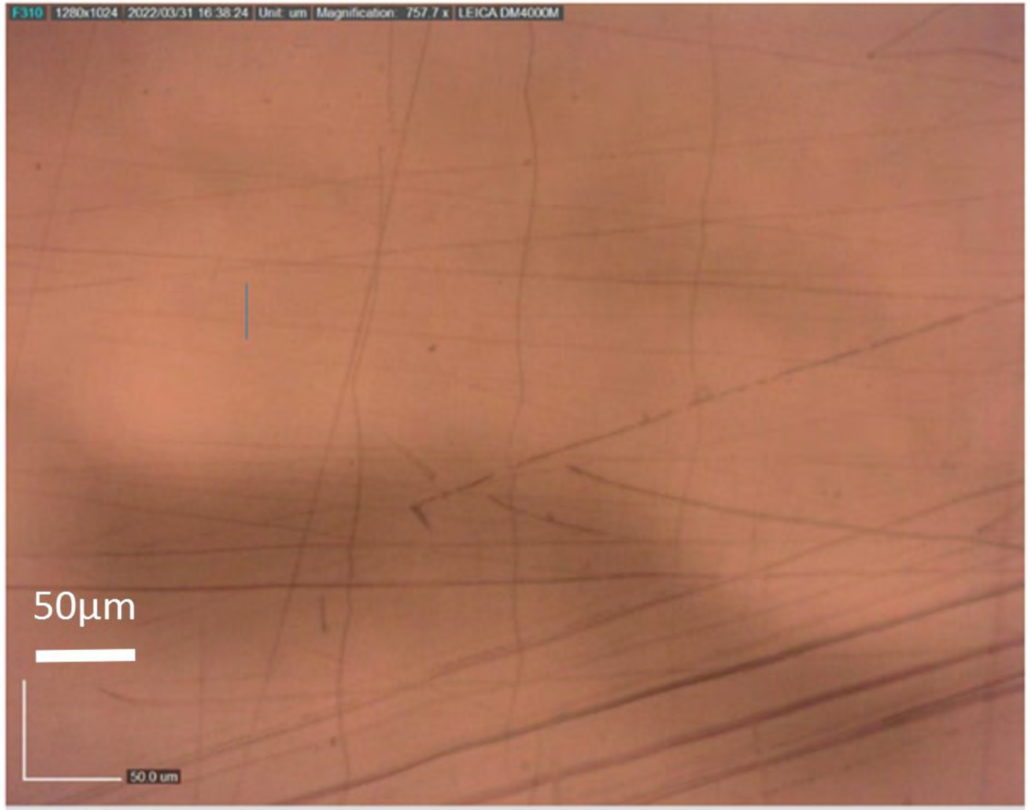


Calendering of commercial PLA pellets

PLA pellets LX530
Corbion

Laboratoire de Chimie Agro-industriel; Toulouse

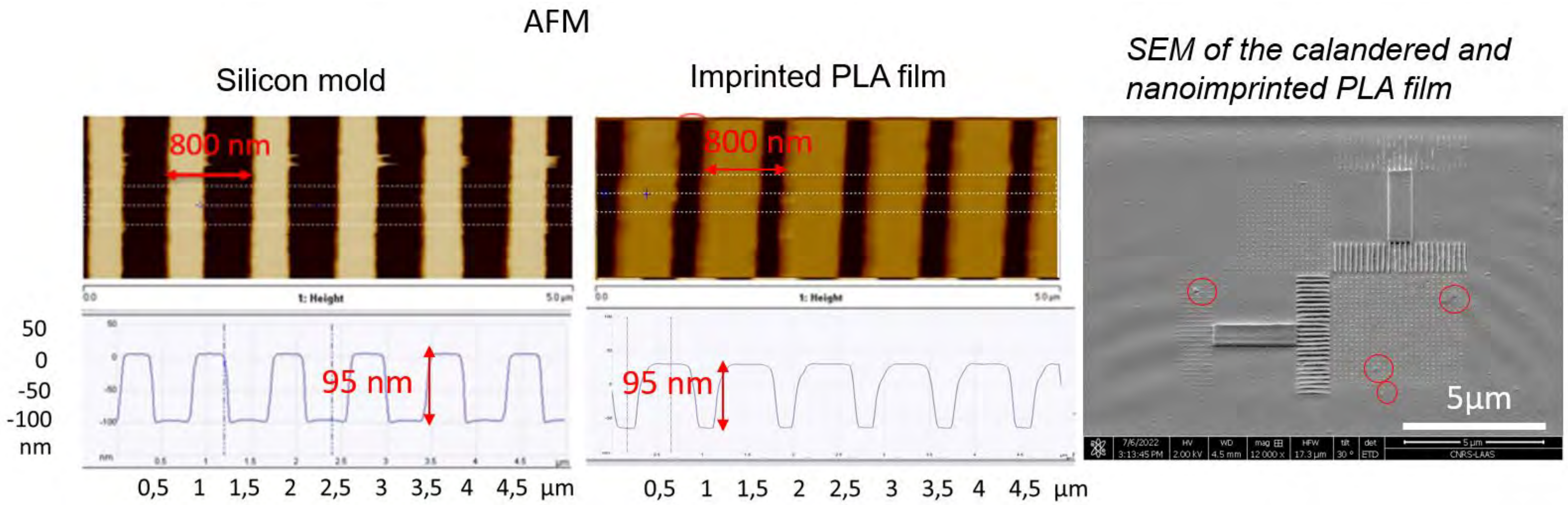
Observation of the PLA calandered ~200µm thick film



Optical micrograph of the calendered PLA film

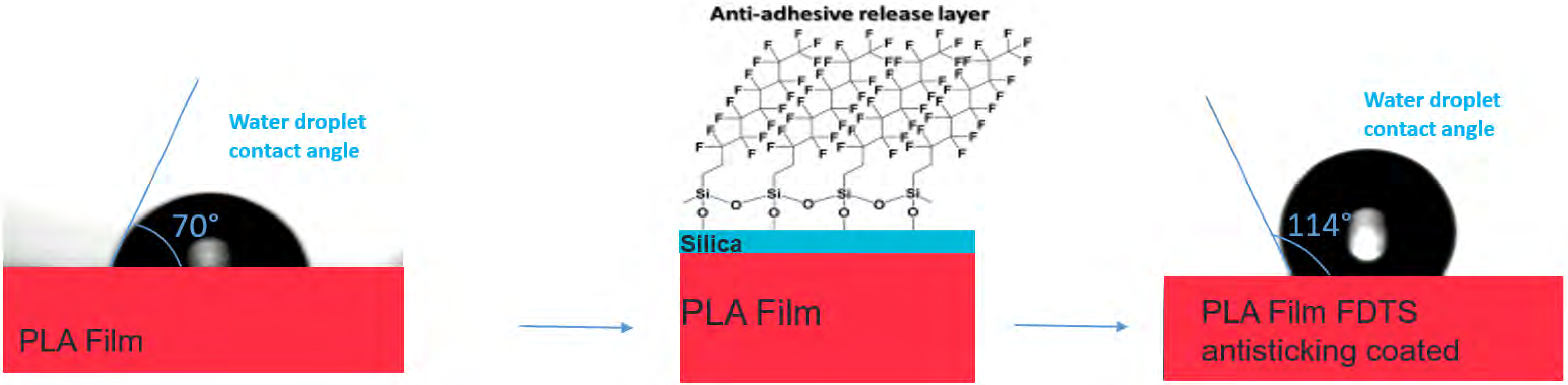
- No microscale round shape defects
- But grooves from the cooling roll can be seen on the film
- Much larger stripes millimeter size can be seen if the rolls speed is not adapted

A) Thermal imprint of PLA film



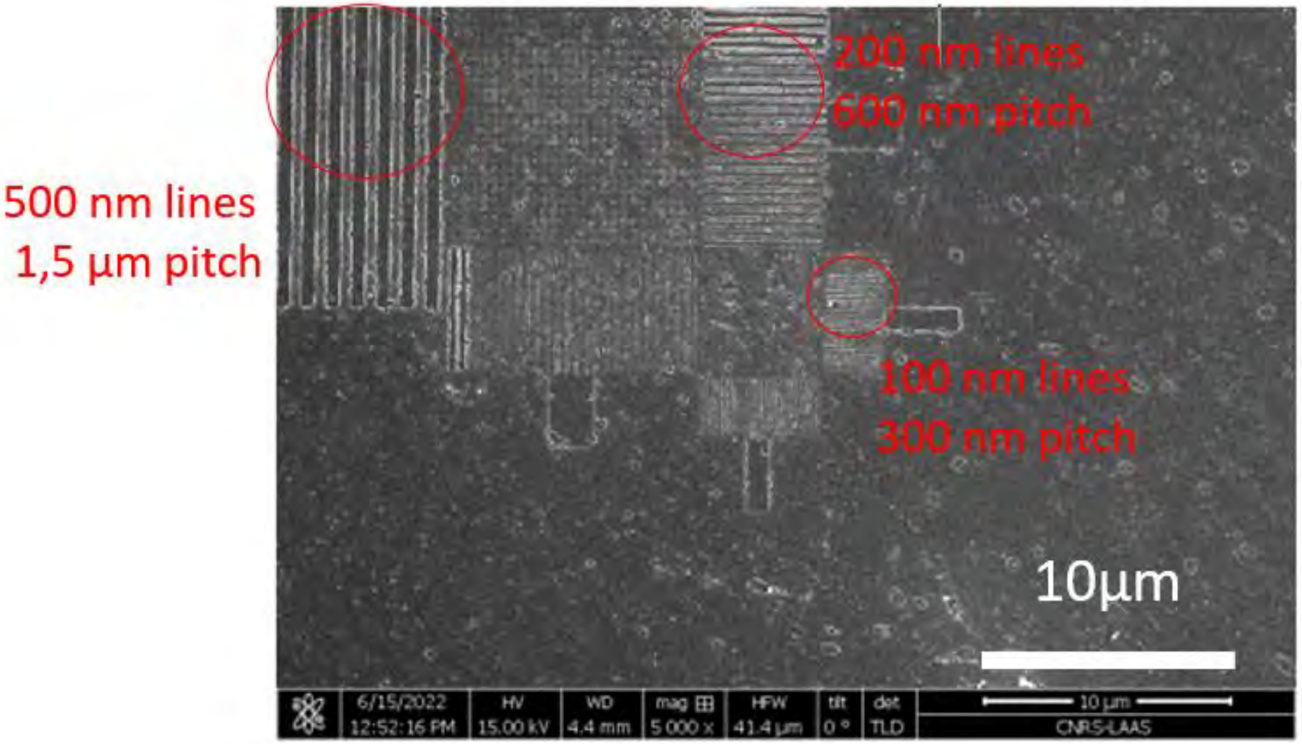
- Accurate pitch and depth
- Inverted structures
- Some Defects

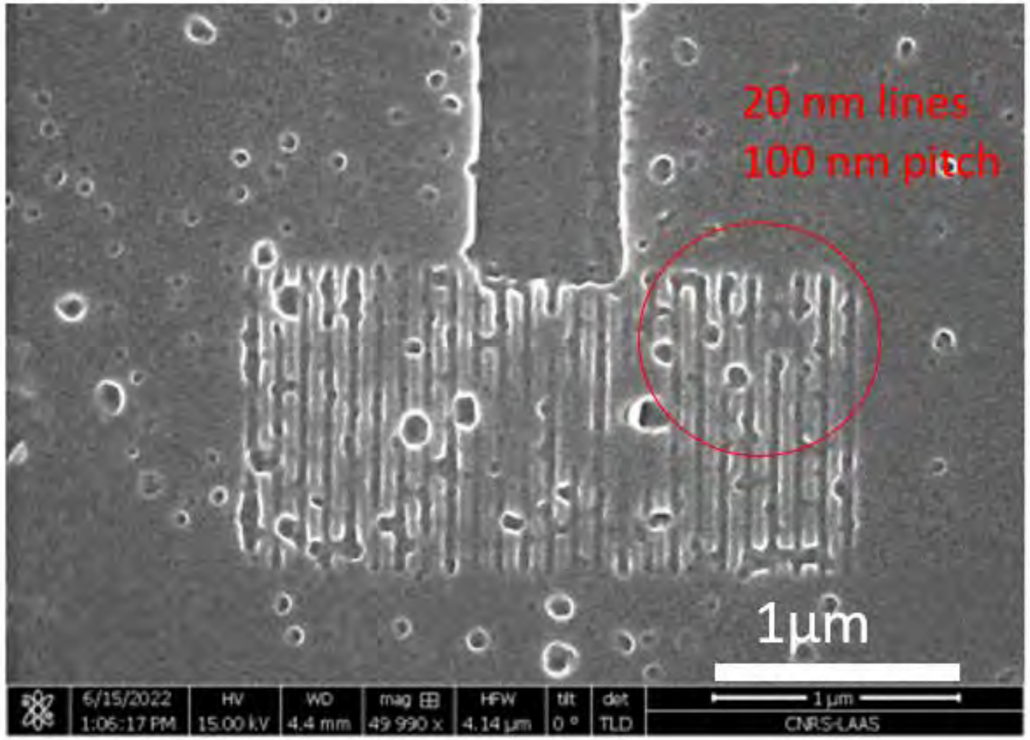
Antiscking surface treatement on the PLA secondary mold



- 1) Thin silica layer deposit
- 2) FDTS anti sticking layer deposit on the silica

B) imprint of UV resist with PLA secondary mold





SEM of UV imprinted resist thanks to PLA secondary mold

Conclusions and perspectives

	Zeonor®COP	Goodfellow PLLA film	Calandered PLA film
Nanoscale printing hability	yes	yes	yes
antisticking needed for UV printing?	no	yes	yes
Milliscale defects	no	no	Yes, but improvable
µscale defects	no	yes	no
Nanoscale defects	no	yes	Yes, improvable ?
biosourced	no	yes	yes
biocompatible	yes	yes	yes
biodegradable	no	yes	yes

- ➢ The films can certainly be used in some needs for biology
- ➢ Further studies including calendering improvement or needed to see if ok for micronanotechnology