ICME 2016
Simulation of plastic injection for nano roughness replication
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aim4np

SEVENTH FRAMEWORK PROGRAMME

Overview

1. Introduction to aim4np project
2. Simulations of plastic injection at nano level
3. Experiments of plastic injection at nano level

1.- Introduction to aim4np project

Aim4np is a FP7 funded project to build an Automated In-line Metrology for (4) Nanoscale Production.

http://aim4np.eu/

1.- Introduction to aim4np project

Production enters nanometer domain

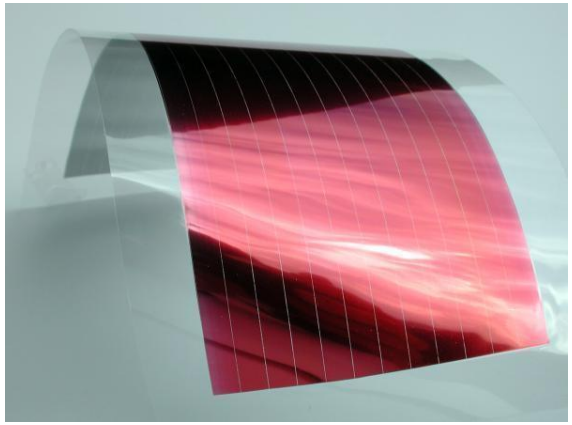


image: www.icsana.com

image: www.syntecoptics.com

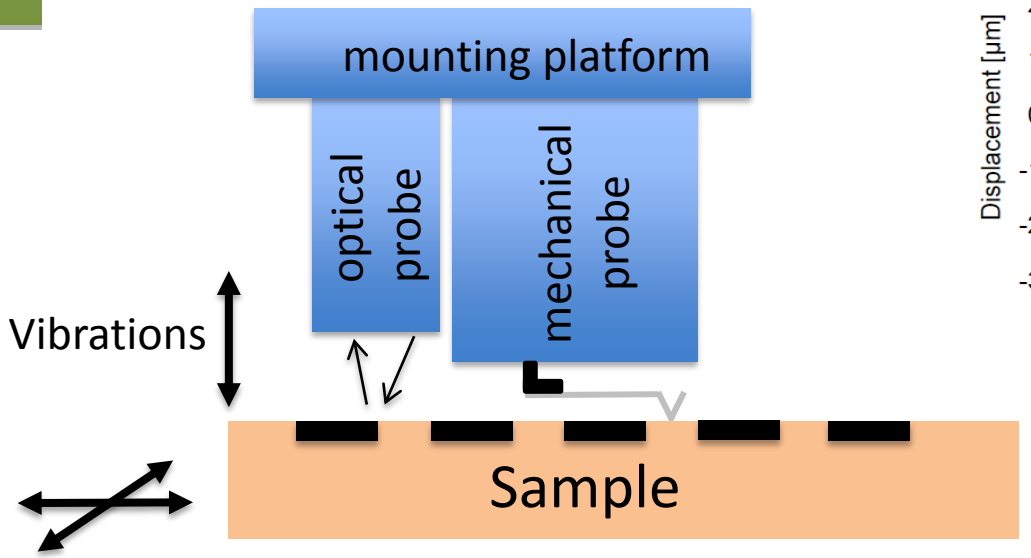
Measurement of nanomechanical properties for:

- Quality control
- Tool-lifetime monitoring
- Maintaining precision
- Processing control

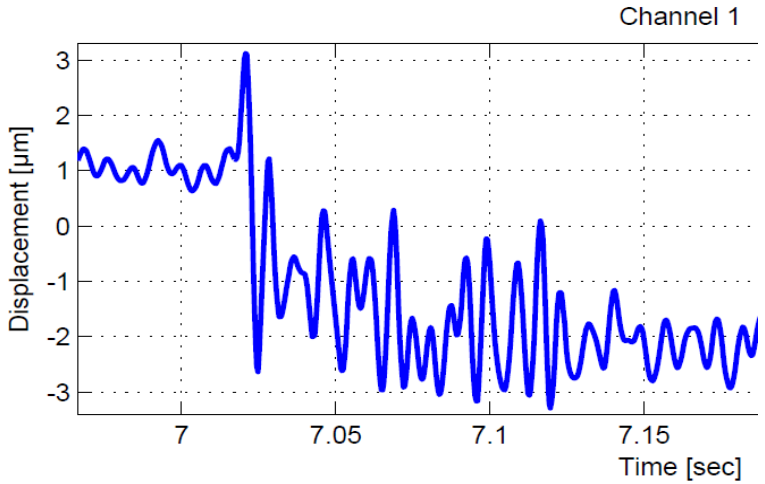
Crucial for an efficient production!

1.- Introduction to aim4np project

Challenge



Sample vibration



Possible implementation of probes:

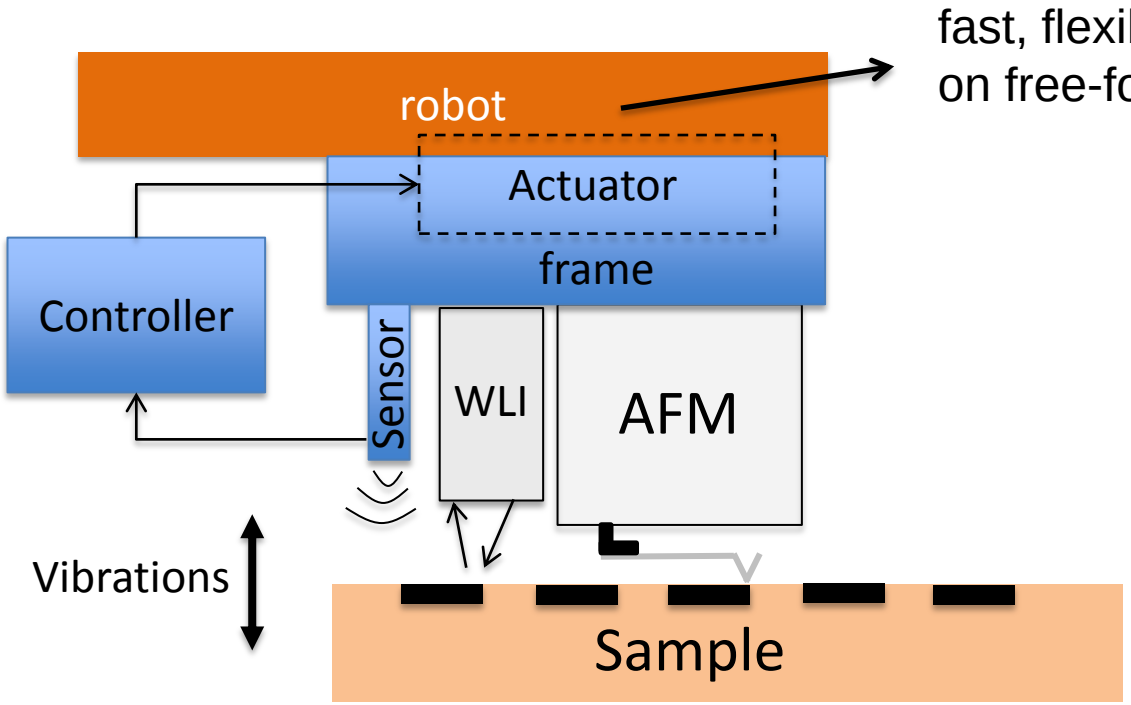
Atomic Force Microscope [AFM]

White Light Interferometer [WLI]

Environmental vibrations hinder the stable proximity needed for conducting nanomechanical measurements!

1.- Introduction to aim4np project

Proposed solution



AFM…Atomic Force Microscope
WLI…White Light Interferometer
MP … Metrology Platform

1.- Introduction to aim4np project

Plastic injection application of aim4np

Plastic injection is selected as a possible application for aim4np to control moulds and plastic parts in-line to assure surface quality.

- Flubetech provides DLC coatings ranging Sq=6 to 35nm.
- CSIC-CNM measure coating on mould Sq=6nm, and plastic parts from 4nm to 0.6nm.
- IQS carries out simulations of plastic injection.
- External partner plastic injection.

2.- Simulations of plastic injection at nano level

2.1. Model to validate

2.2. Approaches

2.3. Submodeling approach

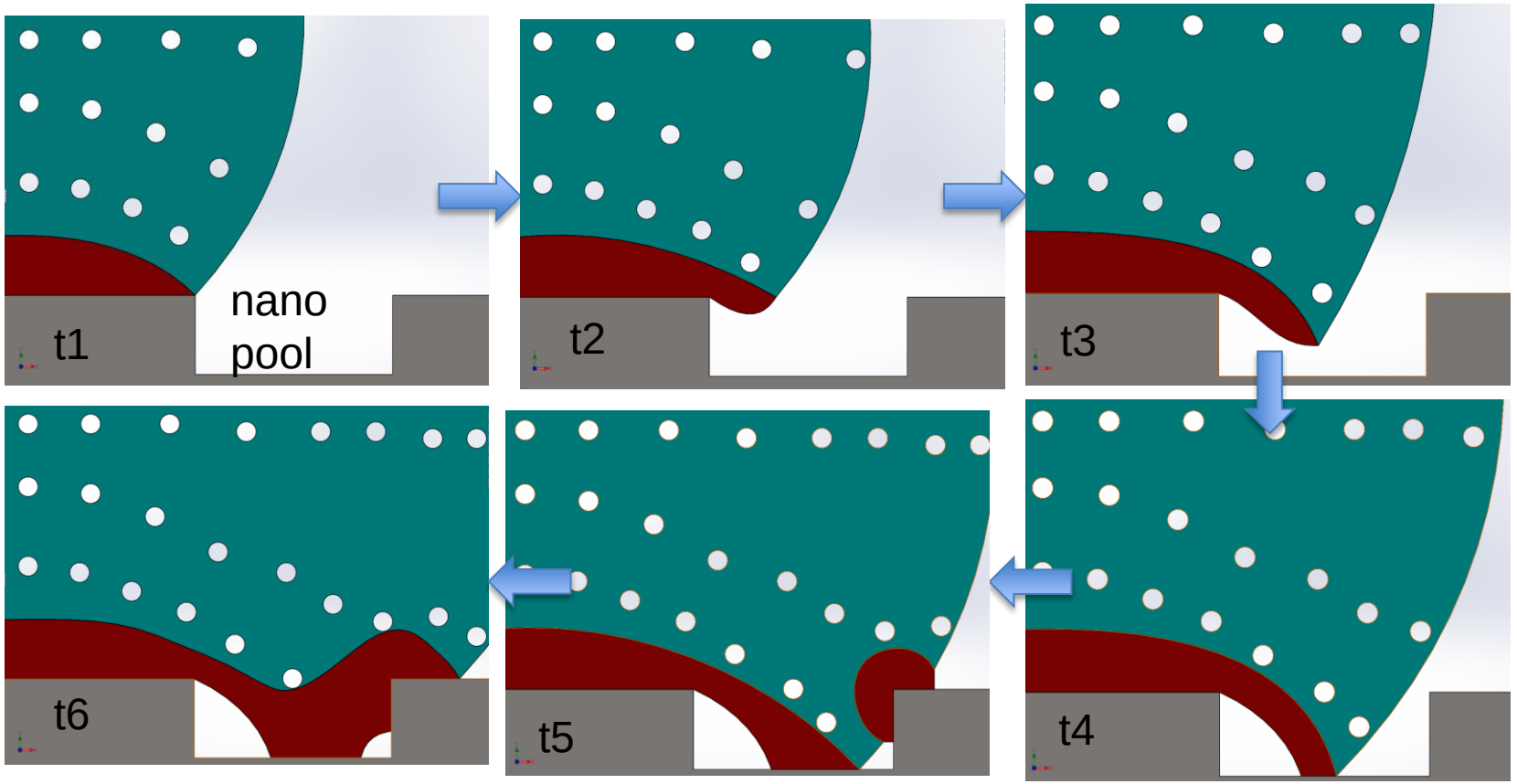
2.4. Results

2.5. Roughness applied

2.- Simulations of plastic injection at nano level

2.1 Model to validate

How does the polymer fill a nanomark? A first intuition could be…

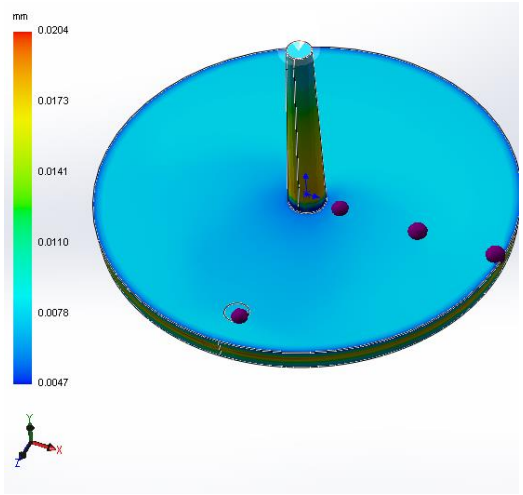


2.- Simulations of plastic injection at nano level

2.2 Approaches

Option 1: Mesh all the mesh at the nanoscale.
Computationally unaffordable. ✗

Option 2: Simulate both size scales in one simulation.
Unphysical results [1, 2] ✗



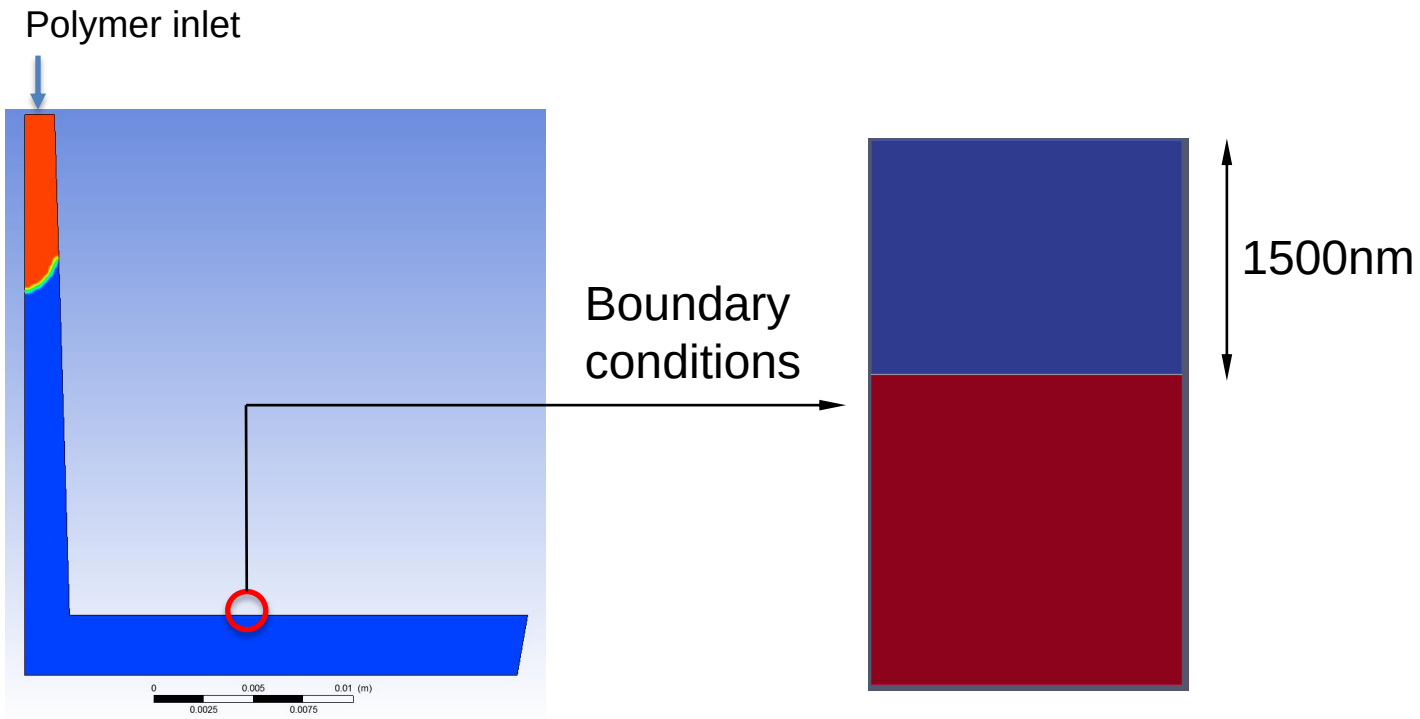
Air trap is detected on nano pools,
but also on fine mesh with flat surface

[1] T. Tofteberg; E. Andreassen in PPS Europe/Africa Regional Meeting, Gothenburg, 2007.
[2] L. Yu; L. J. Lee; K. W. Koelling Polym. Eng. Sci. 2004, 44, 1866.

2.- Simulations of plastic injection at nano level
2.3 Submodeling approach

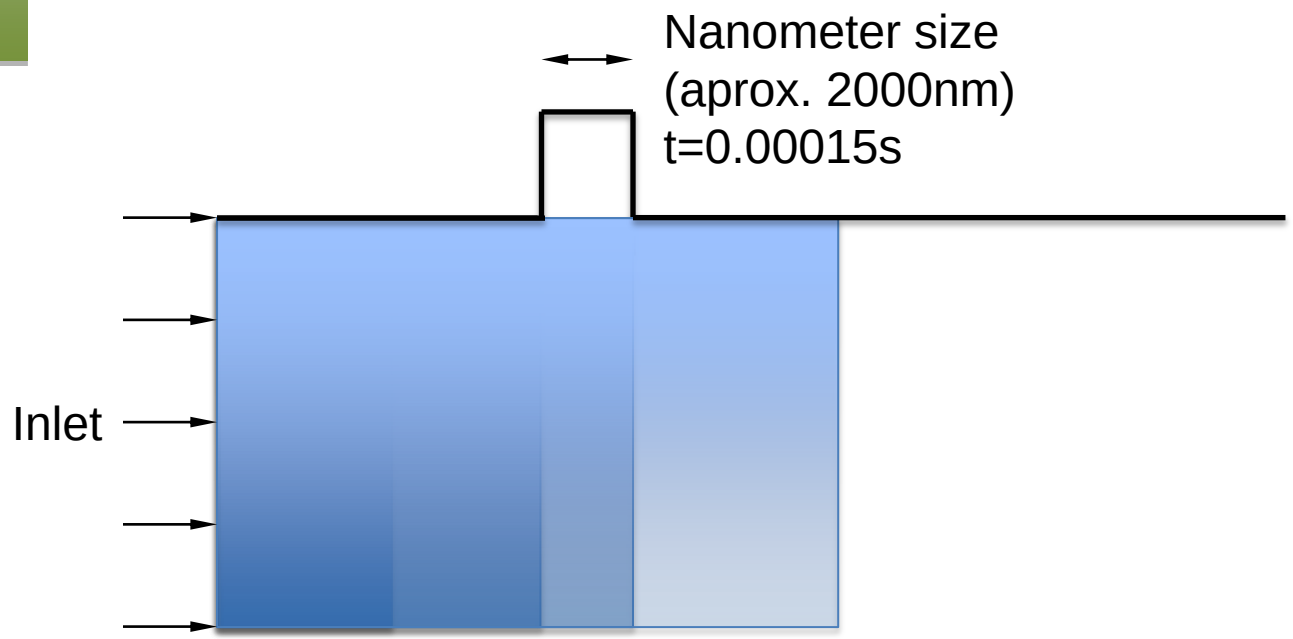
Macro simulation

Nano simulation



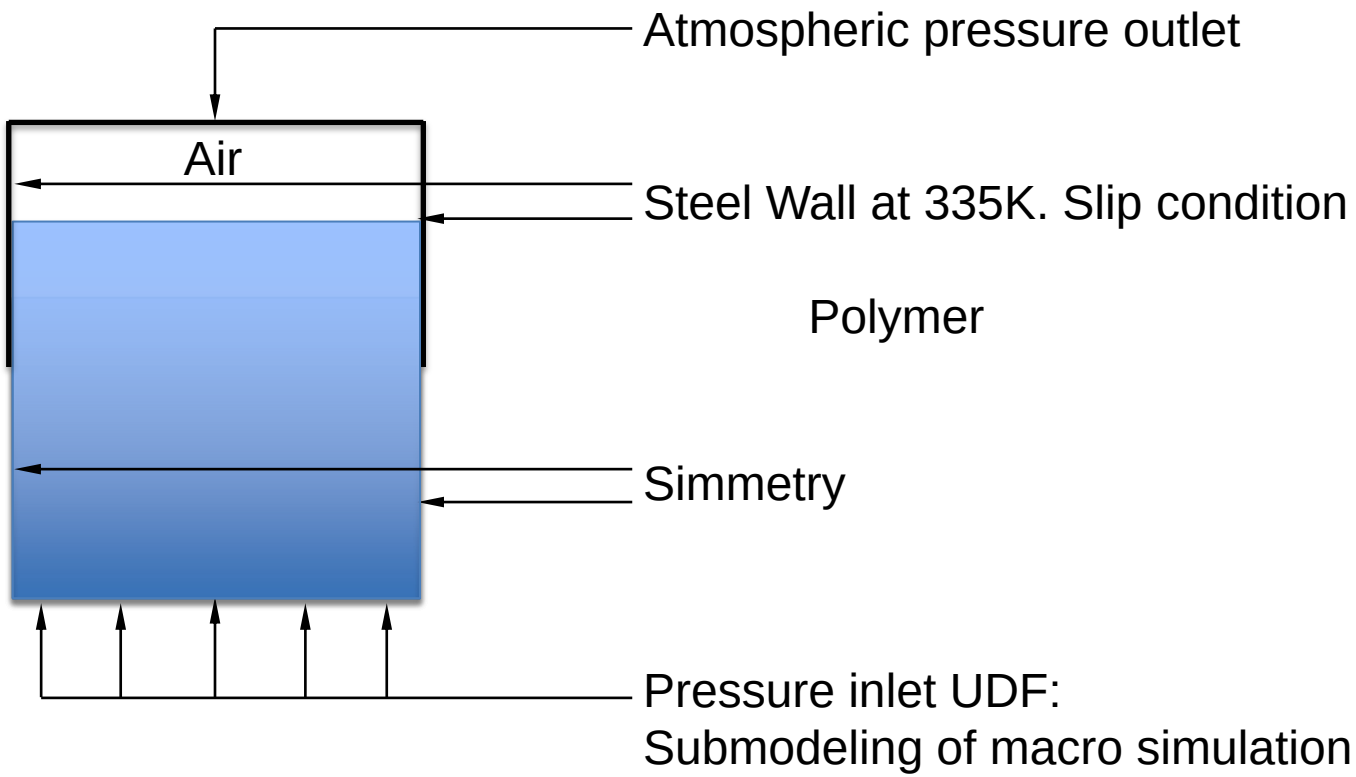
2.- Simulations of plastic injection at nano level
2.3 Submodeling approach

Part 1: The polymer goes through the nanomark

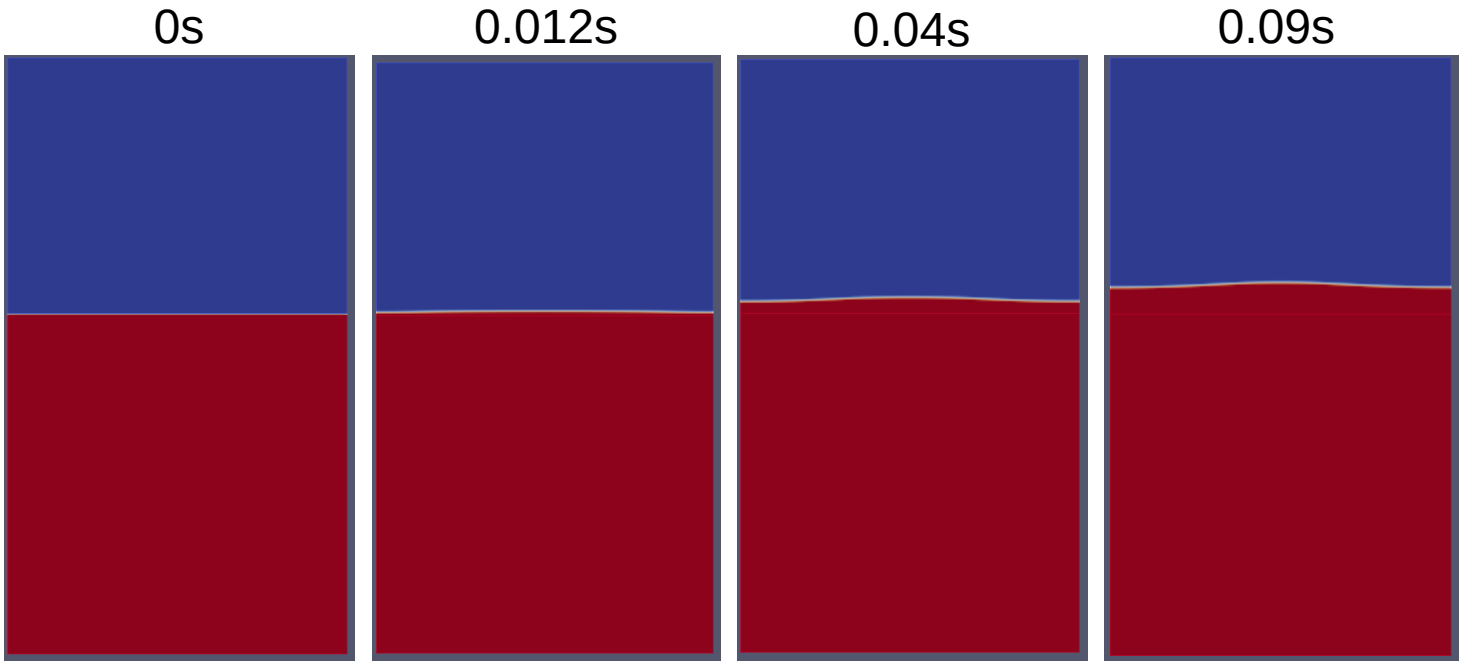


2.- Simulations of plastic injection at nano level
2.3 Submodeling approach

Part 2: The polymer moves into the nanomark until solidification



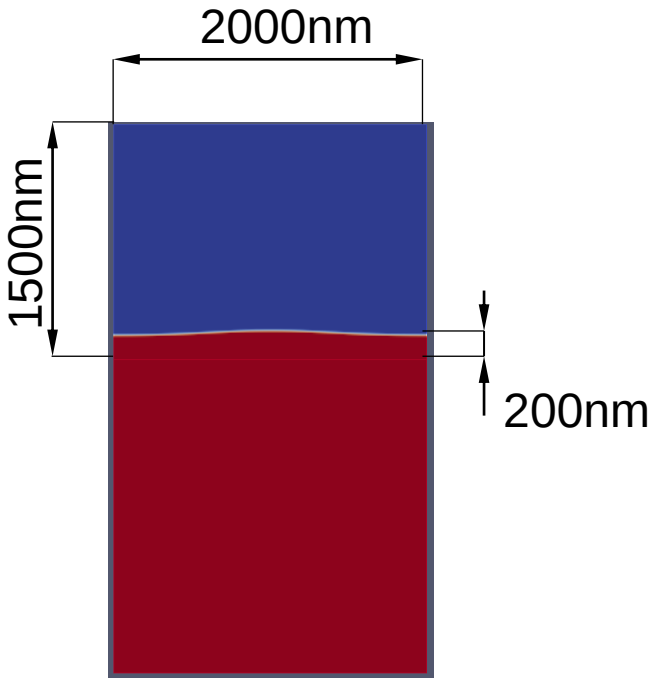
2.- Simulations of plastic injection at nano level
2.4 Results



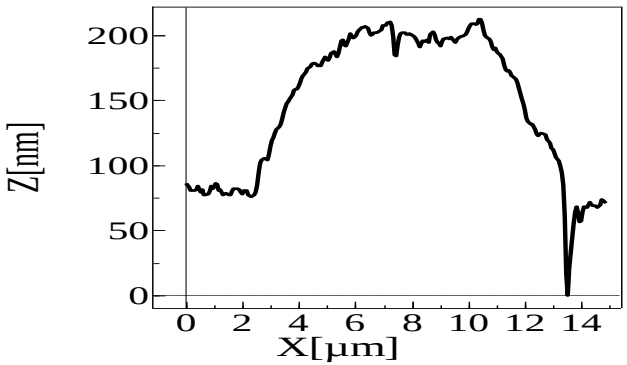
2.- Simulations of plastic injection at nano level

2.4 Results

Simulation

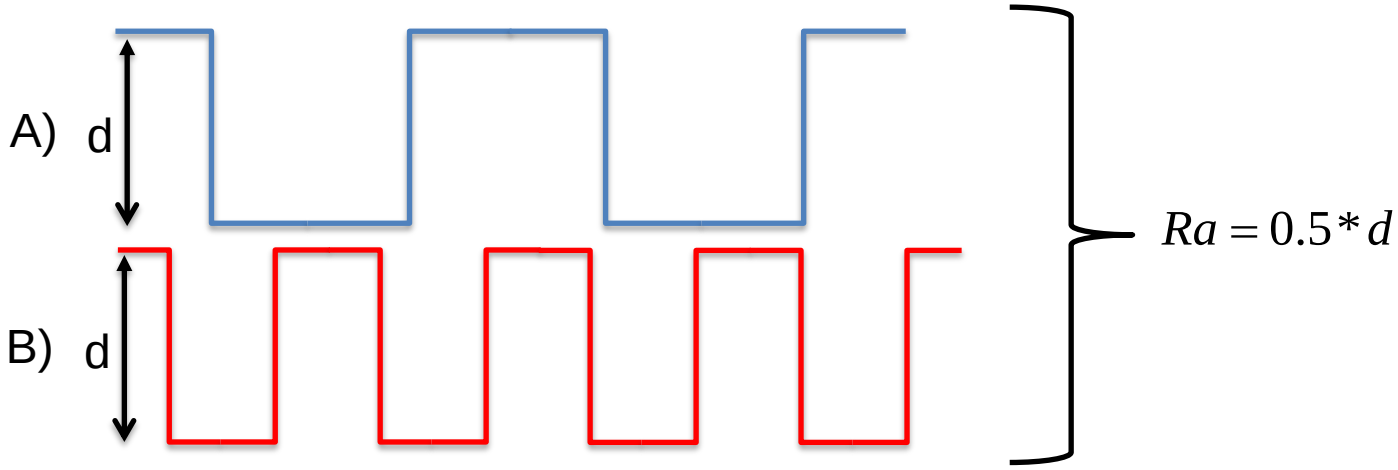


Experimental result



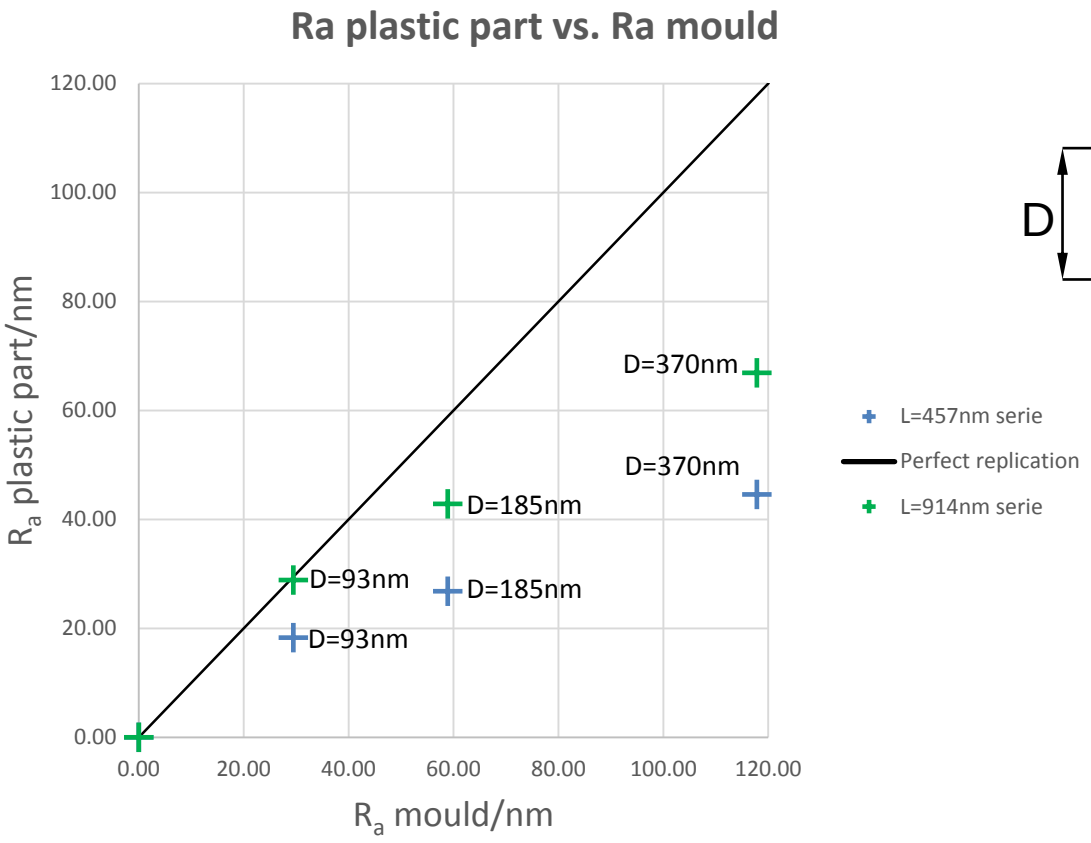
2.- Simulations of plastic injection at nano level
2.5 Roughness applied

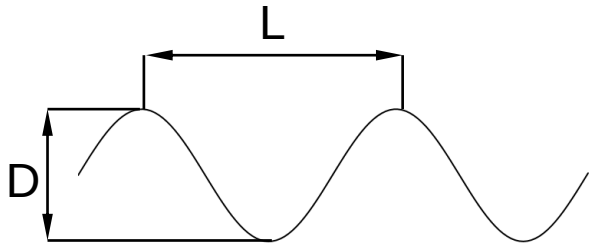
Surface A and surface B have the same roughness…



But surface A roughness is replicated easilier than surface B.

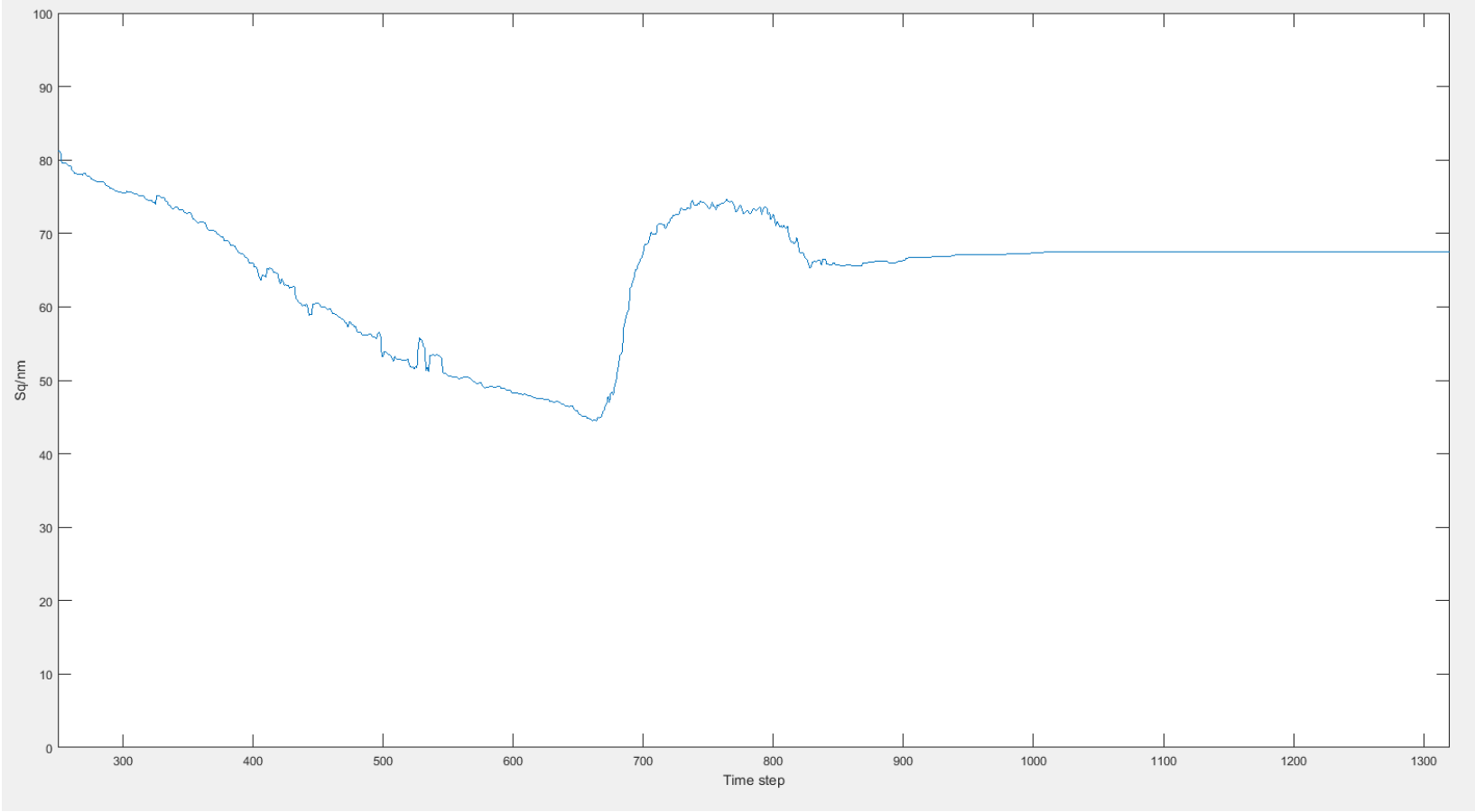
2.- Simulations of plastic injection at nano level
2.5 Roughness applied





2.- Simulations of plastic injection at nano level
2.5 Roughness applied

Evolution of roughness with time

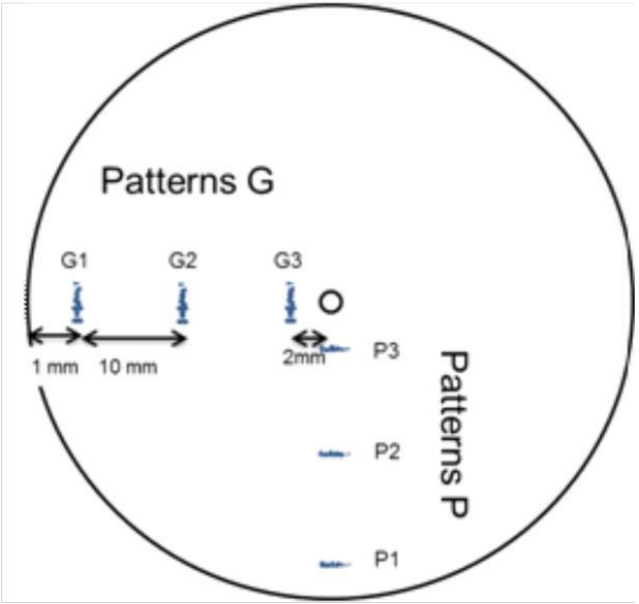


3.- Experiments of plastic injection at nano level

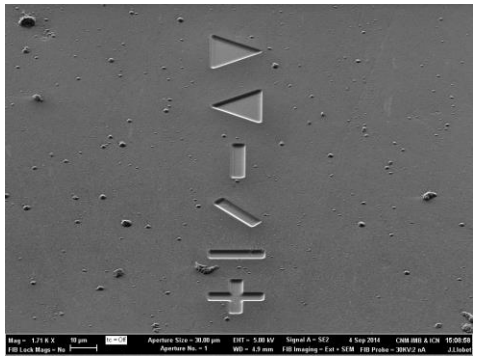
MOULD
Roughness
Micro pattern
Nano pattern

PLASTIC PART
Roughness?
Micro pattern?
Nano pattern?

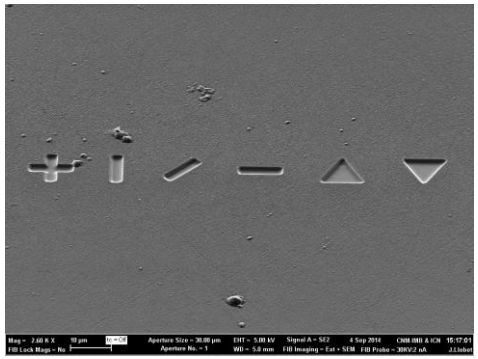
3.- Experiments of plastic injection at nano level



SEM images of the mould nano pools:

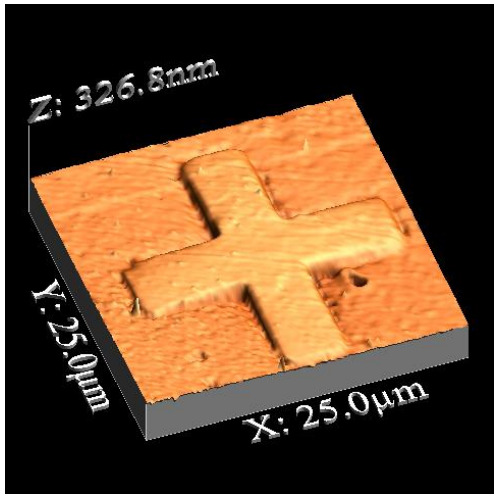


G1. 4x20um



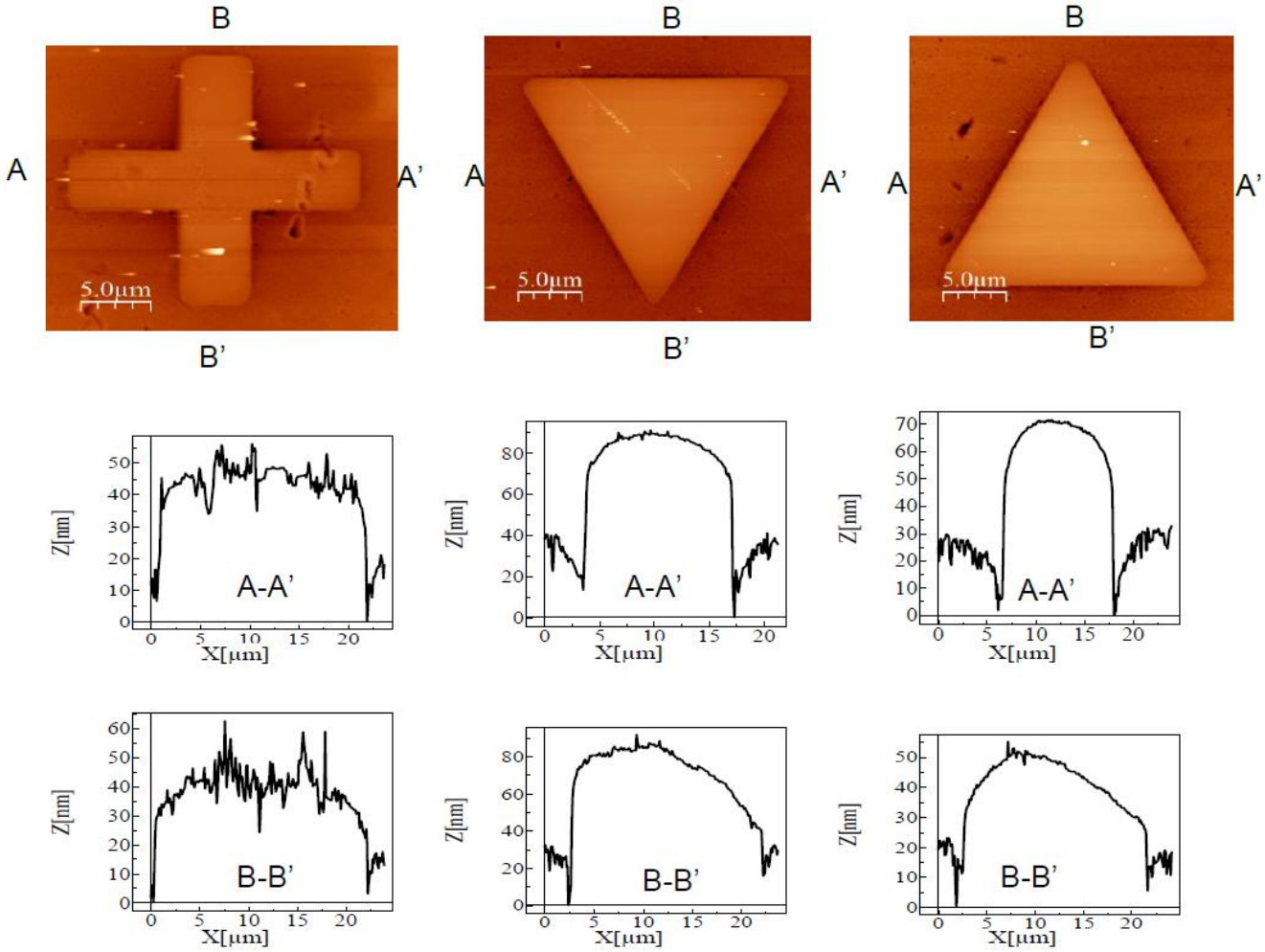
P1: 4x20um

AFM image of the plastic part:

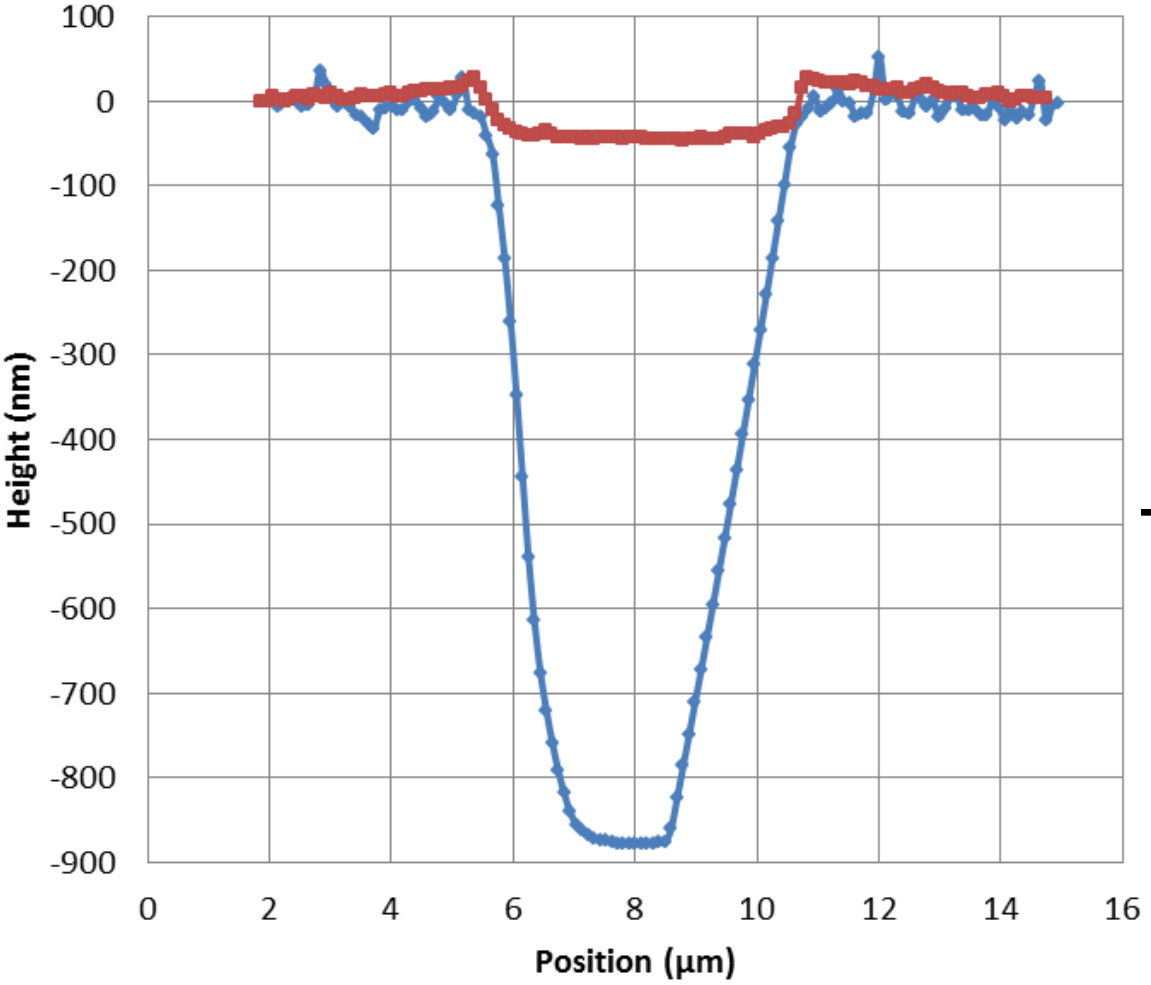


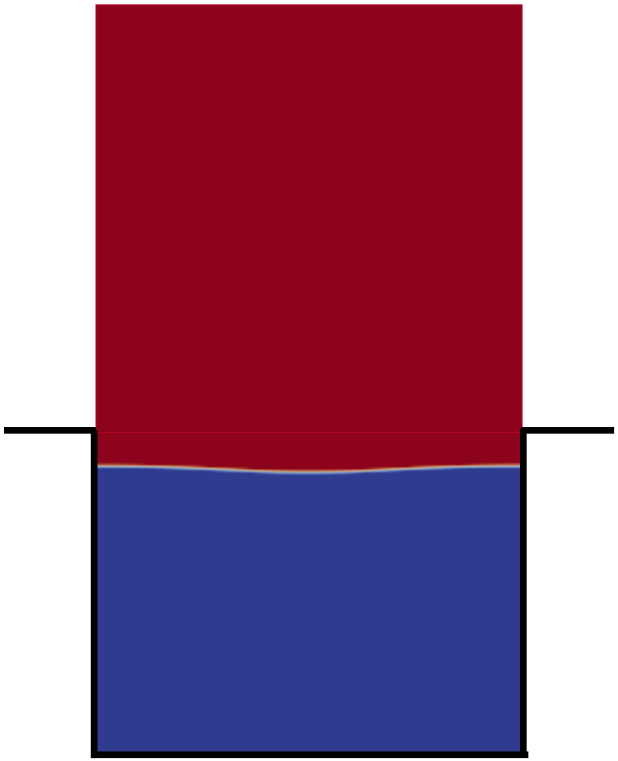
3.- Experiments of plastic injection at nano level

AFM image of the plastic part



3.- Experiments of plastic injection at nano level





4.- Storage of material properties

We need the creation of a database to store material properties used along this project for current polymers and mould conditions.

Such place should be driven by https://emmc.info/


4nm
Thank you
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