

# Interreg



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## PROOF-OF-CONCEPT EXPERIMENT REPORT

### EVALUATION OF POLISHING EFFECT ON STENCIL MASKS FOR PRINTED CIRCUIT BOARDS

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**Proof-of-Concept experiment details**

**Received samples:** 9 steel stencil masks (4x dia.:2 inches, 3x dia.: 3 inches, 2x dia.: 4 inches)

Sample list

Quantity	Mask diameter (inches)	Thickness ( $\mu\text{m}$ )	Polishing
1	3	300	Non-polished
3	3	300	Mechanical
2	2	200	Mechanical
2	2	200	Electropolishing
2	4	200	Electropolishing

**Planned analysis:**

1st step: analysis with optical profilometer to evaluate the roughness after mechanical polishing / electropolishing

2st step: SEM imaging of stencil masks to evaluate the quality of the two polishing processes and the presence of defects

**Sample preparation:** no sample preparation performed, the samples have been observed as received

**Measurement author, dates and place:** the profilometry measurement have been performed by dr. Dal Zilio at IOM-CNR. The SEM measurements have been performed by dr. Mattia Fanetti at University of Nova Gorica (campus of Ajdovščina).

**Observation conditions:**

Optical profilometry:10x objective, Zoom 2x

SEM imaging: beam energy 15 KeV; secondary electron detector

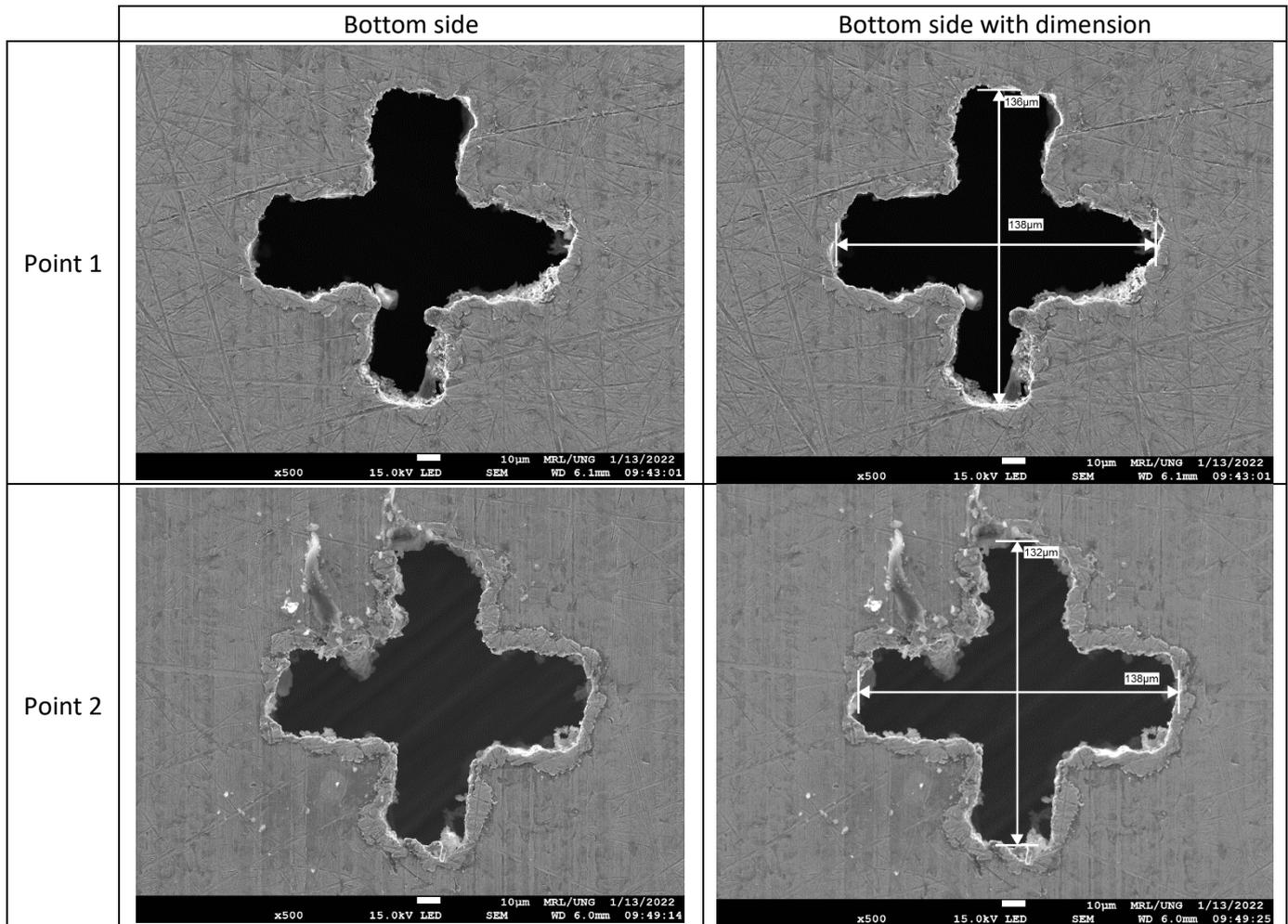
**Main aim of the proposal:** the POC experiment is aimed to verify the effectiveness of optical profilometry and scanning electron microscopy (SEM) in the characterization of polished stencil masks. In particular, the characterization is focused on the surface features resulting from different polishing treatments after the laser cutting: mechanical polishing and electrochemical polishing.

## Results – Scanning Electron Microscopy (SEM)

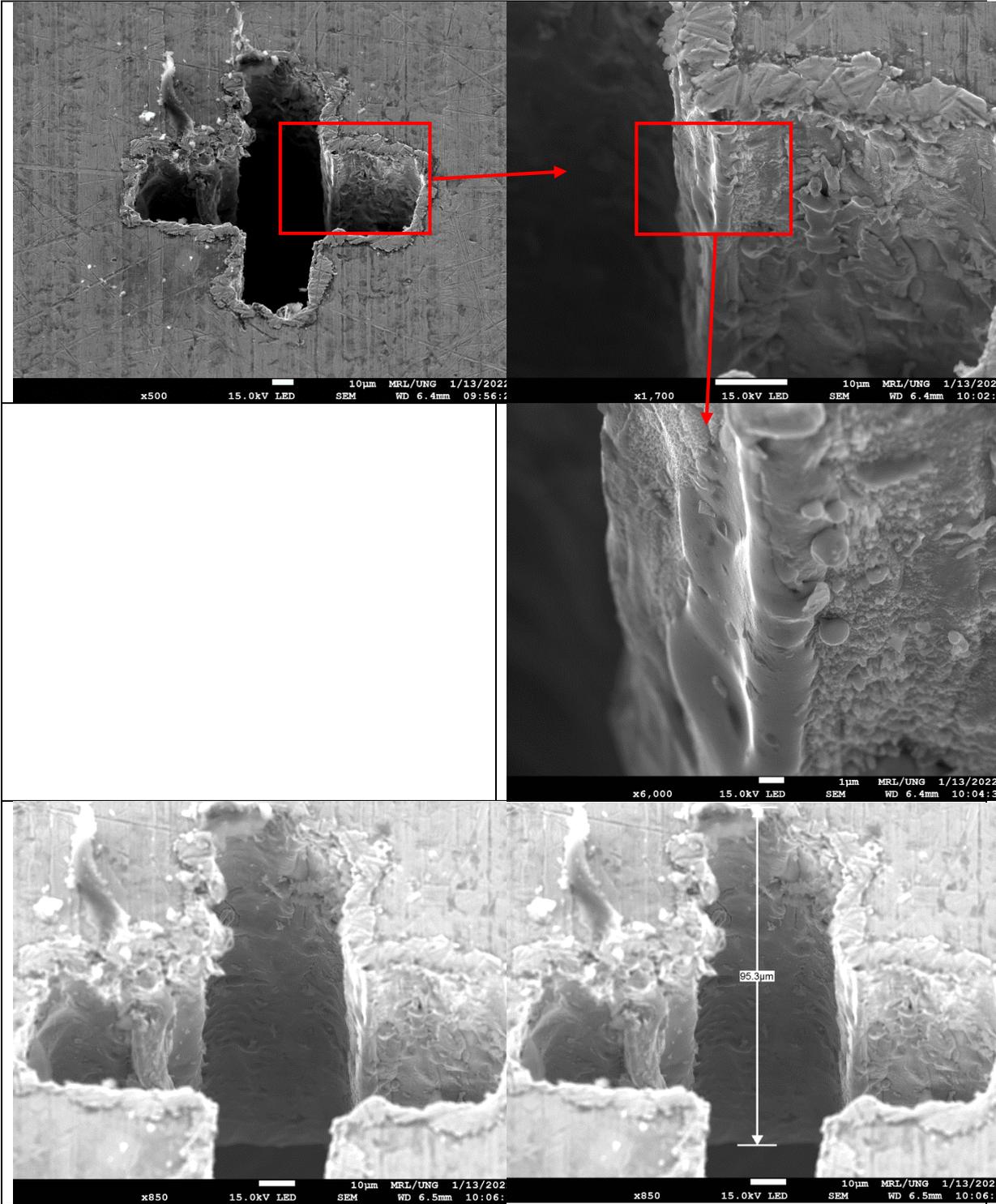
Two 2-inch stencil masks have been analyzed by SEM: 1 mask mechanically polished and 1 electrochemically polished.

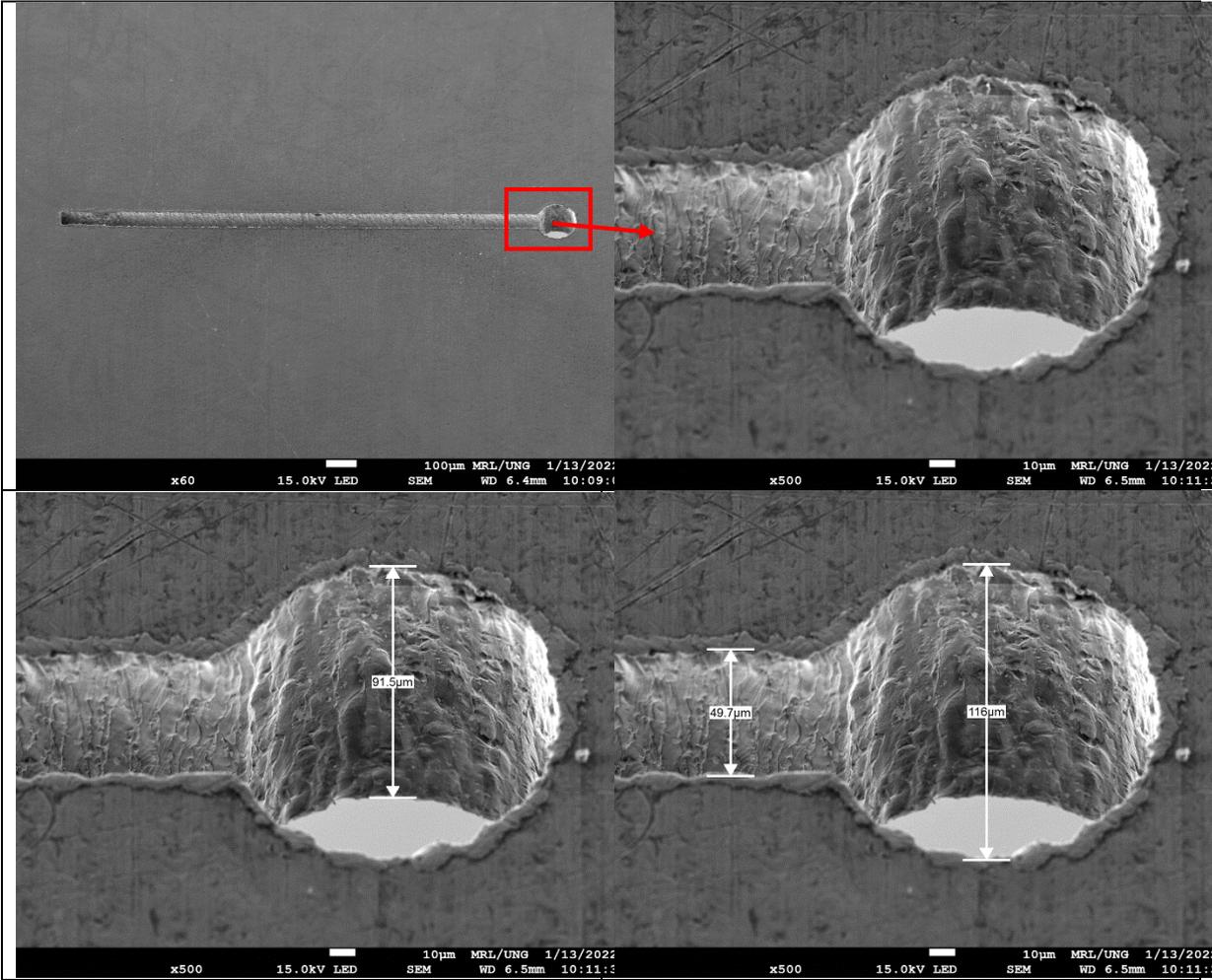
Some examples are reported below:

### Mechanically polished mask



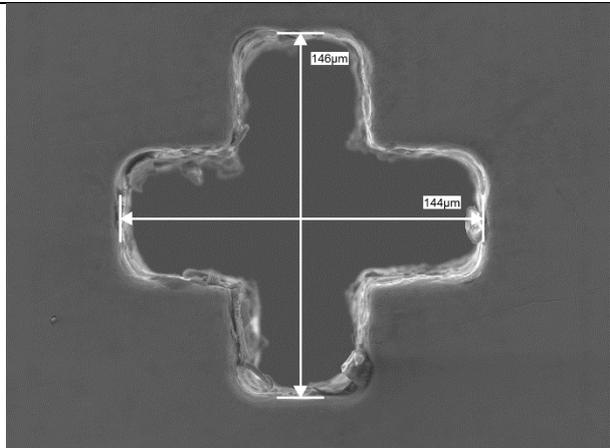
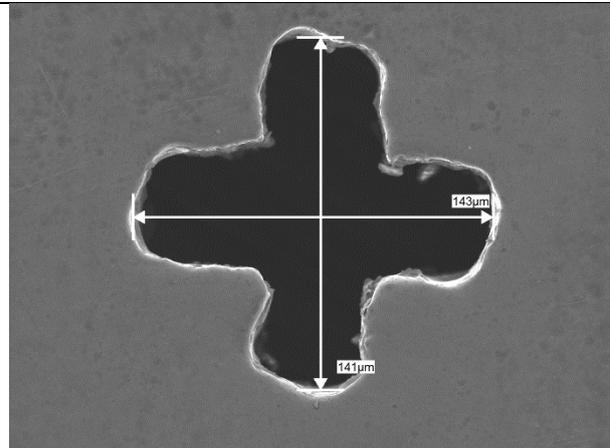
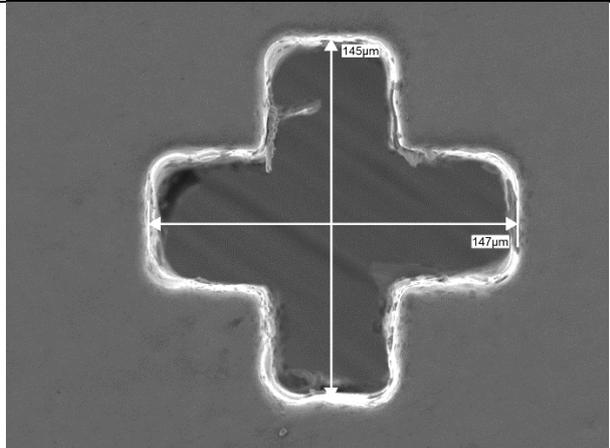
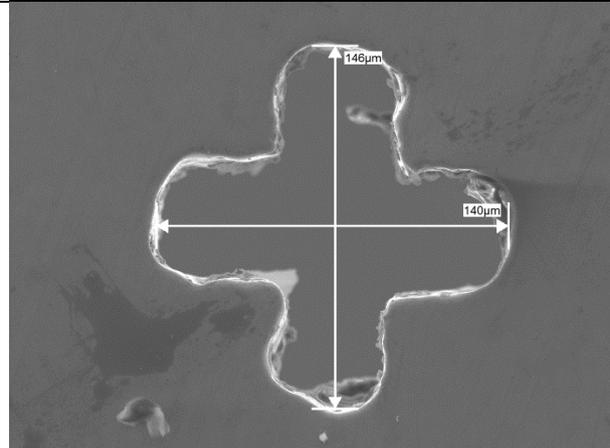
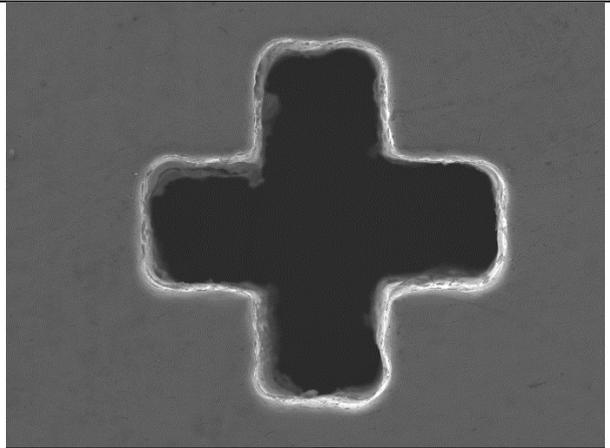
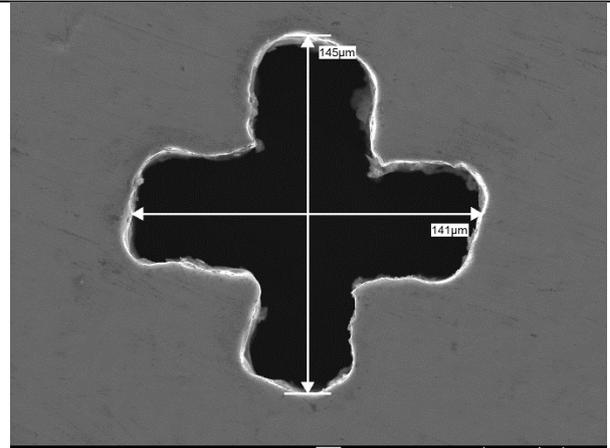
The structures have been analyzed also at higher magnification and tilted 30°, to investigate the vertical wall morphology resulting from laser cutting and to measure the actual thickness and size.



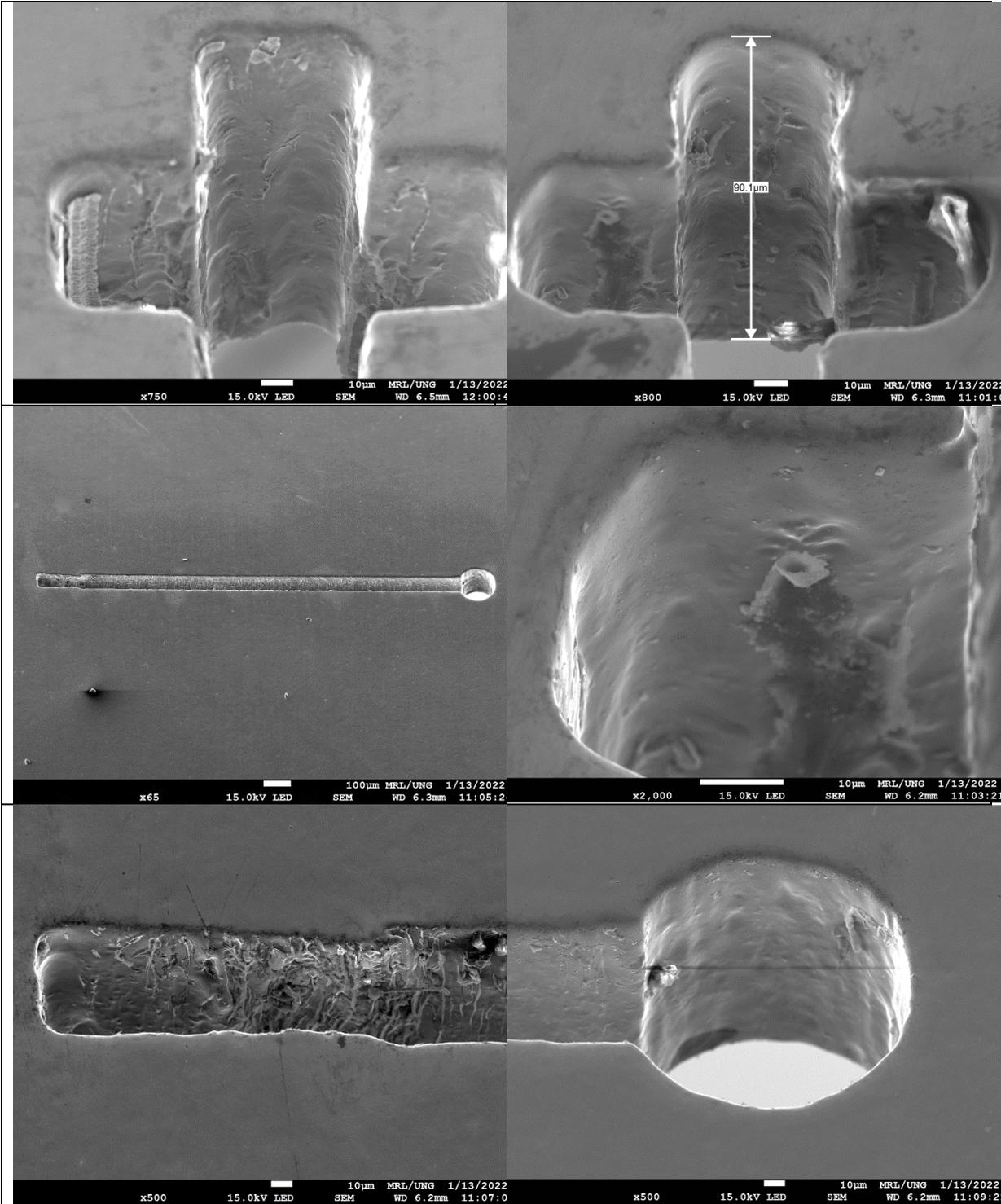


Electrochemically polished mask

Top view

	Top side	Bottom side
Point 1	 <p>146µm 144µm</p> <p>x500 15.0kV LED 10µm MRI/UNG 1/13/2022 SEM WD 5.8mm 11:55:38</p>	 <p>143µm 141µm</p> <p>x500 15.0kV LED 10µm MRI/UNG 1/13/2022 SEM WD 5.8mm 10:48:34</p>
Point 2	 <p>145µm 147µm</p> <p>x500 15.0kV LED 10µm MRI/UNG 1/13/2022 SEM WD 5.9mm 11:52:47</p>	 <p>146µm 140µm</p> <p>x500 15.0kV LED 10µm MRI/UNG 1/13/2022 SEM WD 5.7mm 10:54:37</p>
Point 3	 <p>145µm 141µm</p> <p>x500 15.0kV LED 10µm MRI/UNG 1/13/2022 SEM WD 5.8mm 11:46:53</p>	 <p>145µm 141µm</p> <p>x500 15.0kV LED 10µm MRI/UNG 1/13/2022 SEM WD 5.8mm 10:43:23</p>

High magnification, tilted 30°.



**Discussion about SEM results**

SEM allowed to investigate the stencil mask morphology with high details. The difference between the two polishing processes is evident. The mechanically polished mask displays polishing scratches. The edges of the laser cut features, for example the cross, has more irregular edges than the electrochemically polished, and debris are present beside and inside the holes.

Electrochemically polished mask has less scratched surface and more regular edges of the features. Vertical walls are more smooth, even if some debris are present also there. The high magnification images of the tilted sample allows for qualitative evaluation of the cut and of the vertical wall status.

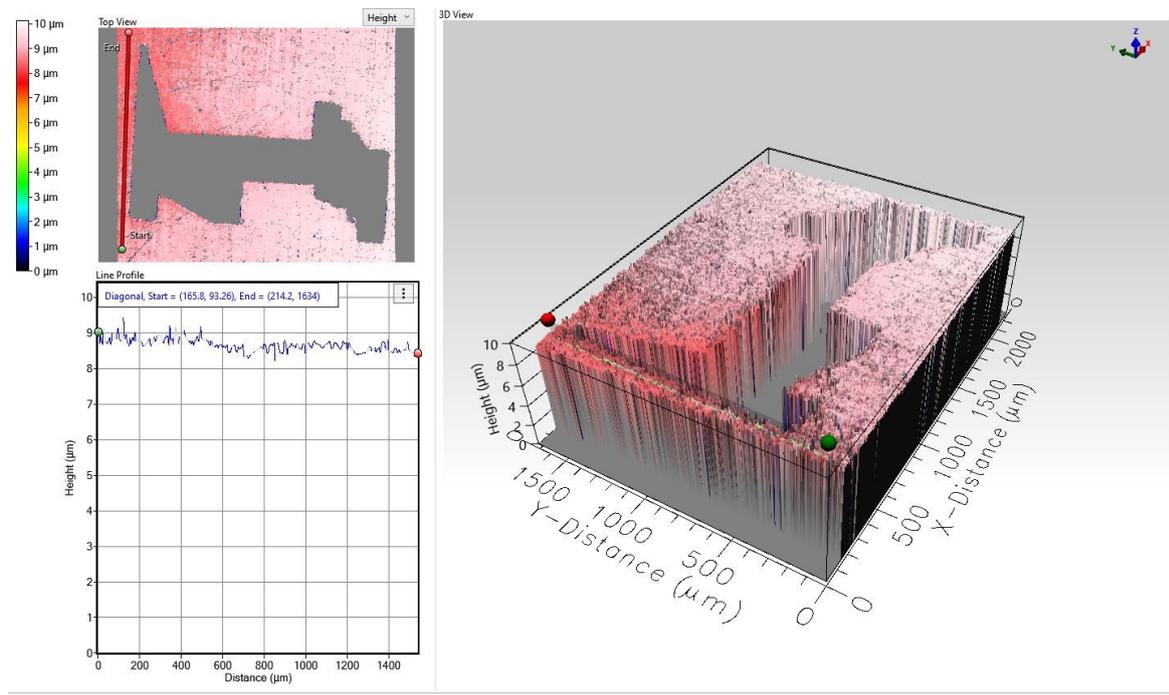
The measured thickness (180-190 mm) is consistent with the expected nominal thickness (200 mm), even if for an accurate evaluation of the thickness a cross-section preparation and analysis would be more appropriate.

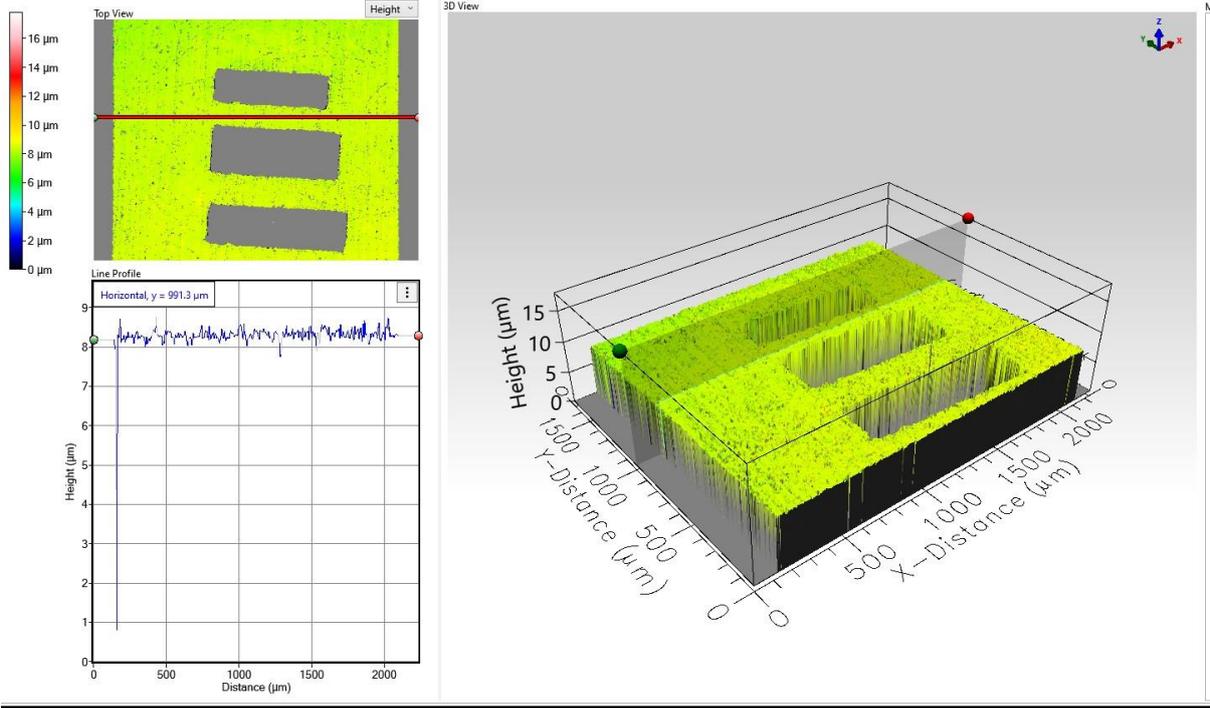
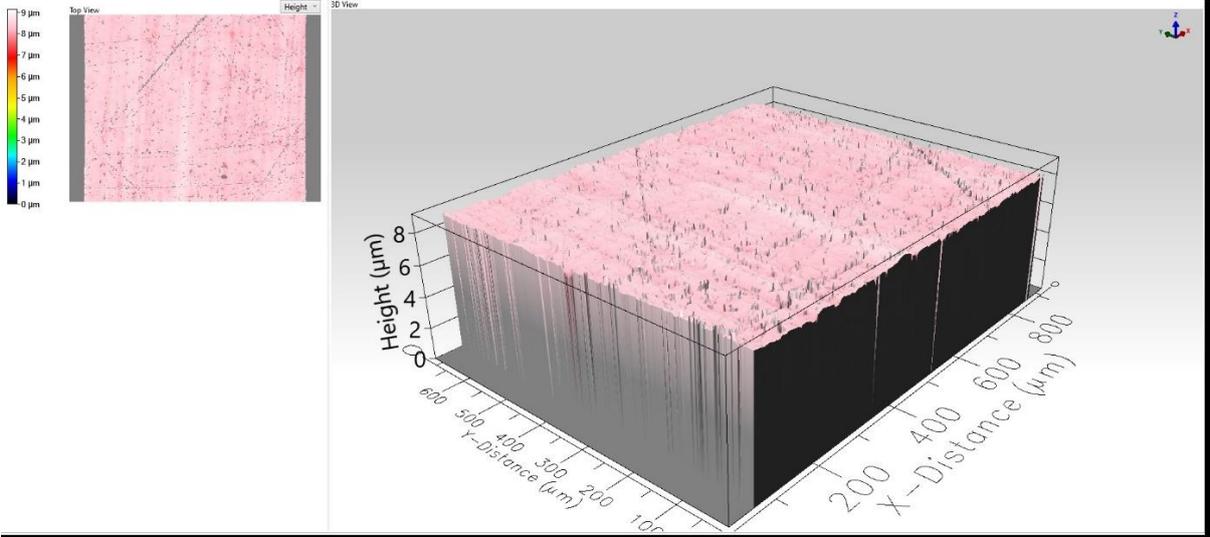
**Results – Optical profilometer**

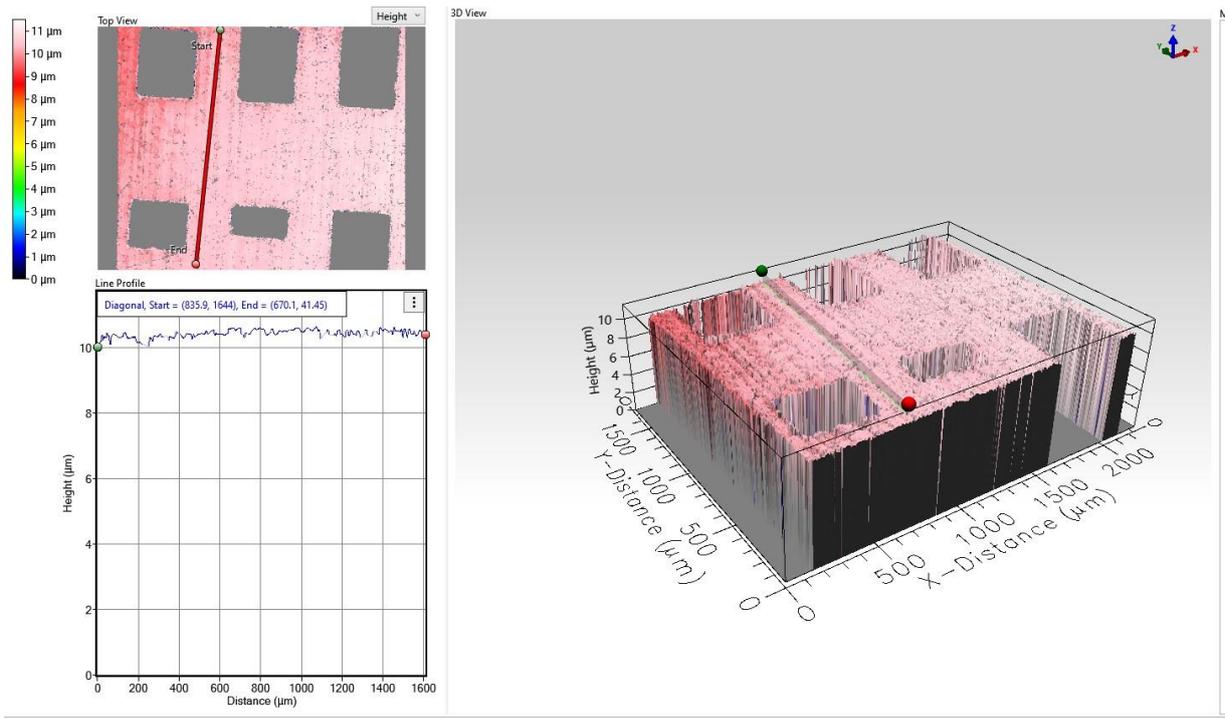
Three stencil masks have been analyzed by optical profilometer: 1 mask mechanically polished (2-inch), 1 electrochemically polished (2-inch) and 1 non-polished (3-inch).

Optical profilometry measurements have been performed to estimate the roughness of the masks after different polishing treatments, especially in proximity of the feature edges.

An example of profilometry measurements on non-polished, are shown in the following:





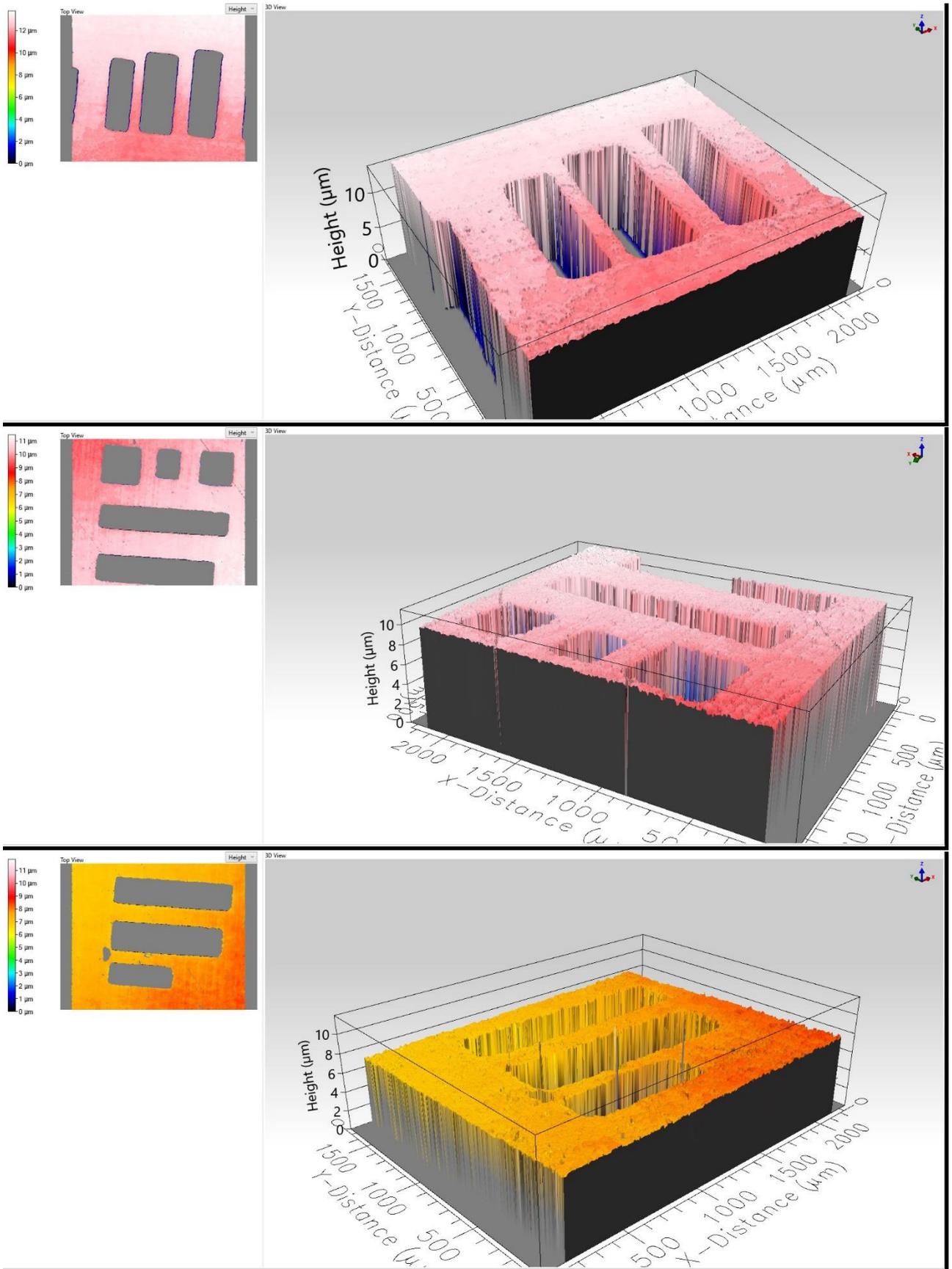


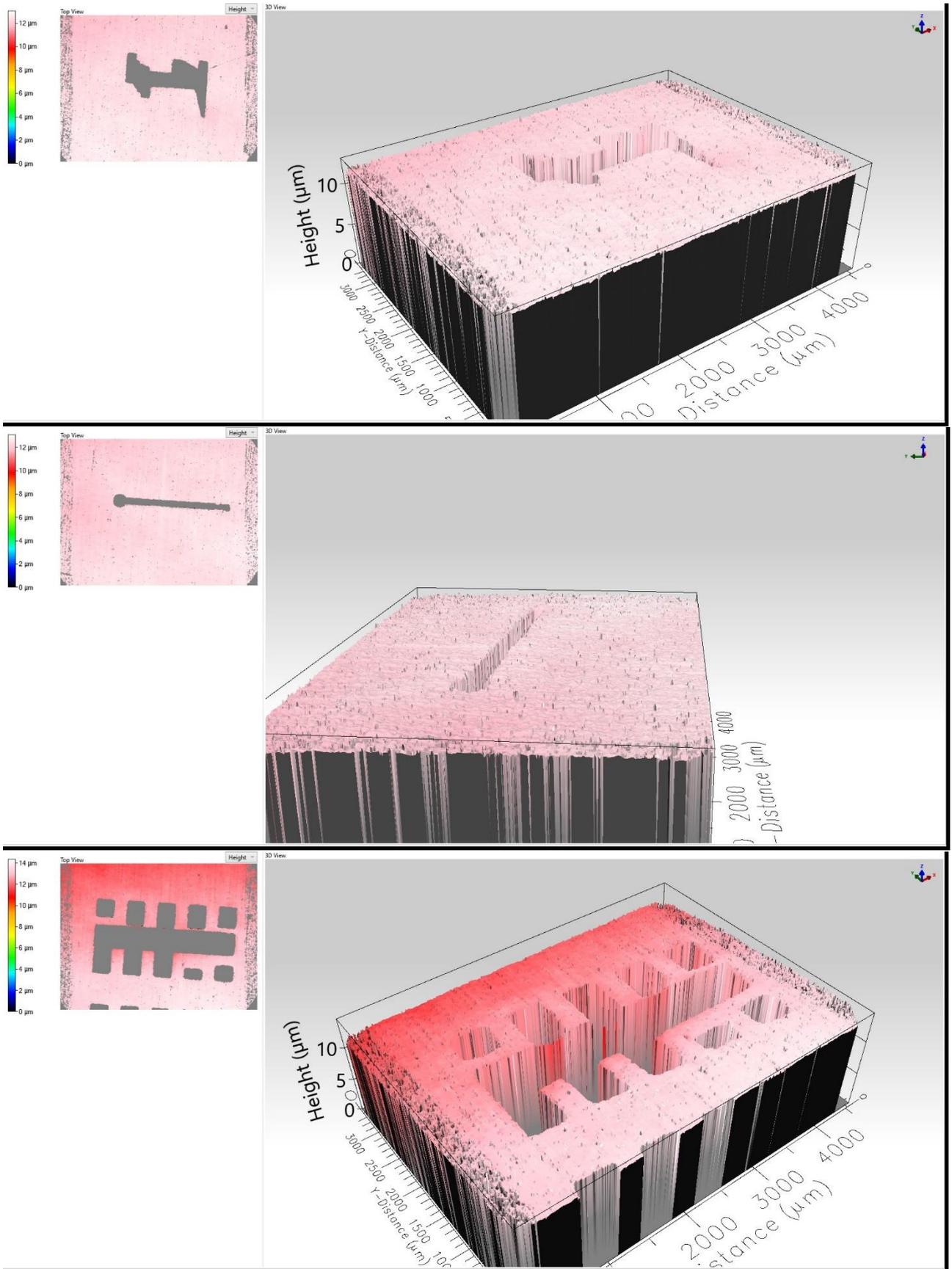
The surface roughness is quantified in an average value (Ra) of 0.066 µm. In addition, the slightly raised edges near the structures produced by the laser cutter are visible.

The average roughness is reduced for the other two samples (polished), as can be seen from the maps collected on the samples that have been treated for electrochemical or mechanical polishing.

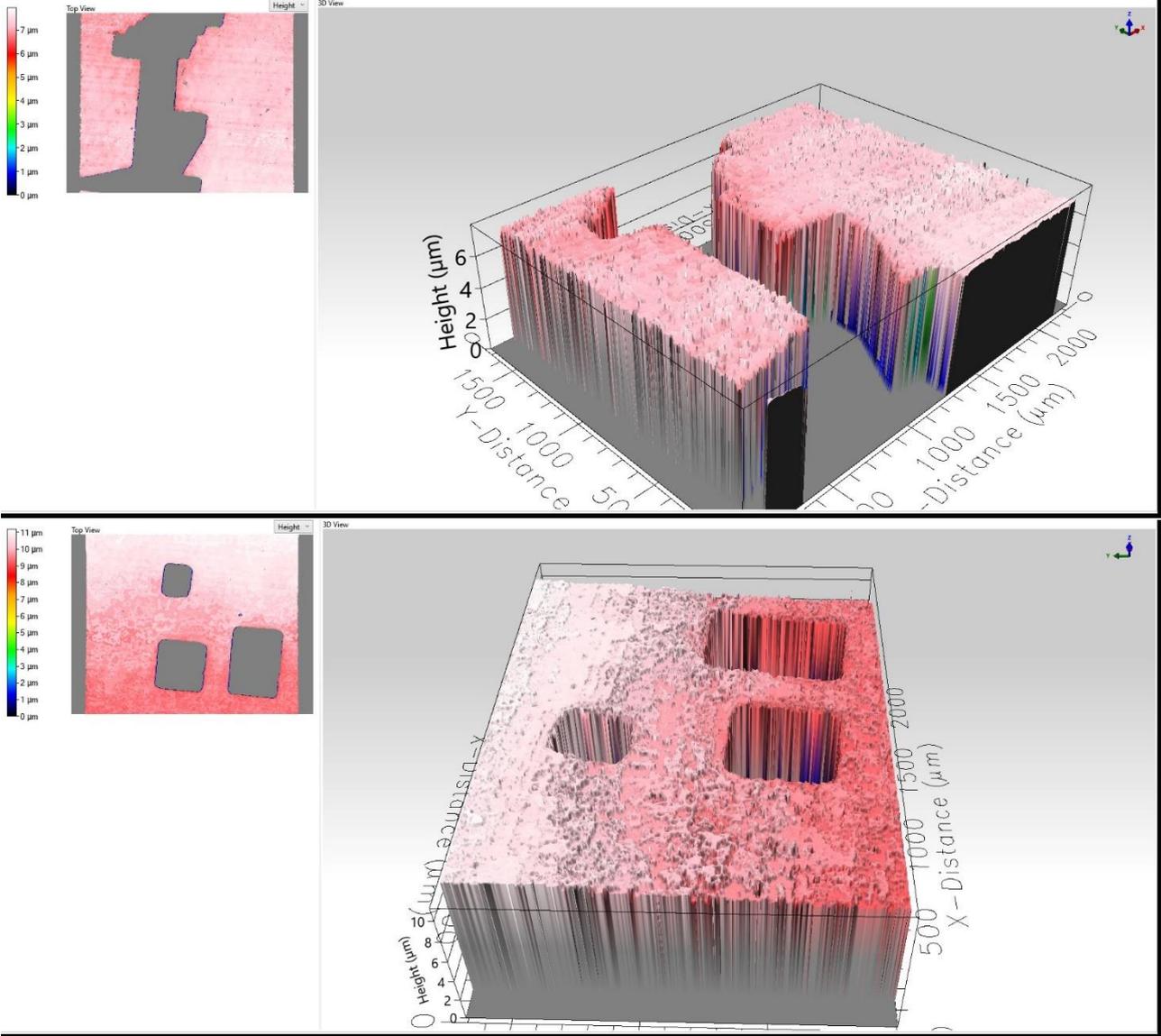
### Electrochemical polishing

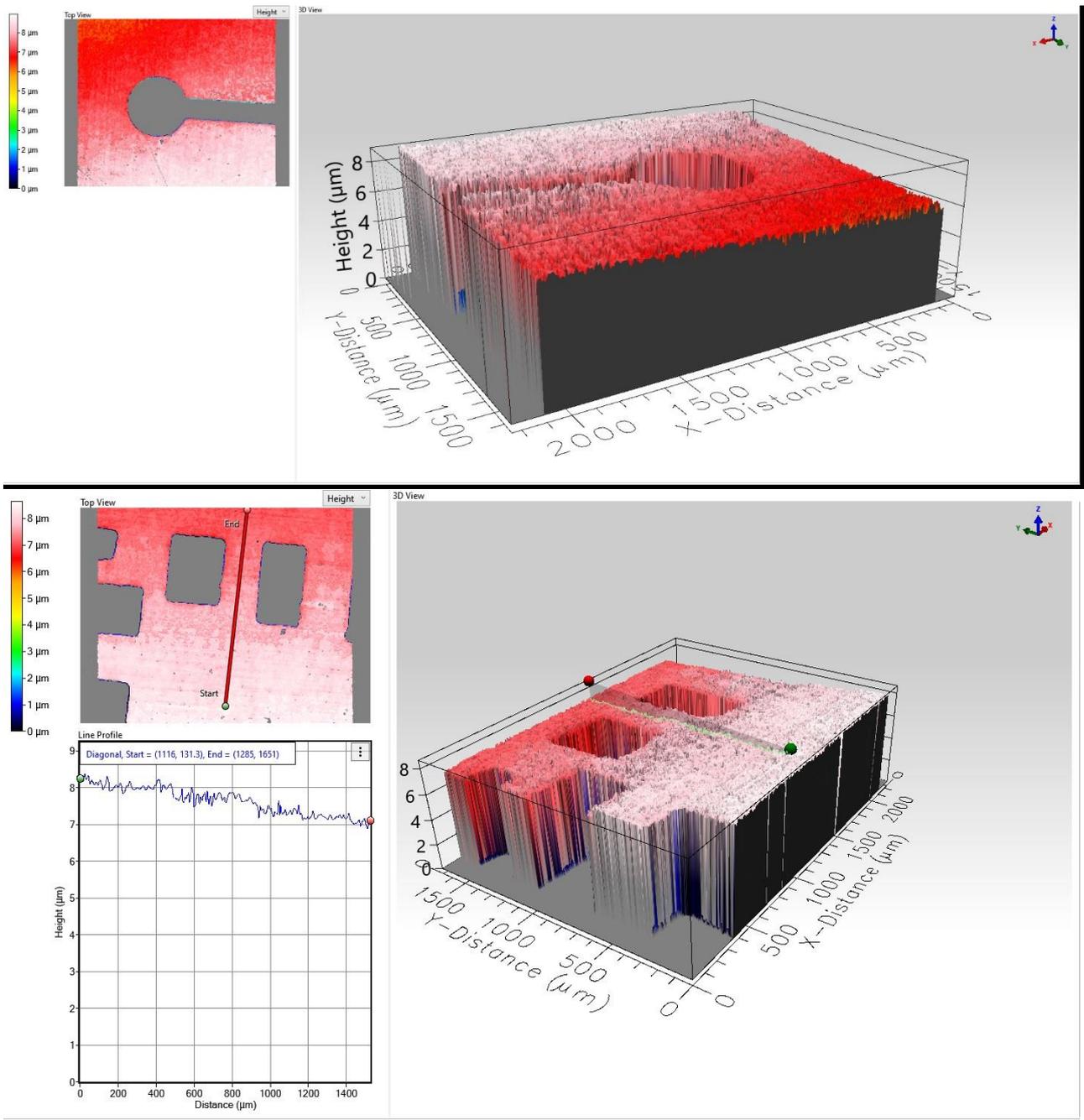
The surface roughness is reduced after the electrochemical polishing and it is quantified in an average value (Ra) of 0.037 µm. The additional effect of the polishing is that the imperfections, such as residuals, all around the milled structures, are not visible anymore.





**Mechanical polishing**





The surface roughness is quantified in an average value (Ra) of 0.049 µm. Some residuals around the milled structures are still visible.

### Discussion about optical profilometry

Optical profilometer allowed to have a good overview of the sample quality in term of uniformity and roughness. As expected, the polishing allow the reduction of the average roughness and the removal of residual of the milling process; the mechanically polished mask displays higher roughness and there are visible polishing scratches. Electrochemically polished mask looks more uniform and lower in roughness.

**Summary about the analytical capability of SEM and optical profilometry in the study of these specimens:**

- SEM is effective in the analysis of polished stencil masks (morphology, features size, ...), and allows for high-resolution investigation of the polishing effects and the morphology differences upon different polishing treatments.
- optical profilometry is effective in the quantification of the average roughness Ra and the evaluation of general uniformity of the sample.

This report has been written by Mattia Fanetti and Simone Dal Zilio (10 May 2022)