SURFACE ANALYSIS STUDY OF LASER MARKING OF ALUMINUM

Julie Maltais[1], Vincent Brochu[1], Clément Frayssinous[2], Réal Vallée[2], Xavier Godmaire[1] and Alex Fraser[1]

1.Laserax Inc., Québec, QC, Canada, G1X 4S8

2.Laval University, Québec, QC G1V 0A6

Presented by: Julie Maltais

ICSOBA

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- **Name: Julie Maltais**
- **Degrees and date earned: College diploma (2012)**
- **Affiliation: Laserax/Laval University**
- **Present position: Laser process researcher**
- **Work experience: Summer internship at Laserax**

Plan

- Introduction
- Experimental setup
- Results
- Discussion
  - Whitening
  - Blackening
  - Influence of laser parameters
- Conclusion

Introduction

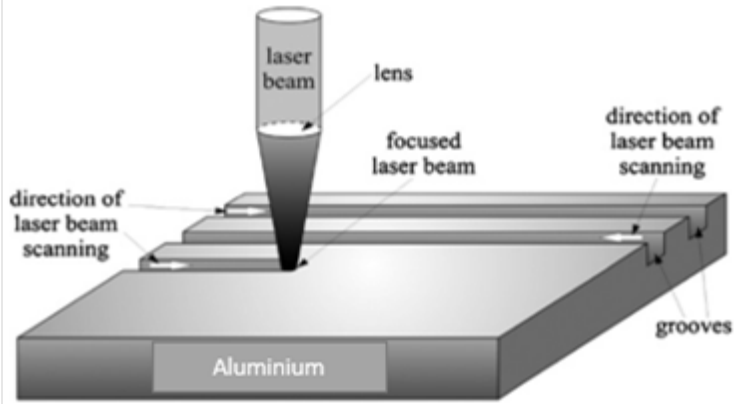
- **Part traceability is a crucial process in many industries:**
  - **Automotive**
  - **Aeronautics**
  - **Medical**
  - **Electronics**
  - **Metal working**

Introduction

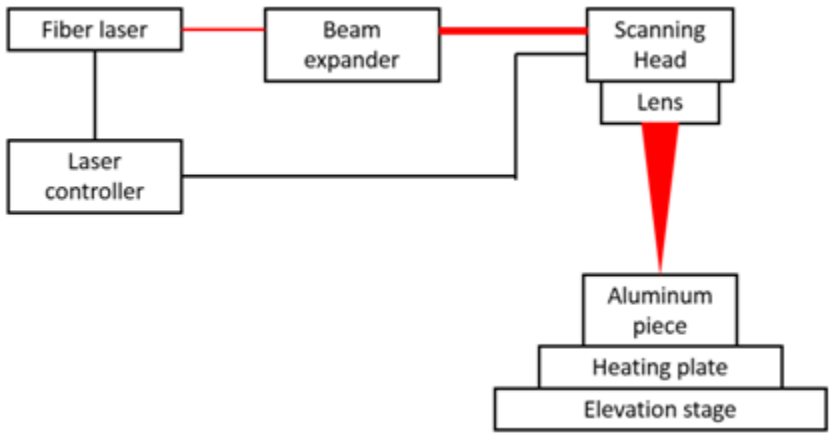
- **Laser marking:**
  - **High speed**
  - **Permanent mark**
  - **Non-contact technique**
  - **Consumable free**
  - **Easy maintenance system**

Introduction

- **Principle of laser marking**
  - **Texturing of the surface with a laser beam**
- **Important parameters**
  - **Marking speed**
  - **Line spacing**
  - **Spot size**
  - **Temperature**



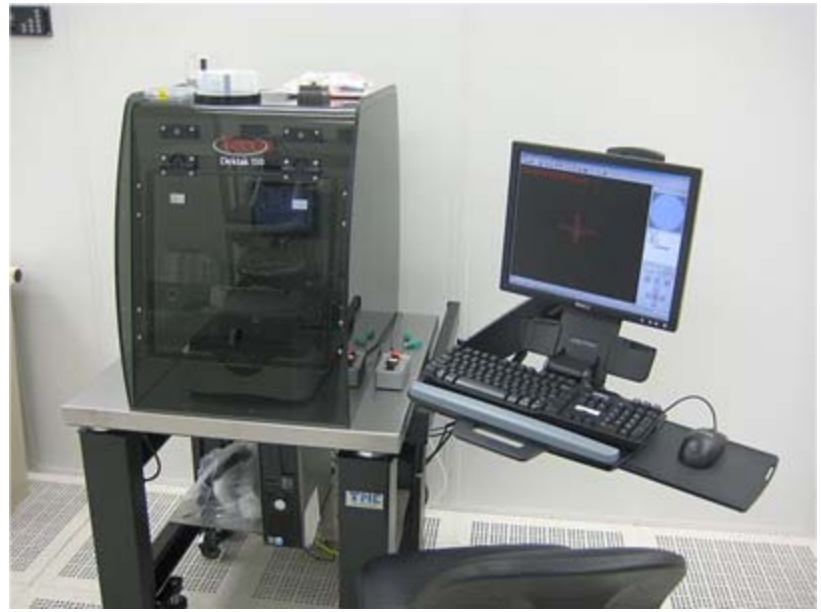
Experimental setup



Laser source type	Q-switched
Manufacturer	IPG Photonics
Model	YLP series
Max average power	100 W
Wavelength	1.06 μm
Cooling	Air
Pulse duration	100 ns
Pulse repetition rate	100 kHz
Pulse energy	1 mJ
M²	1.6

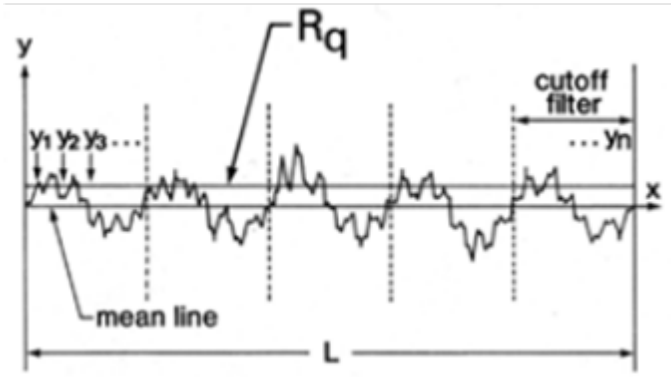
Experimental setup

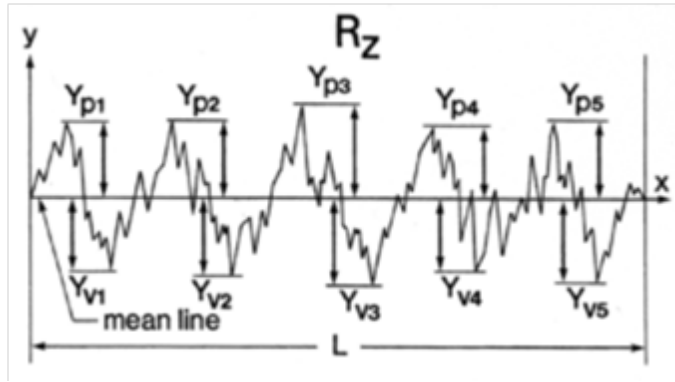
- **Scanning electron microscope (SEM)**



- **Surface profiler (DEKTAK 150)**

Experimental setup

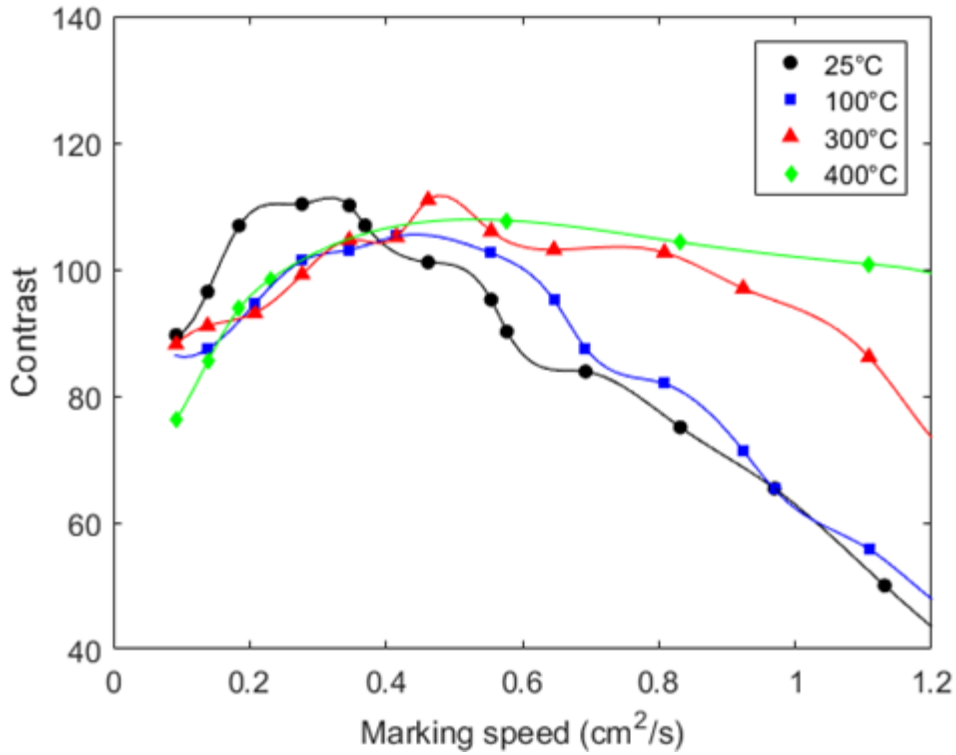




- **Root-mean-square value of roughness**
- **Average height difference between the five highest peaks and the five lowest valleys**

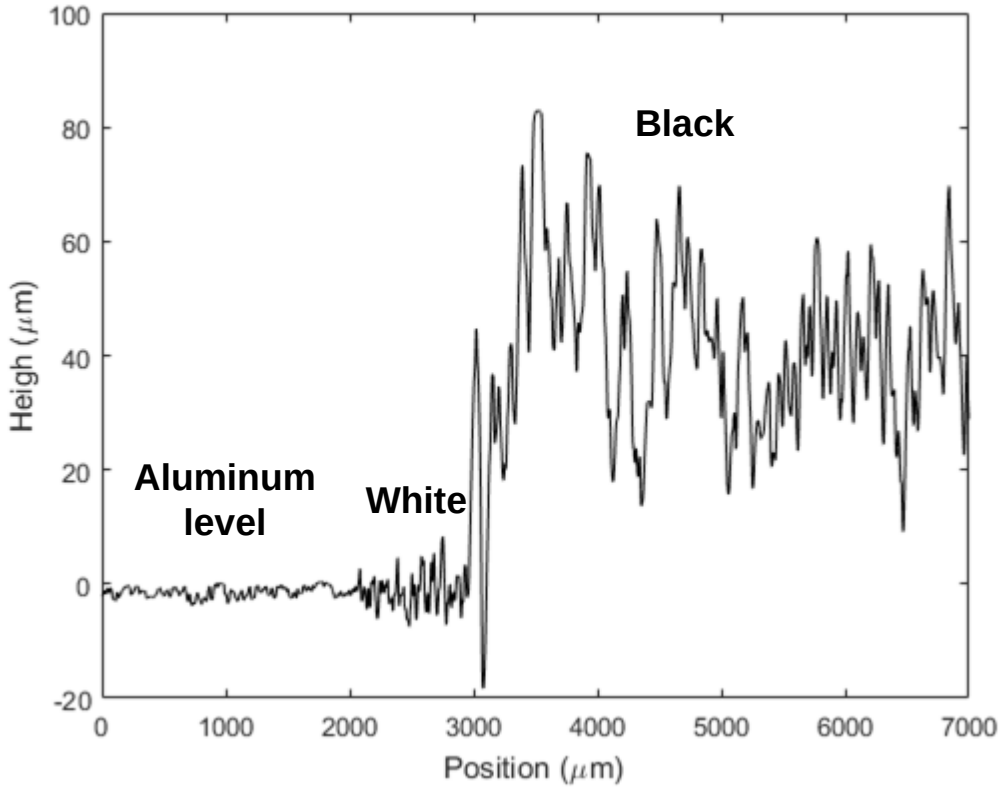
Results

- **Contrast vs marking speed in cm²/s**



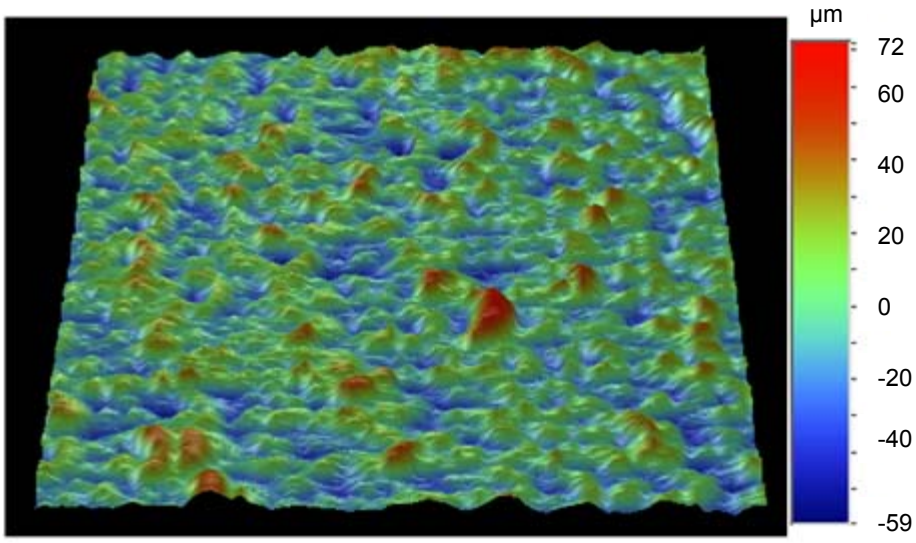
Results

- **Typical surface profile**

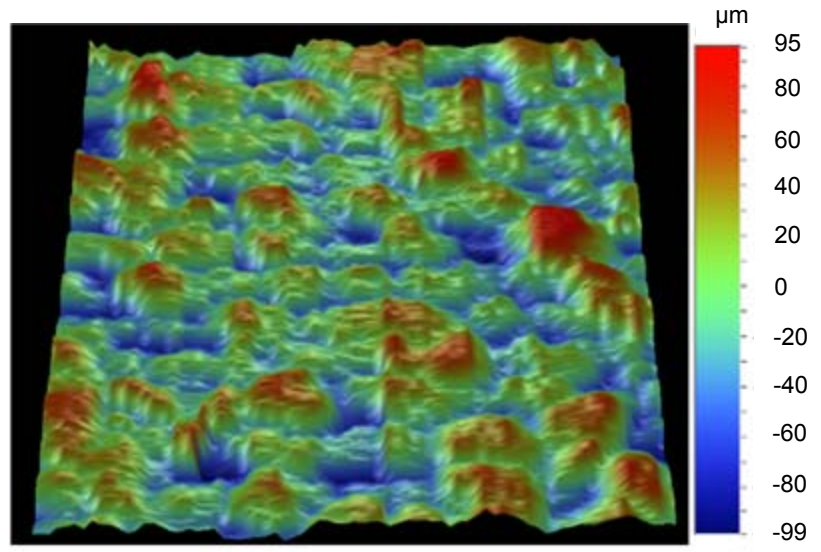


Results

- **High resolution 3D obtained with Dektak 150**



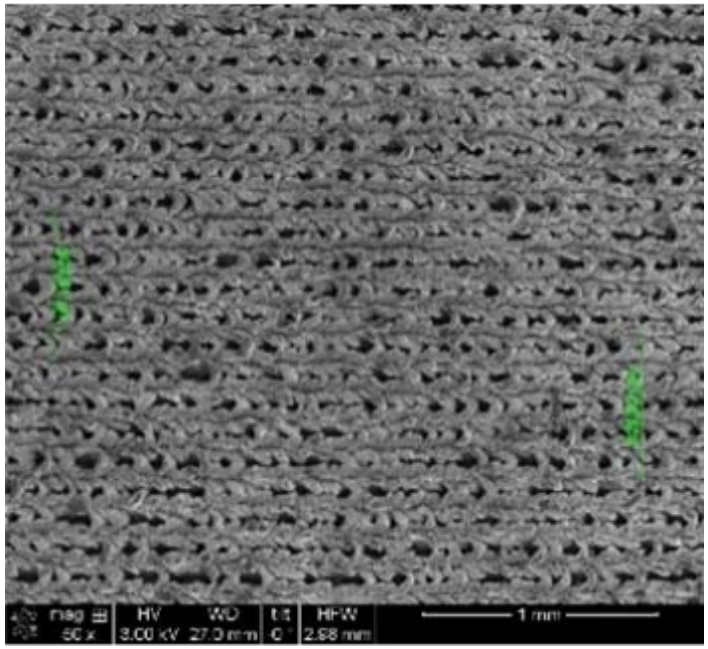
- **T = 25 °C**



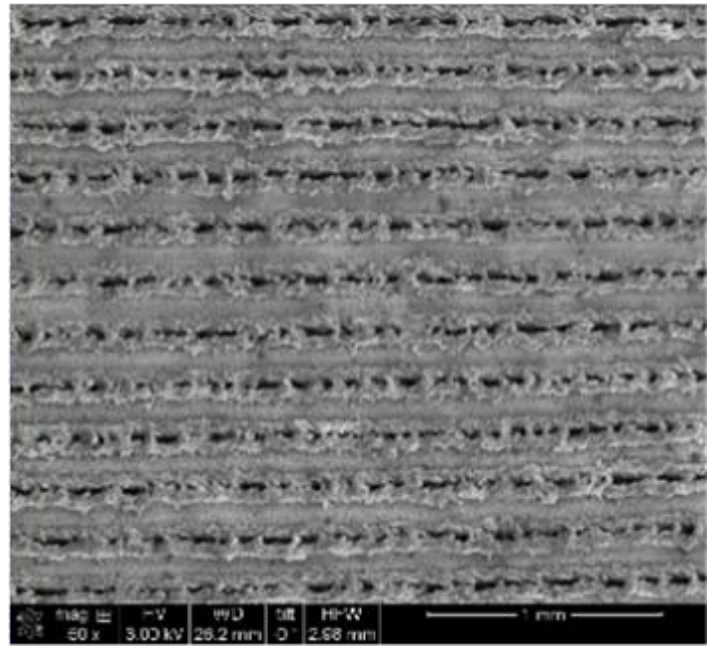
- **T = 400 °C**

Results

- **Scanning electron microscope (SEM) images of blackened samples at 25°C**



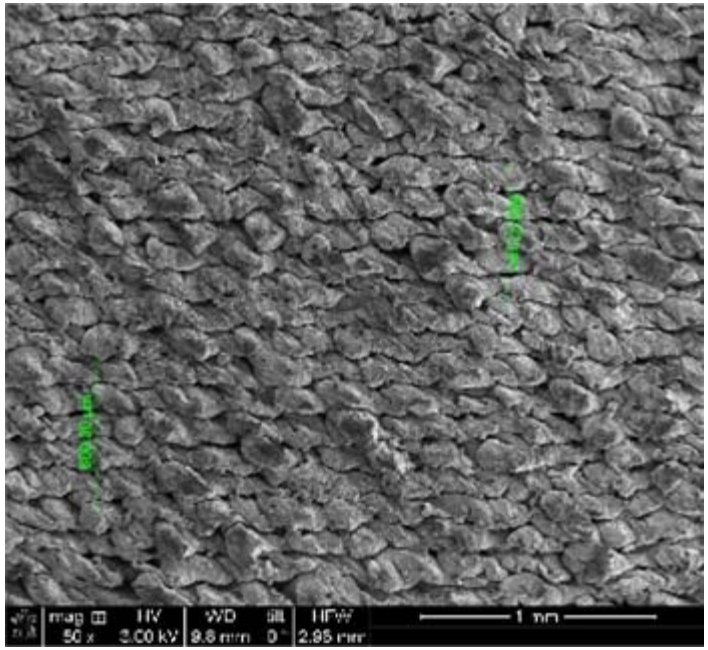
- **Line spacing = 0.125 mm**
- **Marking speed = 300 mm/s**
- **Contrast = 110.1**



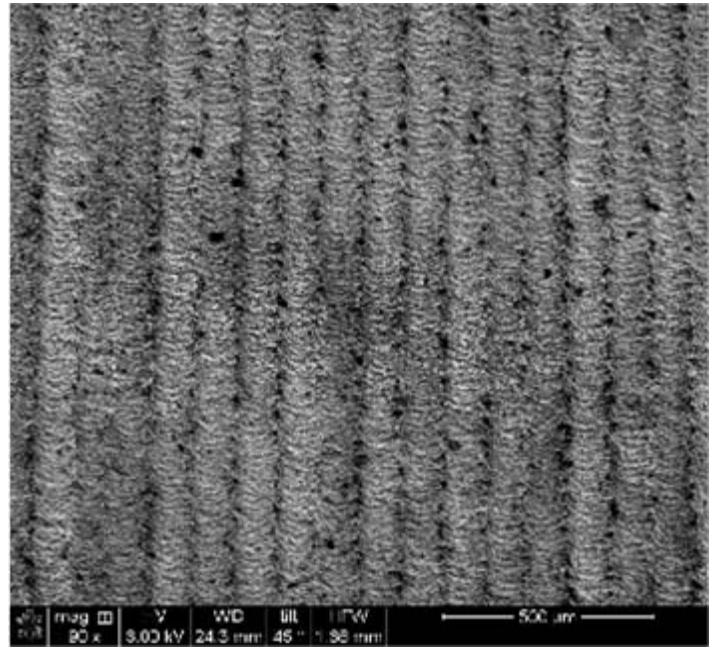
- **Line spacing = 0.225 mm**
- **Marking speed = 300 mm/s**
- **Contrast = 21.8**

Results

- **Scanning electron microscope images**



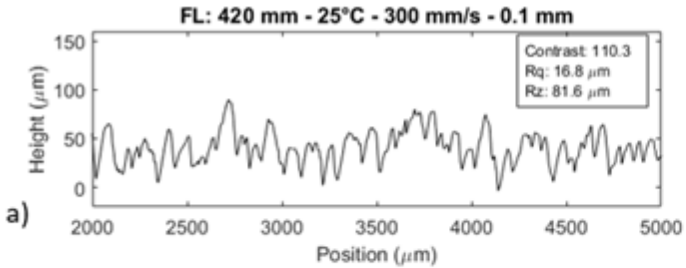
- **T=400°C**
- **Line spacing = 0.125 mm**
- **Marking speed = 500 mm/s**
- **Contrast = 107.5**

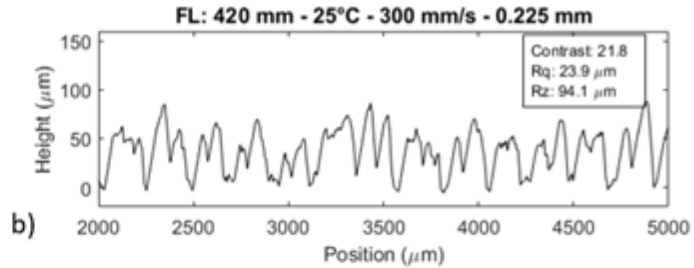


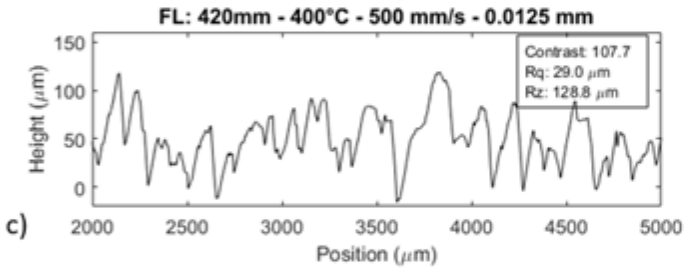
- **White**
- **Line spacing = 0.225 mm**
- **Marking speed = 2 500 mm/s**

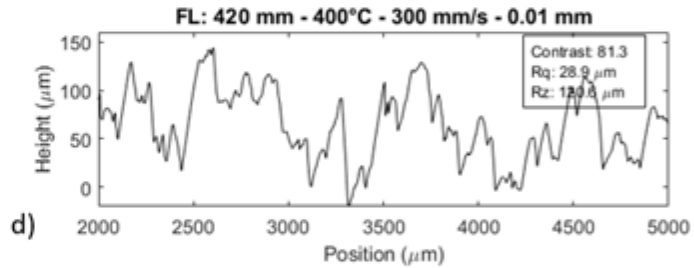
Results

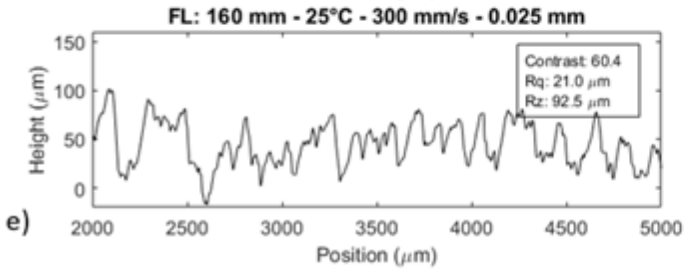
- **Surface profile**

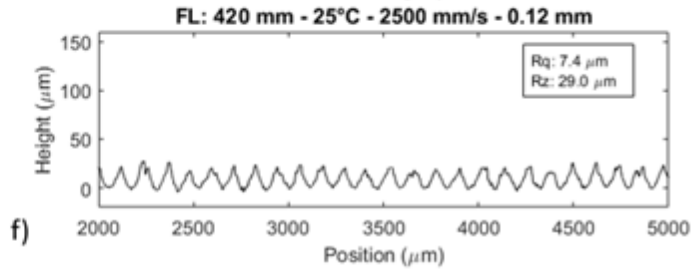








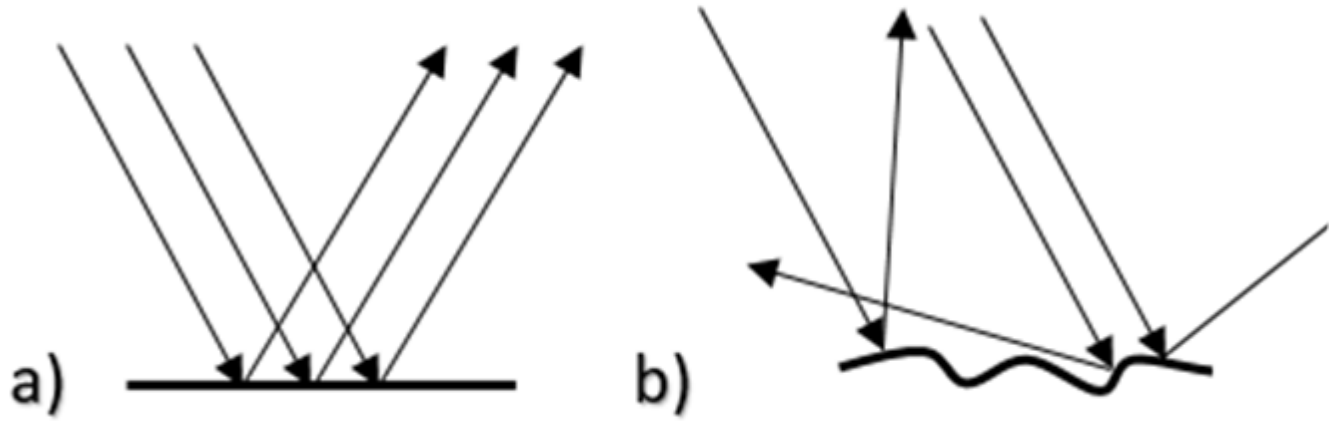




Focal length – Temperature – Marking speed- Line spacing

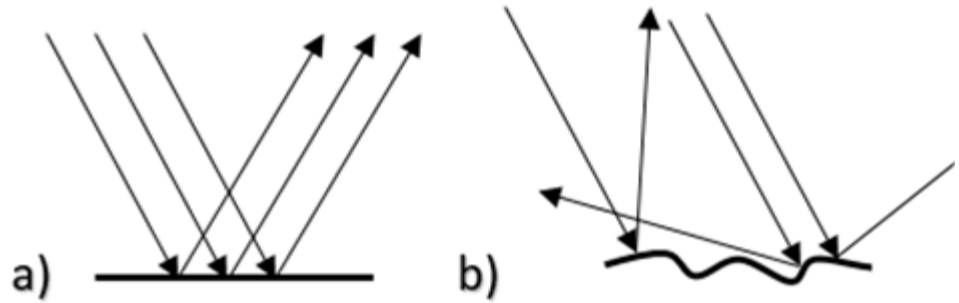
Discussion

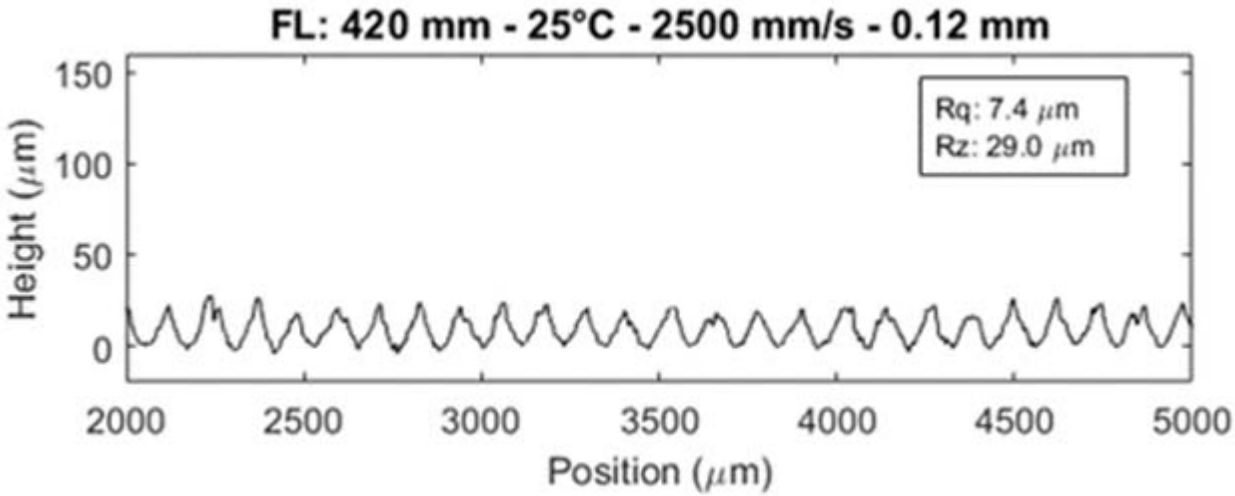
- **Whitening**
  - **Diffuse reflection of all the wavelength of the visible spectrum**

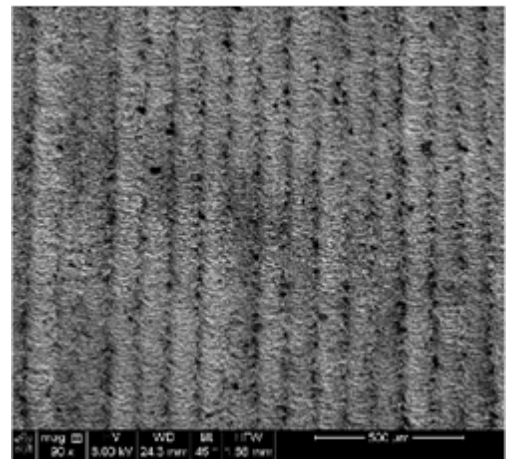


Discussion

- **Whitening**





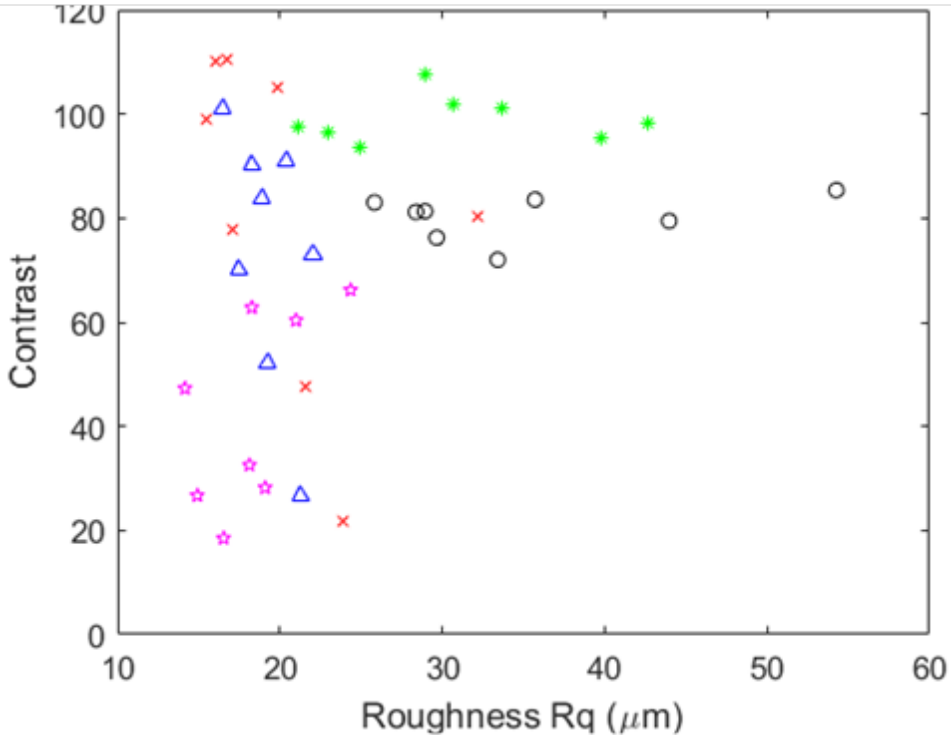


Discussion

- **Blackening**
  - **Distance peak to valley much larger**
    - About 5 times greater than the white surface.
  - **Light trapping inside the material**
    - If only 5 % of the light is absorbed at each reflection, 36 % of the light will get out for 20 reflections and 13 % for 40 reflections.

Discussion

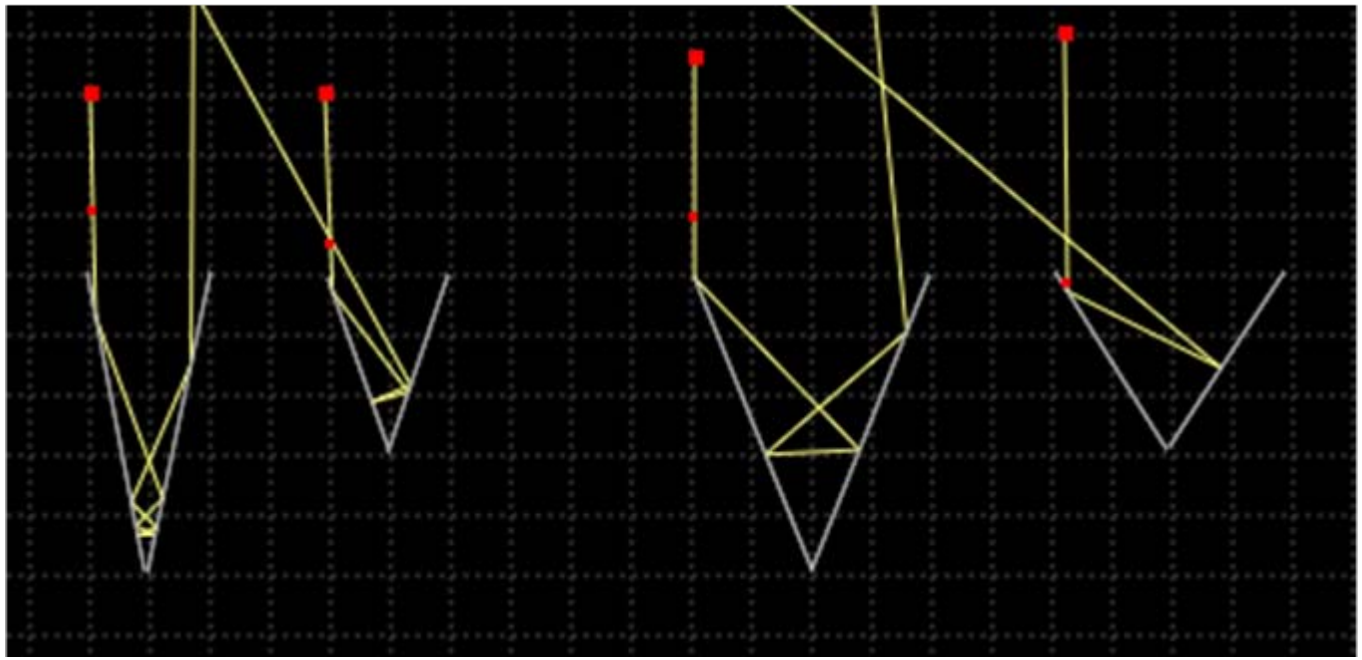
- **Influence of laser parameters**
  - **Roughness vs Contrast**



Symbole	Temperature (°C)	Marking speed (mm/s)	FL (mm)
×	25	300	420
△	25	500	420
○	400	300	420
✳	400	500	420
☆	25	300	160

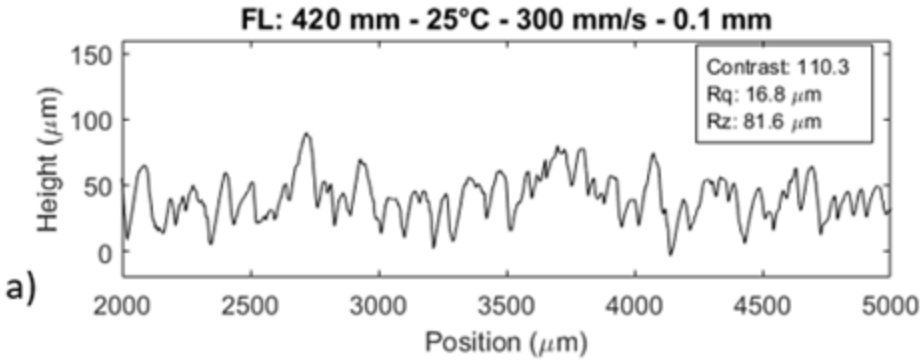
Discussion

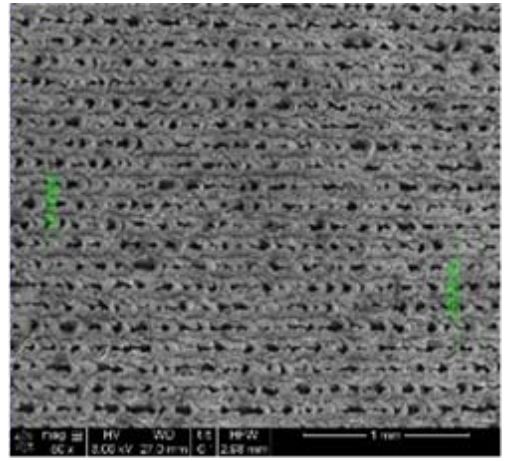
- **Influence of laser parameters**
  - **Number of reflections depends on the ratio of the depth and the width.**

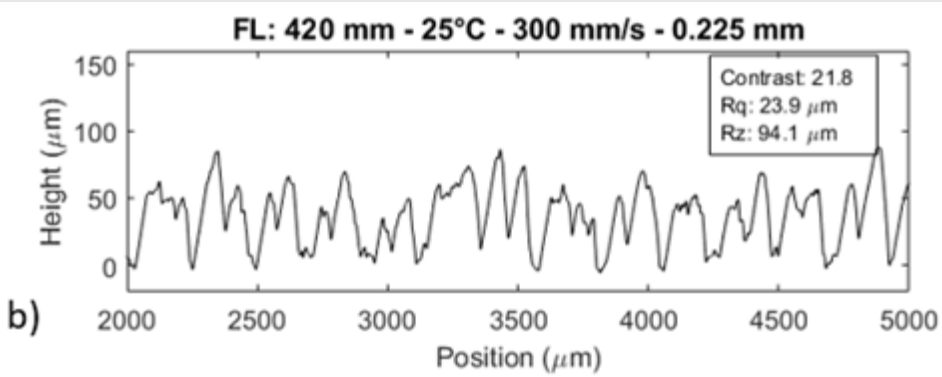


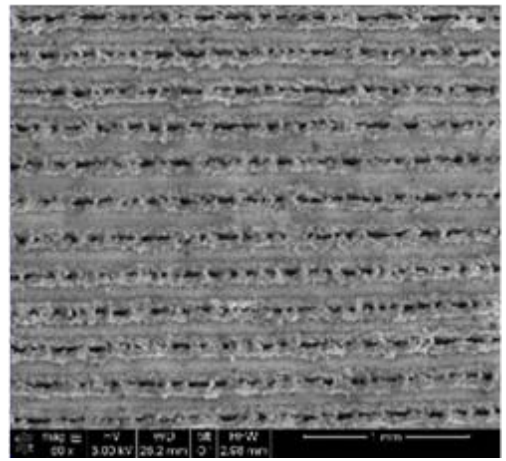
Discussion

- **Influence of laser parameters**
  - **Line spacing**



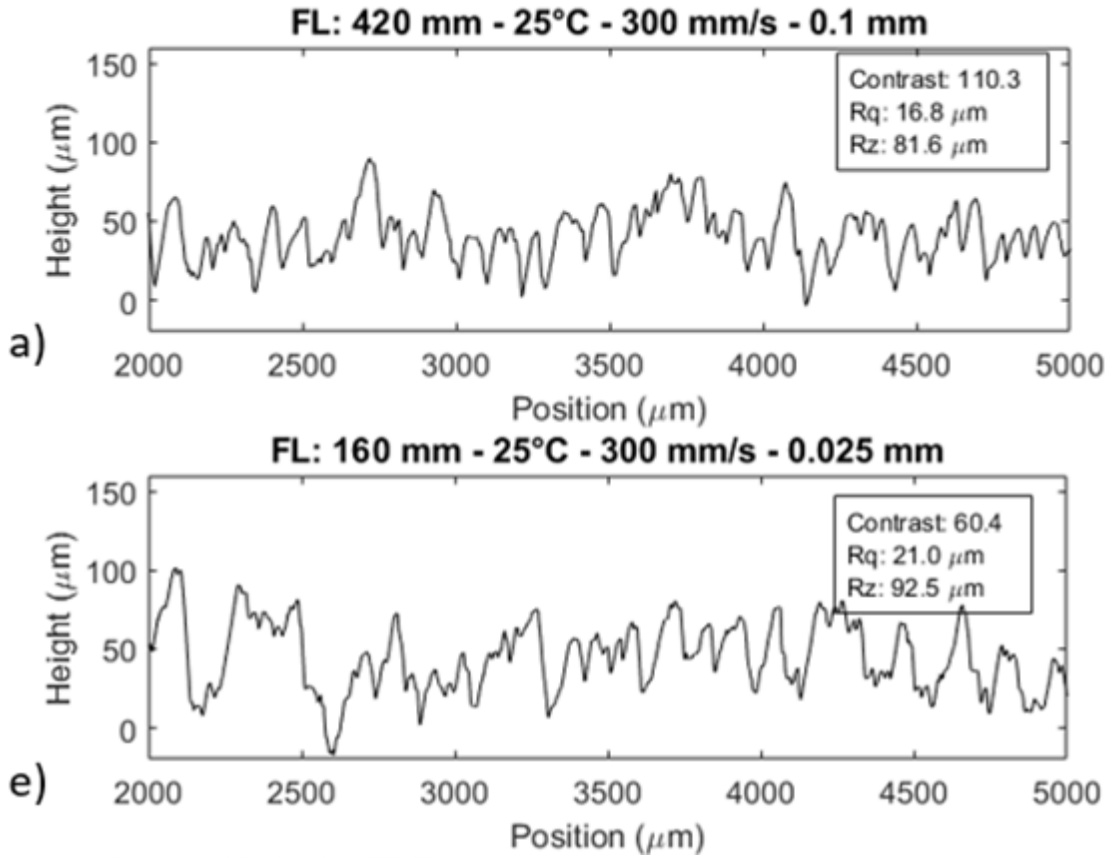






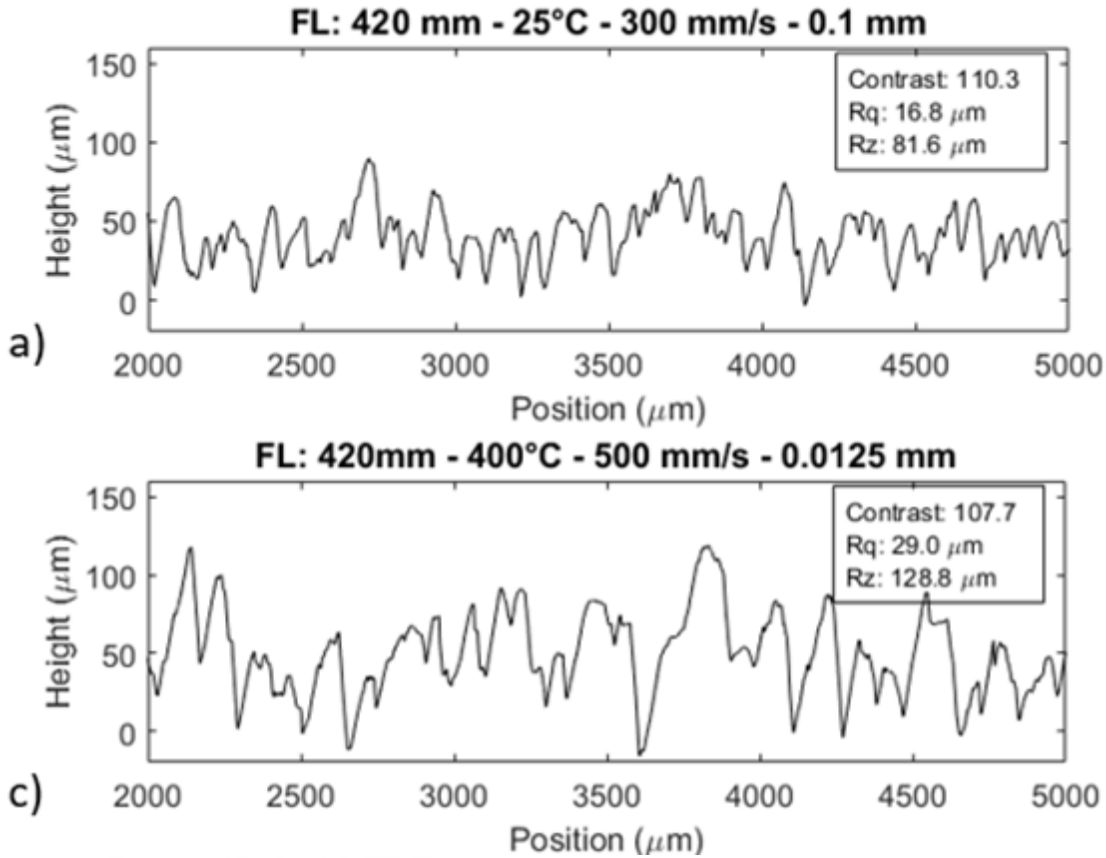
Discussion

- **Influence of laser parameters**
  - **Focal length**



Discussion

- **Influence of laser parameters**
  - **Temperature**



Conclusion

- **Whitening:**
  - **Diffuse reflection created by small alteration of the surface.**
- **Blackening:**
  - **Coupling of the light within the material.**
- **Effect of the sample temperature:**
  - **Optimal speed marking increases with temperature.**
- **Effect of the line spacing:**
  - **Too large line spacing leads to a decrease of the contrast.**