Microlavolazioni con burst di impulsi laser ultrabrevi

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Bari, 6 Novembre 2017

OUTLINE

- Overwiew: LIPSS and their origin
- Goals
- Experimental setup
- Results
- Future goals

LIPSS

Laser-Induced Periodic Surface Structures

Characterization:

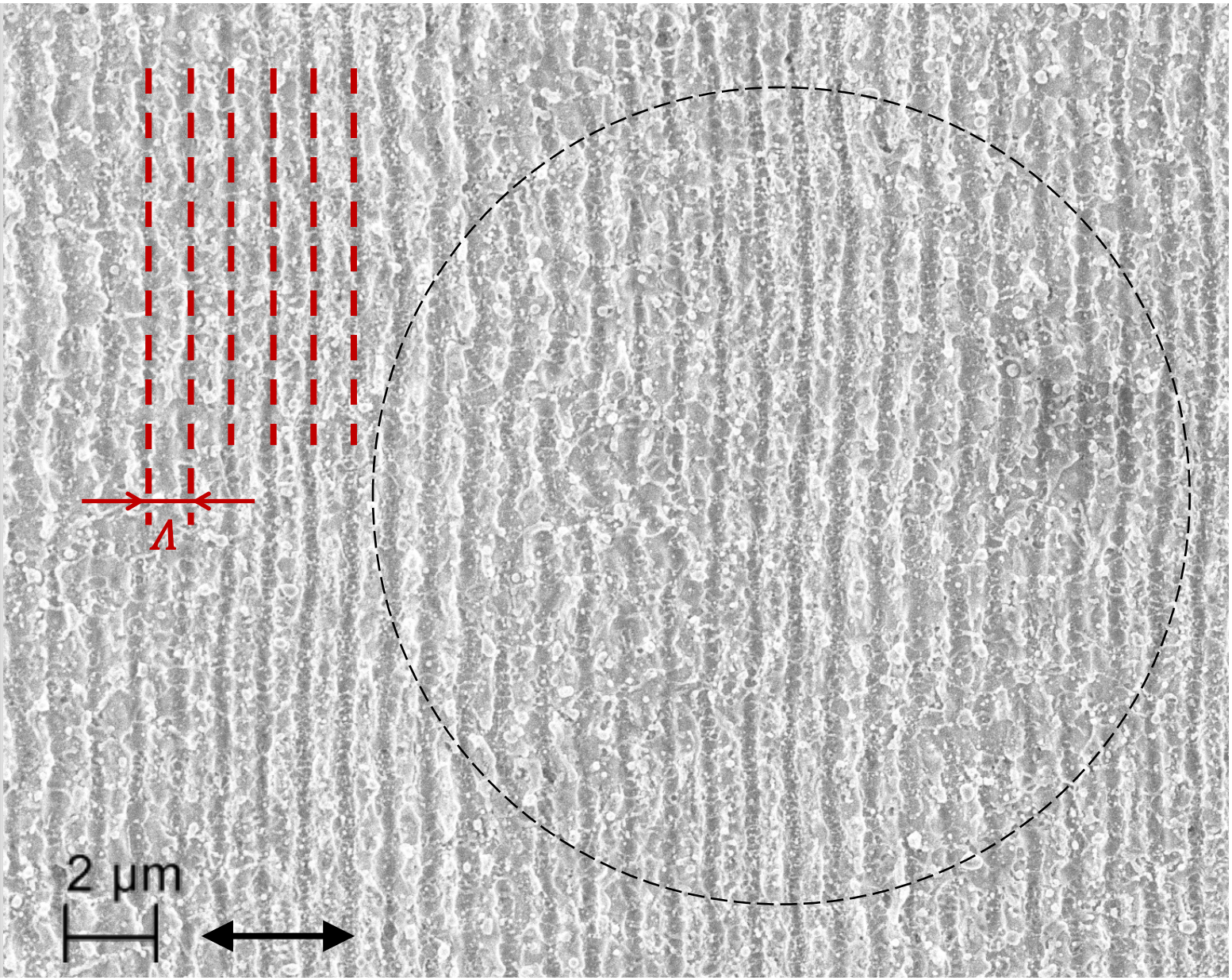
LIPSS spacing (Λ)

LIPSS depth (Δz)

Orientation

Regularity DLOA

Dispersion of the LIPSS Orientation Angle



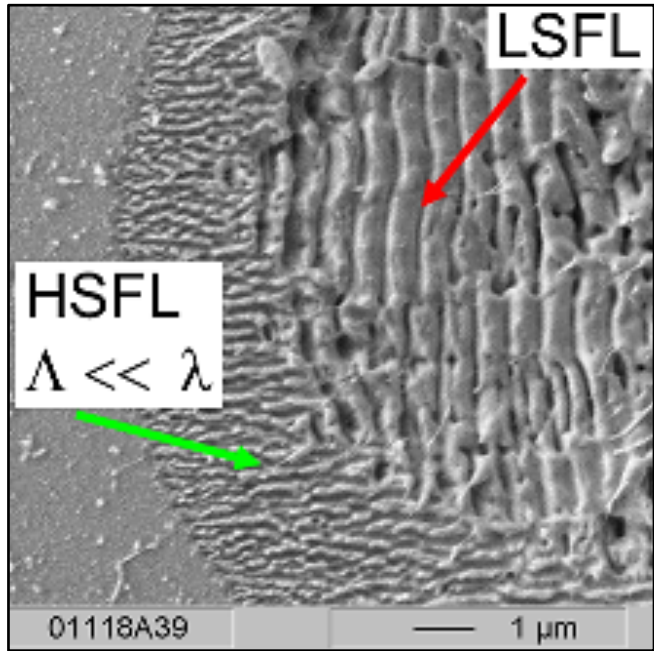
LIPSS
Laser-Induced Periodic Surface Structures

LSFL
Low Spatial Frequency LIPSS

- Spatial period Λ close to laser wavelength λ $(\lambda/2 \leq \Lambda_{LSFL} \leq \lambda)$
- Orietation perpendicular to the laser light polarization for metal and semiconductor
- Origin investigated

HSFL
High Spatial Frequency LIPSS

- Spatial period $\Lambda_{HSFL} < \lambda/2$
- Orietation parallel to the polarization direction (in general)
- Origin is still controversial



C. K. Schmising, "Material modification with femtosecond laser pulses"

LIPSS

Laser-Induced Periodic Surface Structures

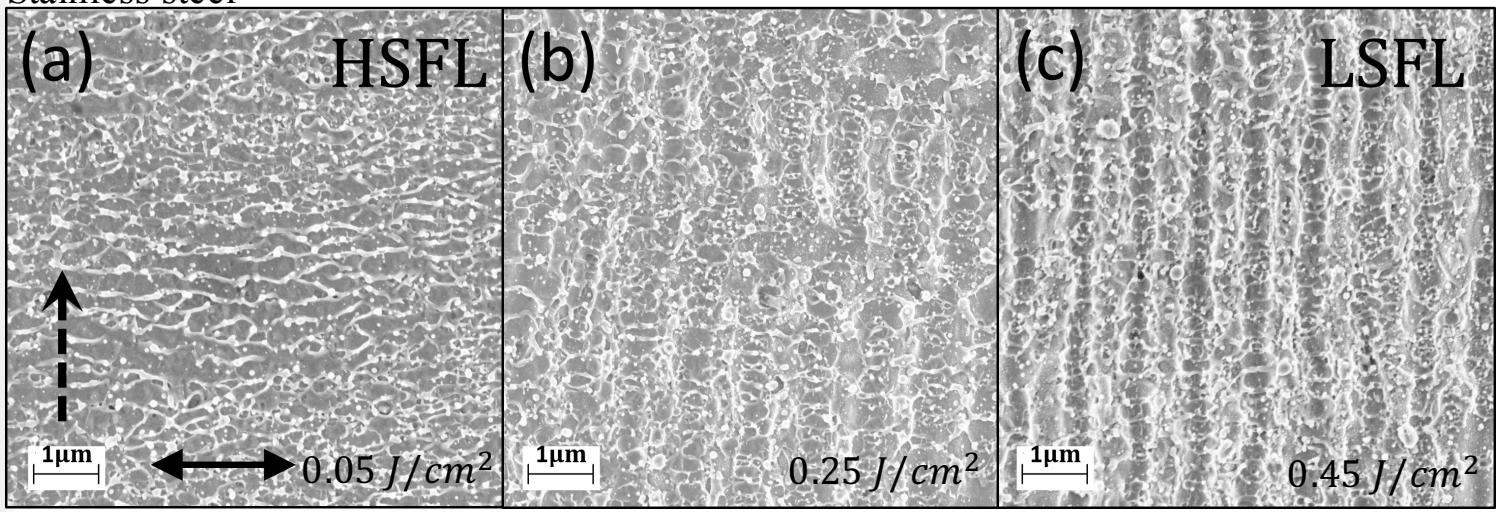
LSFL

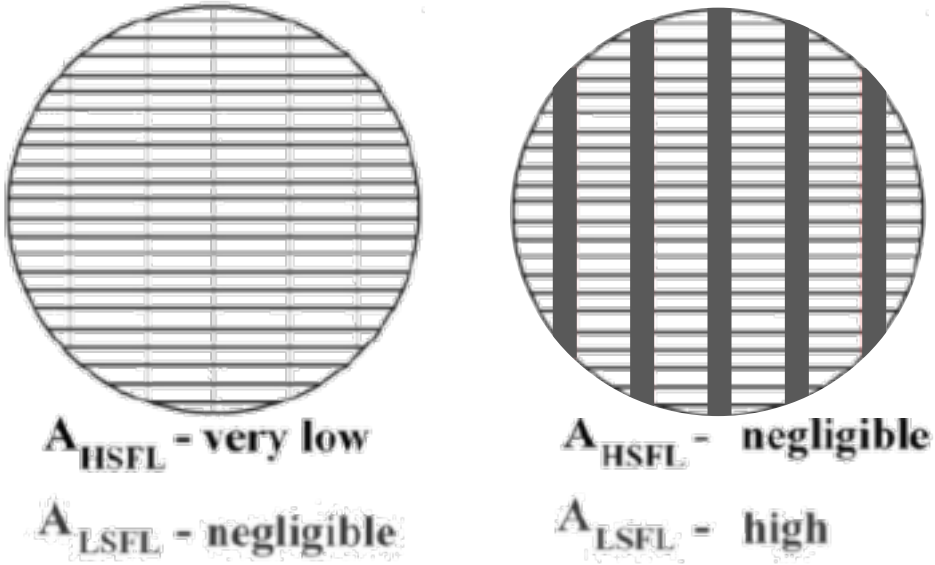
Low Spatial Frequency LIPSS

HSFL

High Spatial Frequency LIPSS

Stainless steel





J. V. Obona, Appl. Surf. Sci. **258**, 5420 (2011)

LIPSS

Laser-Induced Periodic Surface Structures

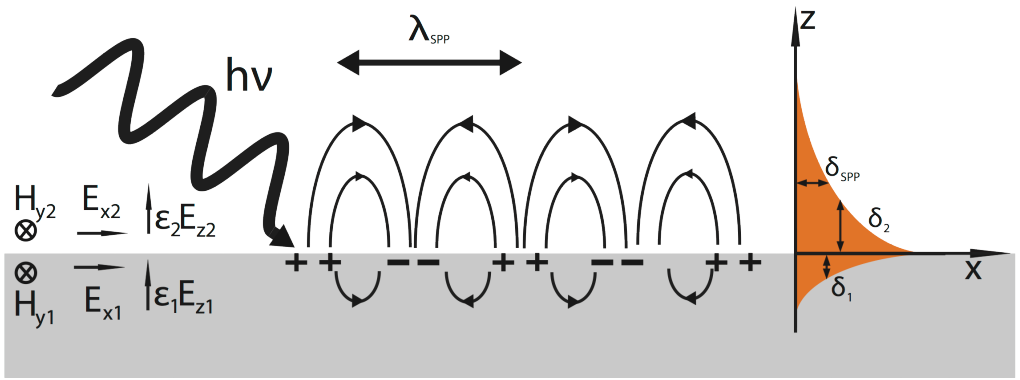
LSFL

Low Spatial Frequency LIPSS

Origin: Interference of the incident light with Surface Electromagnetic Wave (SEW) excited by irradiation: periodic pattern of laser energy absorption on the irradiated surface

The spatial period of the modulated electromagnetic field of the Surface Plasmon Polariton (SPP) can be estimated

$$\lambda_{SPP} = \lambda \left(\frac{\varepsilon' + \varepsilon_d}{\varepsilon' \varepsilon_d} \right)^{1/2}$$



M. Huang, ACS Nano **3**, 4062 (2009) J. Zhang, J. Phys. D: Appl. Phys. **45**, 113001 (2012)

LIPSS
Laser-Induced
Periodic Surface Structures

LSFL
Low Spatial Frequency LIPSS

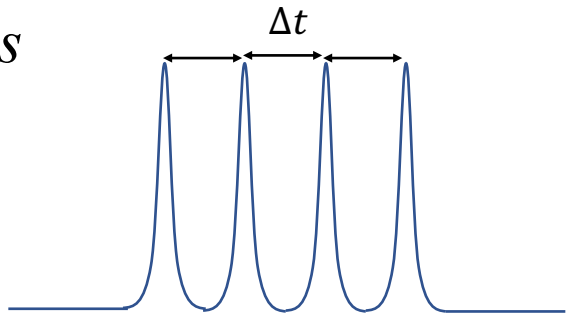
LSFL topography/morphology depends on:

- Substrate material
- Laser wavelength λ
- Pulse duration
- Dielectric-sample interface
- Incident angle
- Number of pulses

LIPSS
Laser-Induced
Periodic Surface Structures

LSFL
Low Spatial Frequency LIPSS

Use of Bursts



How the LIPSS morphology changes with:

- number of sub-pulses in the burst, n
- time separation between sub-pulses, Δt
- sub-pulses polarization

Could the textured surface with burst be beneficial in tribological/wettability application?

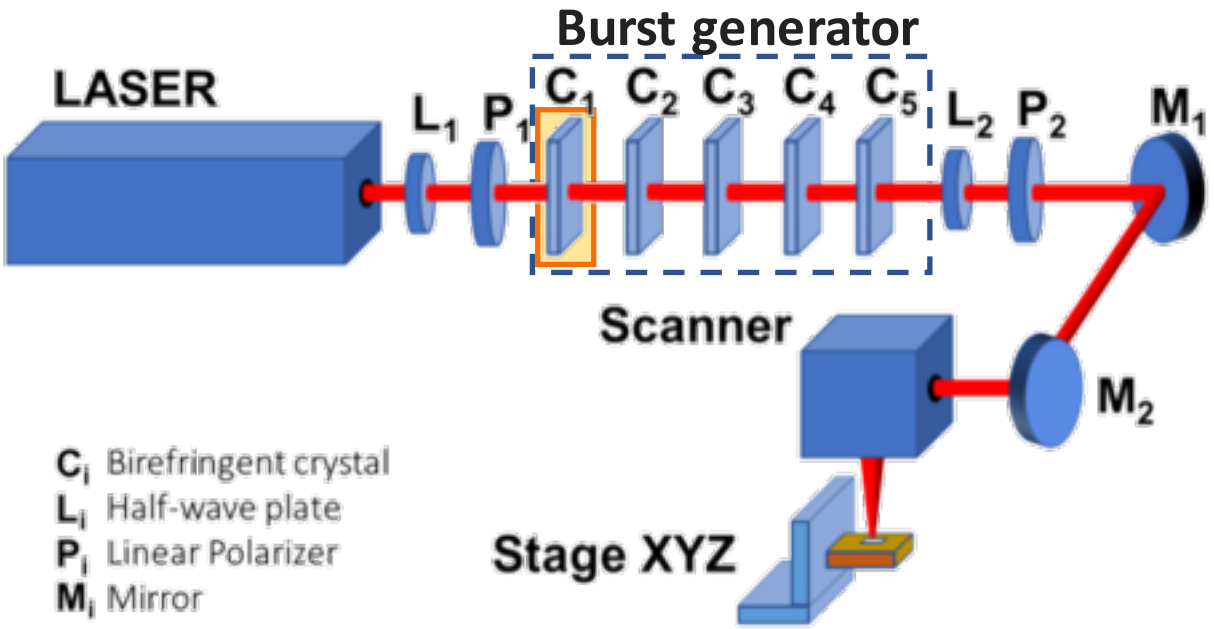
Experimental setup

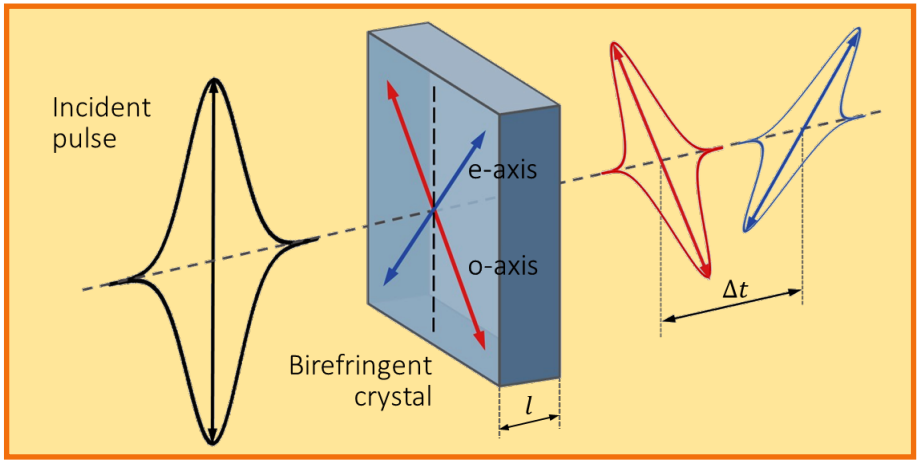
Burst composition:

Number of sub-pulses
$n = 2, 4, 8, 16, 32$

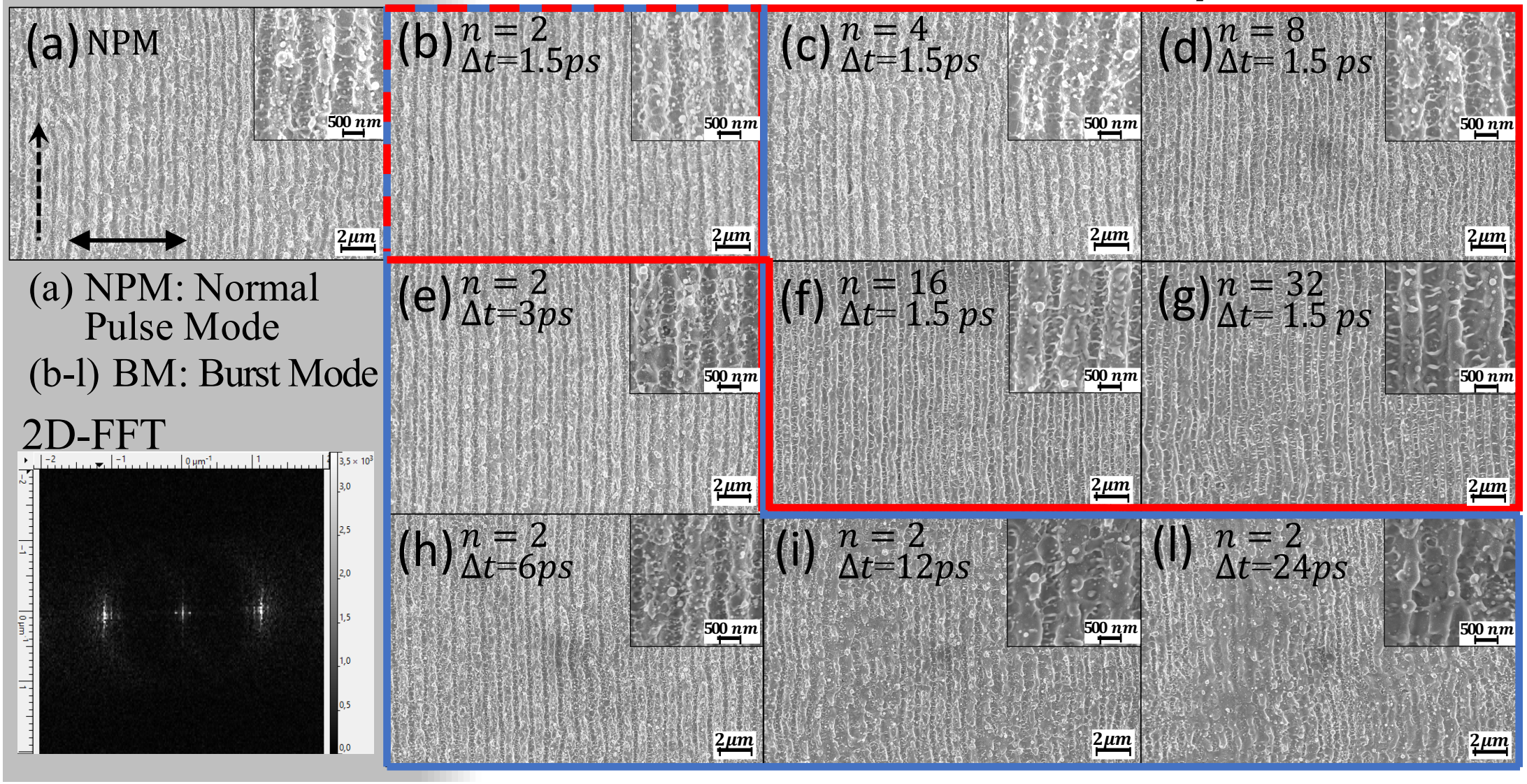
Time separation
$\Delta t(ps) = 1.5, 3, 6, 12, 24$

Polarization
P = linear ($\leftrightarrow$)





LSFL: SEM images



(a) NPM: Normal Pulse Mode

(b-l) BM: Burst Mode

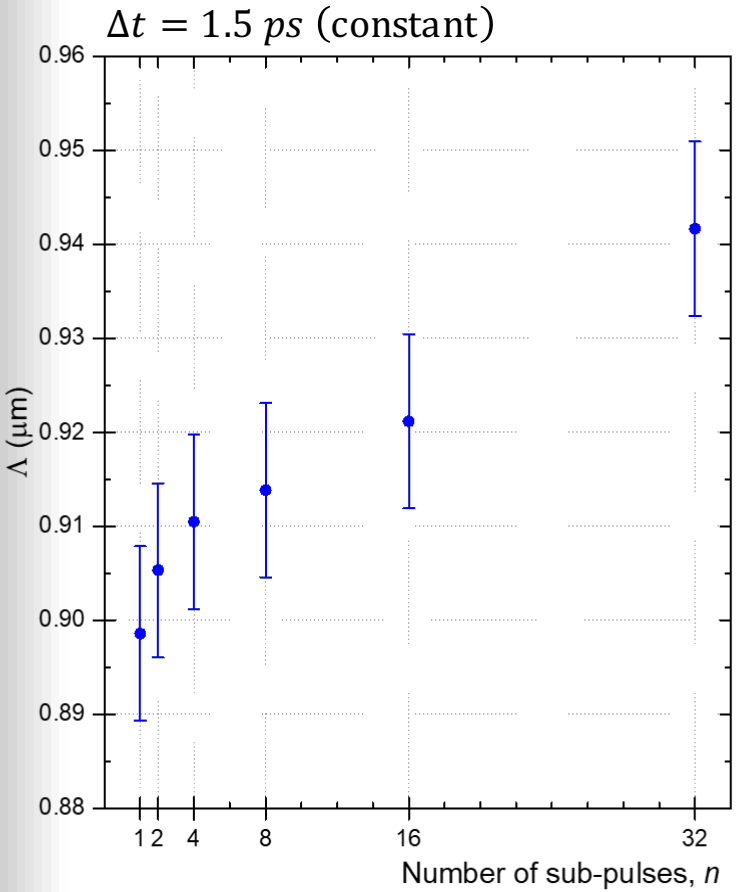
2D-FFT

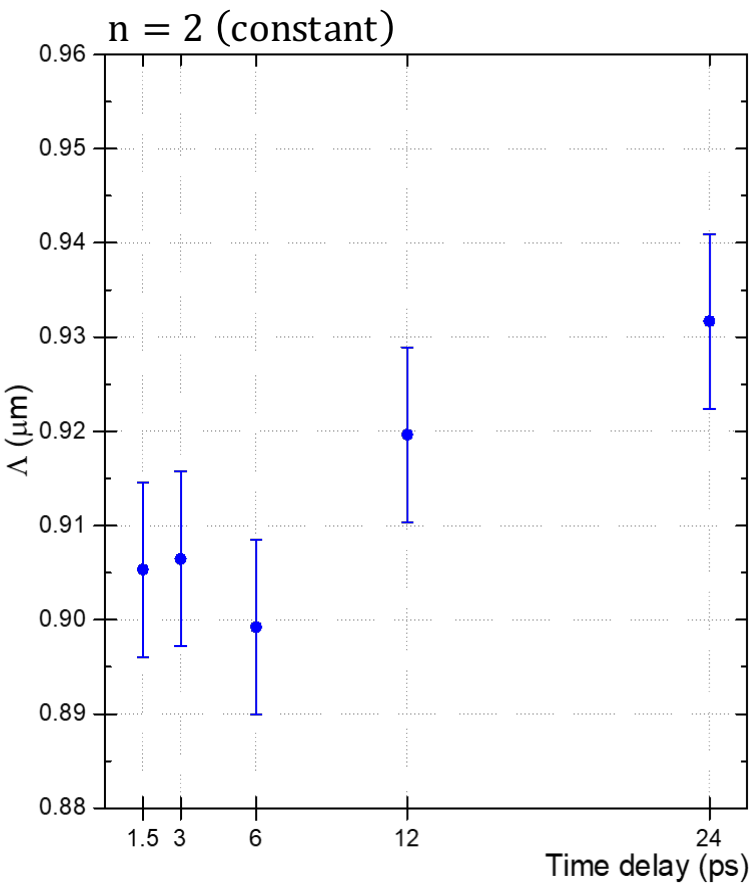
SEM images analysis: LSFL period (Λ)

Ripples spacing Λ rises with:

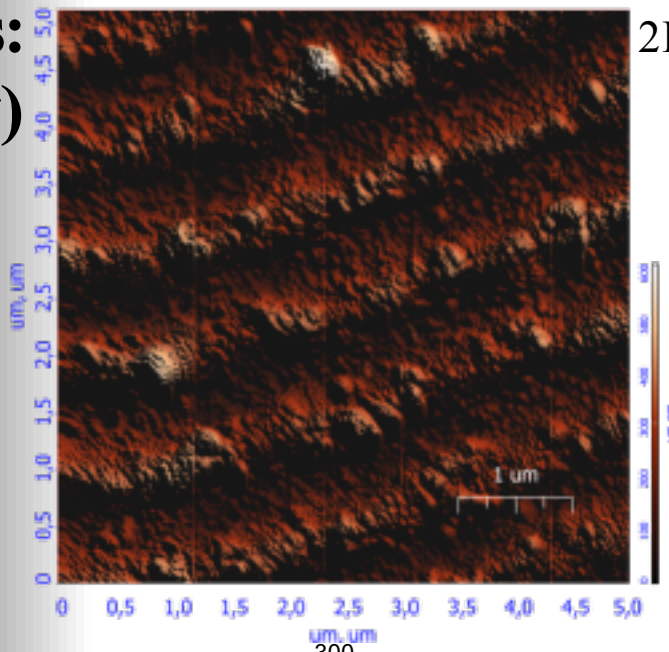
number of sub-pulses n in the burst for $\Delta t = 1.5\ ps$

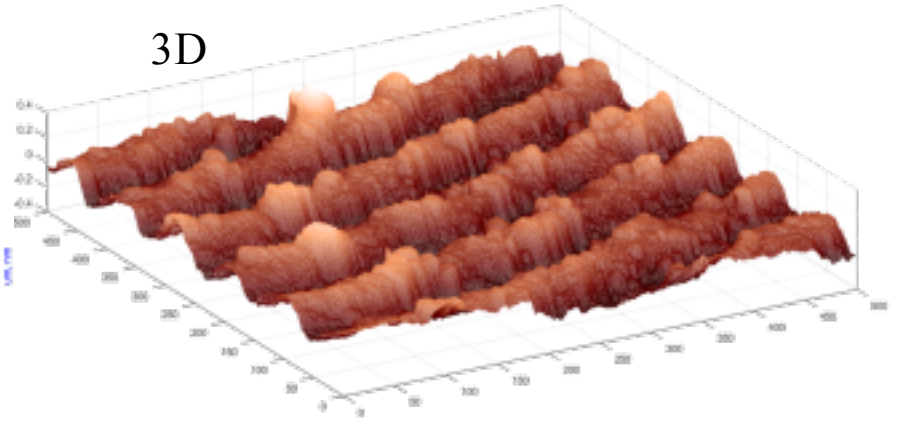
time separation between sub-pulses (investigated case n=2)





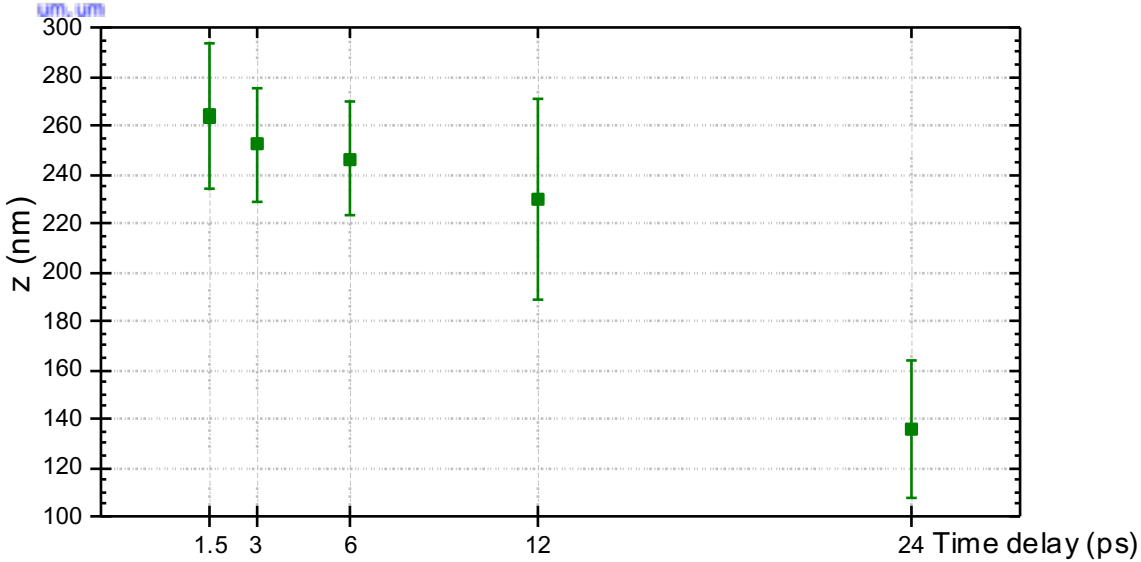
AFM images analysis: LSFL depth (Δz)





(Preliminary results)

LSFL depth decreases with large time separation between the 2 sub-pulses of the burst



Future goals

LIPSS depth as a function of the burst features

Surface structures burst-induced with crossed polarization of the sub-pulses

Ablation rate in Burst Mode

$$\frac{dV_{abl}}{dt}$$

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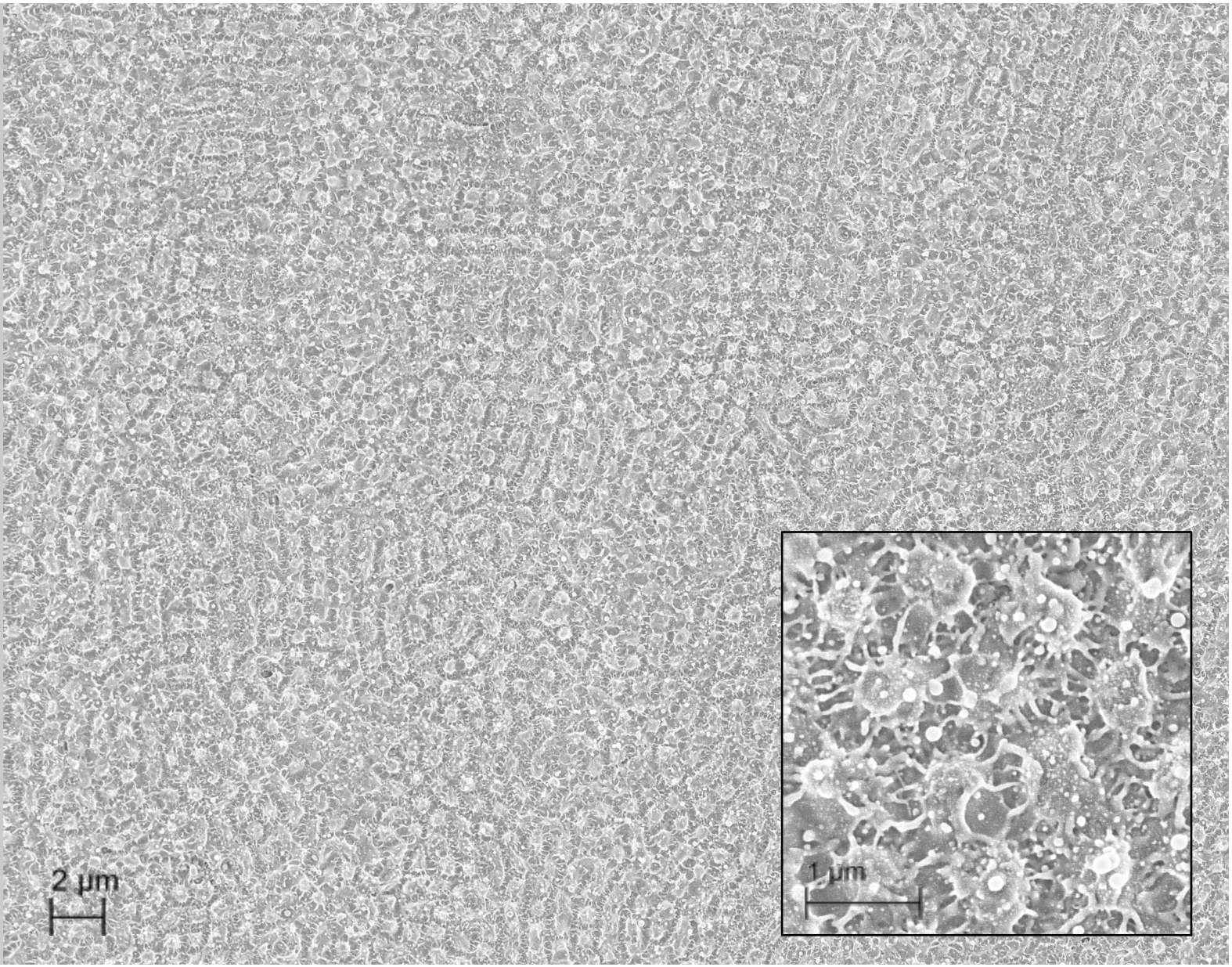


Thanks for your attention

Conferenze e seminari

LiM 2017 - Lasers in Manufacturing (26 – 29 giugno, 2017, Monaco di Baviera - Germania)
"Incubation effect during laser irradiation of stainless steel with bursts of fs-pulses", G. Giannuzzi, C. Gaudiuso, P. M. Lugarà, A. Antonio.

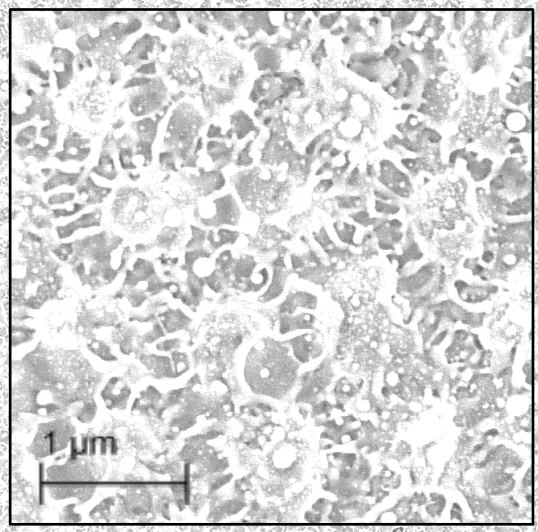
IFN-DAY 2017, Istituto di Fotonica e Nanotecnologia (10-11 gennaio, 2017, Bari)
Poster: "Incubation effect in burst mode fs-laser ablation of stainless steel", C. Gaudiuso, G.Giannuzzi, A. Volpe, P.P. Calabrese, A. Ancona, P.M. Lugarà.

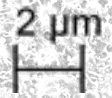
Pubblicazioni

"Incubation during laser ablation with bursts of femtosecond pulses with picosecond delays", C. Gaudiuso et al, Opt. Exp. (sottomesso)

Esperienze didattiche

Attività di insegnamento A.A.2017/2018 della disciplina Fisica (8 ore) nel corso di "corsi di preparazione ed approfondimento per lo studio delle materie di base e del CAD" presso il Politecnico di Bari.





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