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Laser drilling of a Copper Mesh

Vincenzo Berardi

IFN U.O.S. Bari, Italy
Institute for Photonics and Nanotechnologies

Dip. Interuniversitario di Fisica
“M. Merlin”

Laser Ablation Definition

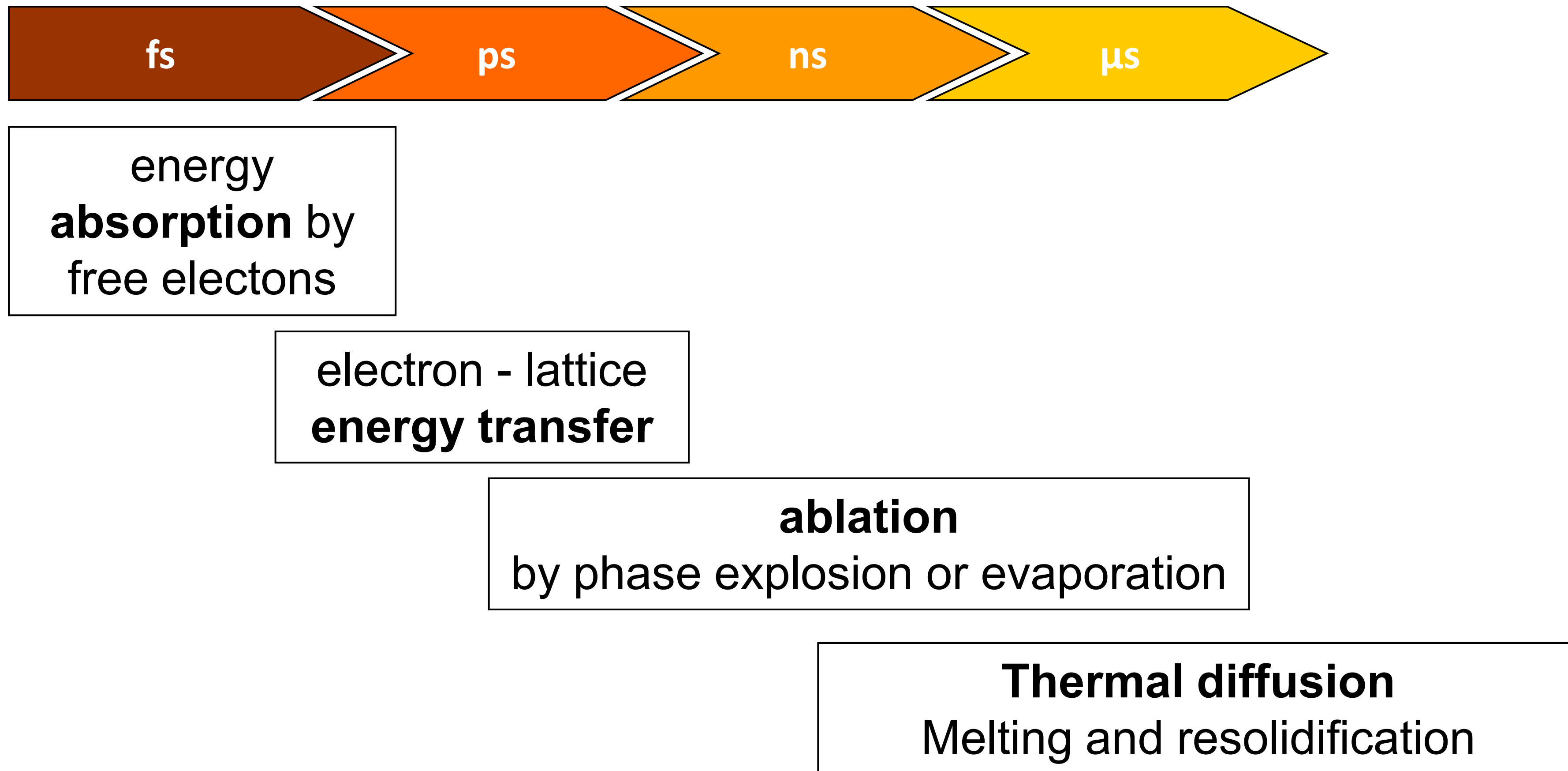
Laser ablation is the process of removing material from a solid surface by irradiating it with a laser beam.

At low laser flux, the material is heated by the absorbed laser energy and evaporates or sublimates.

At high laser flux, the material is typically converted to a plasma.

Usually, laser ablation refers to removing material with a pulsed laser

Timescales of the laser ablation process



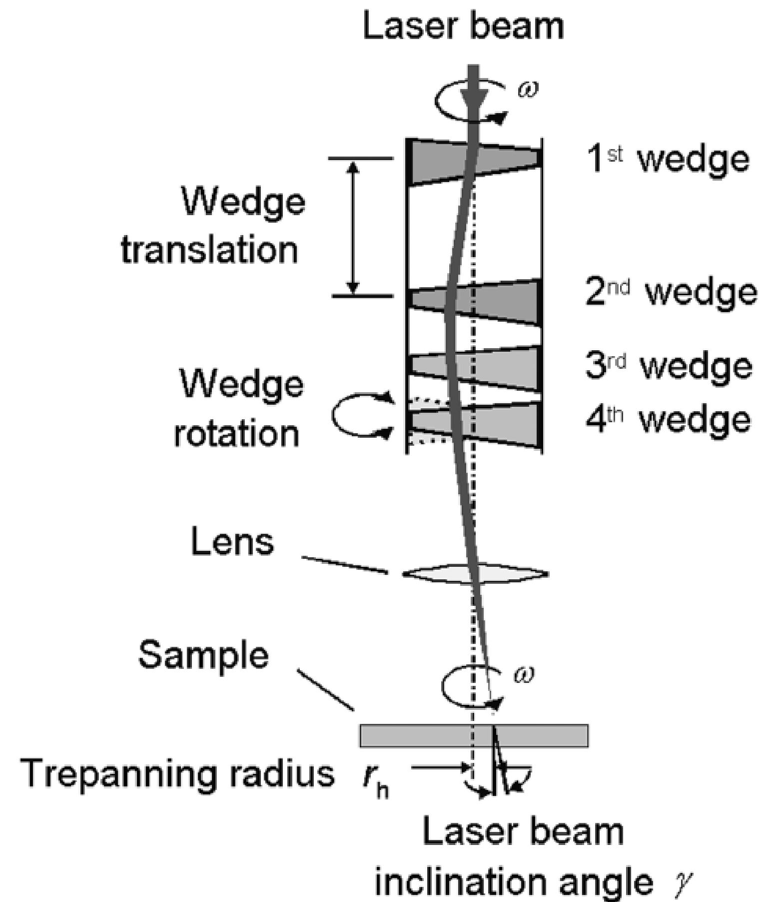
Mazur et al. Nature Materials ***2****, 217 (2002)*

Laser drilling strategies for high accuracy

Percussion drilling
Single pulse
More pulses

Trepanning
Mechanical trepanning
Optical trepanning
Annular laser beam

Trepanning optic for helical drilling



F. Dausinger et al., *Springer* (2004)

Cu Parameters

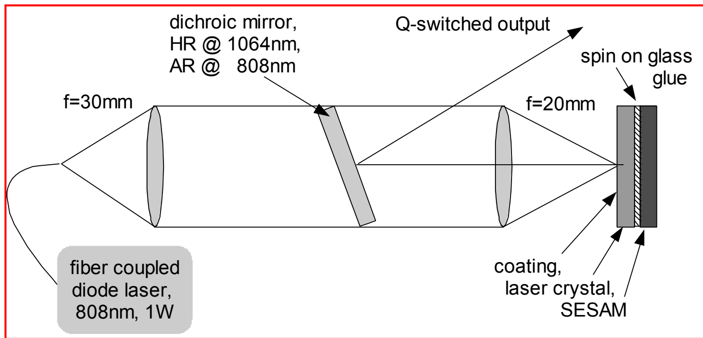
	Material	Density (g cm^{-3})	Thermal Conductivity (W m^{-1} K^{-1})	Melting point (°C)	Vaporization temperature (°C)
Copper	Metal	8.94	400	1084	2562

- Finding optimal laser process parameters (pulse duration, wavelength, fluence, drilling strategy)
- Copper oxide around the hole walls (post process cleaning could be required)

Advantages

Flexible technology: complete control of the hole morphology (taper, diameter) and geometry (density of the holes mm^{-2}, distribution)

Microchip laser fiber amplifier (100 ps)



Quasi-monolithic Q-switched microchip laser

μ-chip

OD

λ/2-plate

40mm

0.55 m PM-DC

8mm

11mm

5 Watt

M1

20mm

40mm

IF

Pump diode

50mm

8mm

20mm

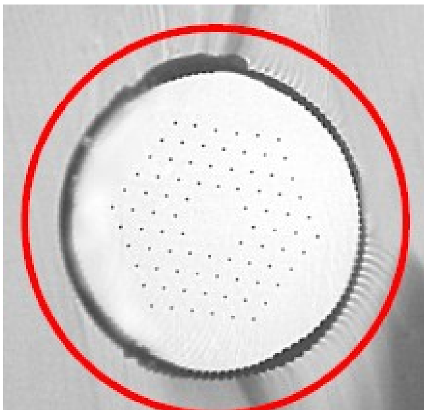
M2

OD

1.5 m PM-PCF

M3

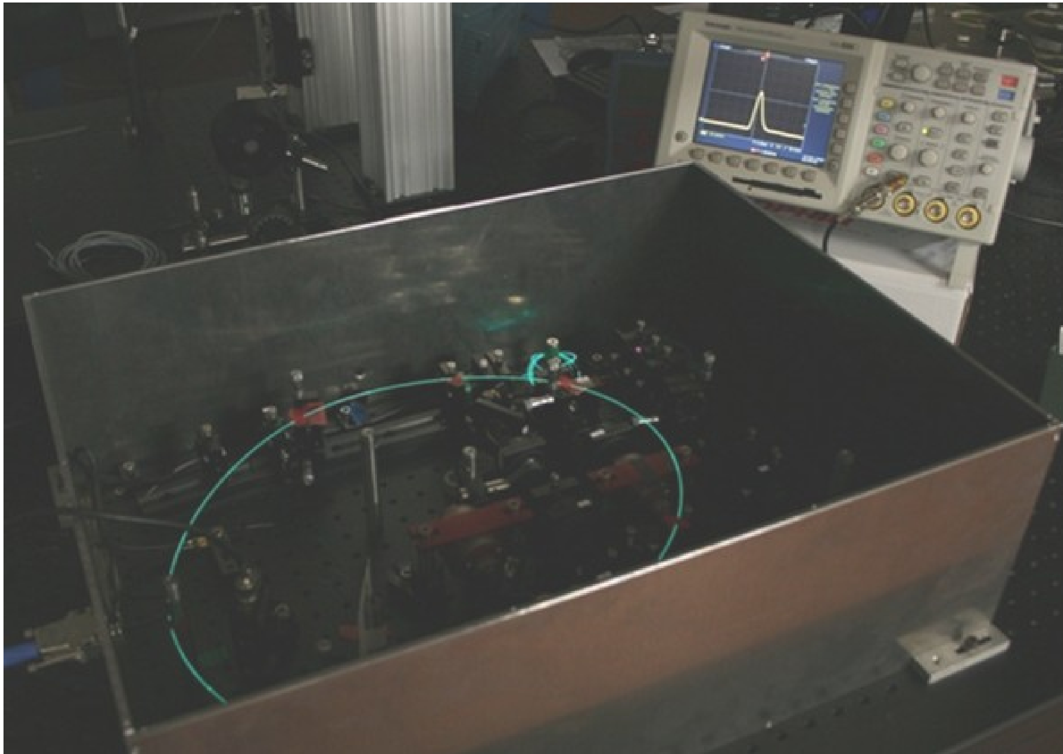
18 Watt

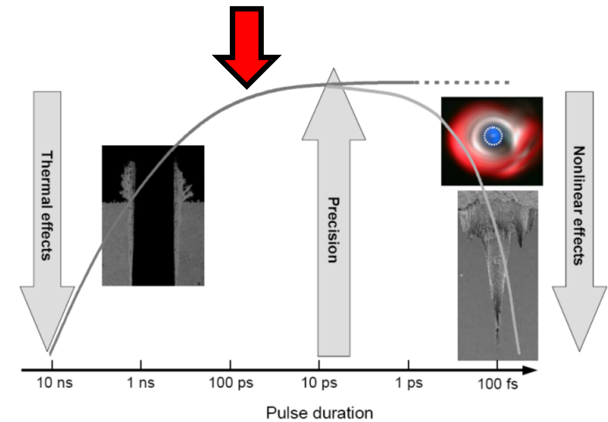


Yb-doped photonic crystal fiber

CNR-IFN Bari - Laser materials processing lab

Short pulse 100 ps fiber laser





Specifications	
Wavelength	1064 nm
Pulse duration	100 ps
Repetition rate	≈ 100 kHz
Pulse energy max.	100 μJ
Average power	10 W
Peak power max.	1 MW

Collaboration

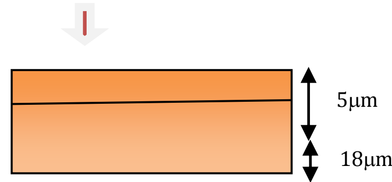
CNR-IFN Bari

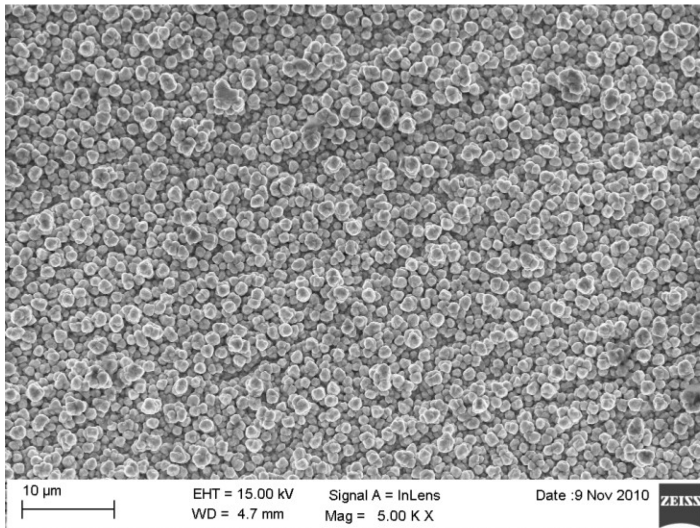
FSU JENA

Post process Analysis

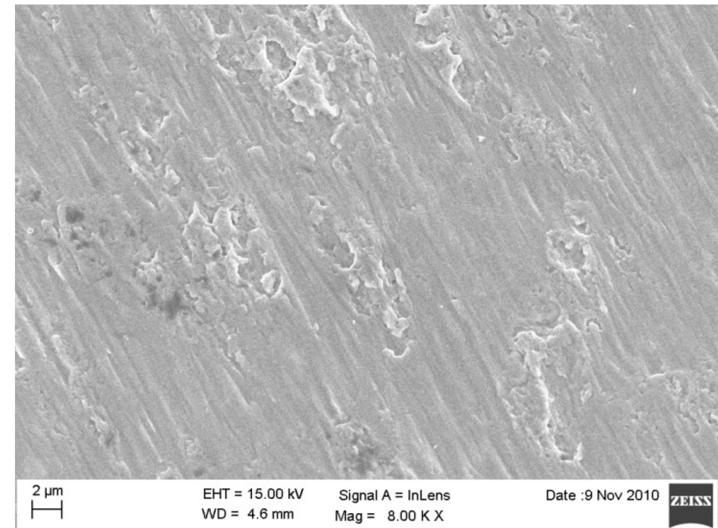
- Electron Microscopy - Field Emission
- EDS (EDX) (Energy Dispersive X-ray Spectroscopy)

A look at the surface(s)



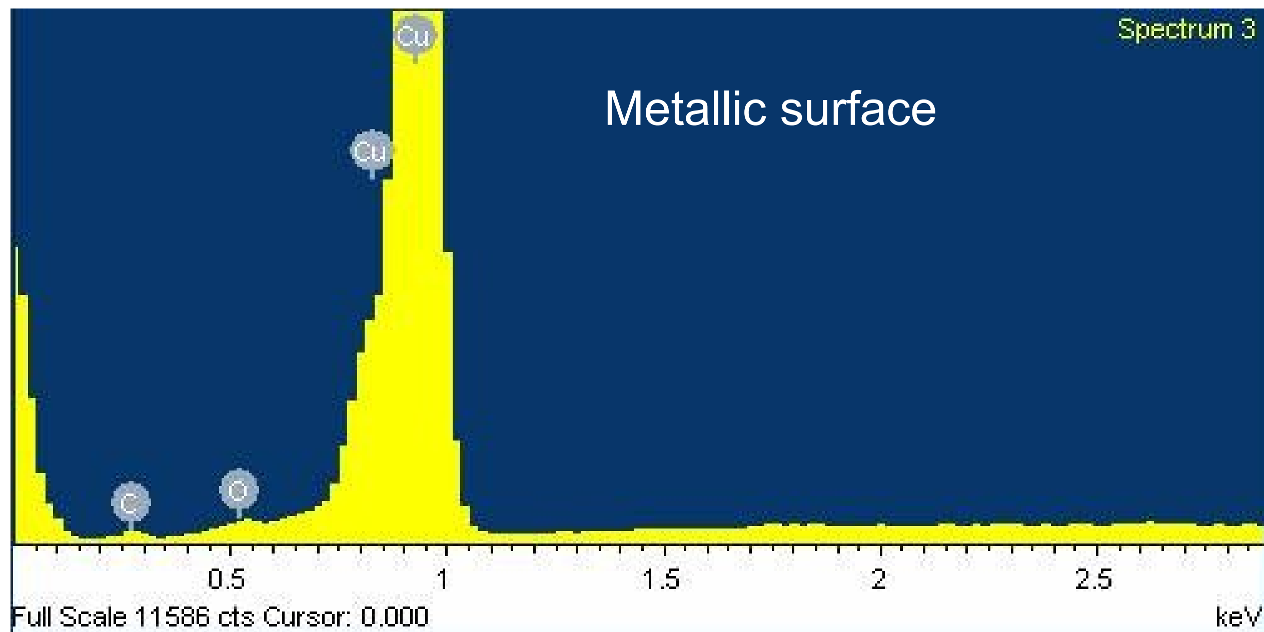


5μm layer front surface

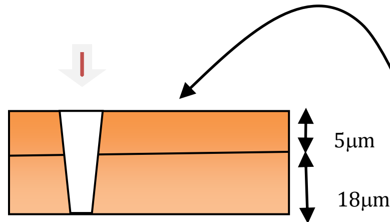


5 μm layer back surface

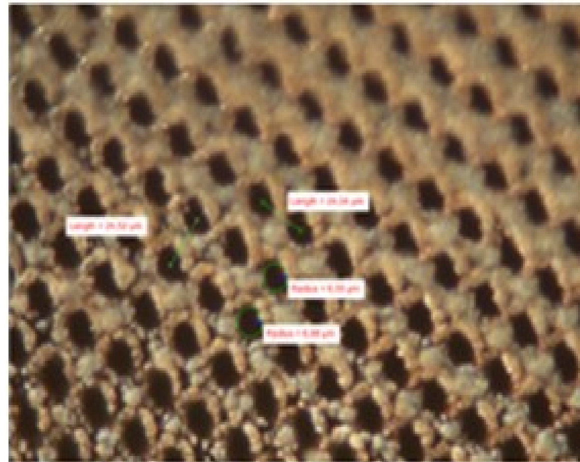
EDS



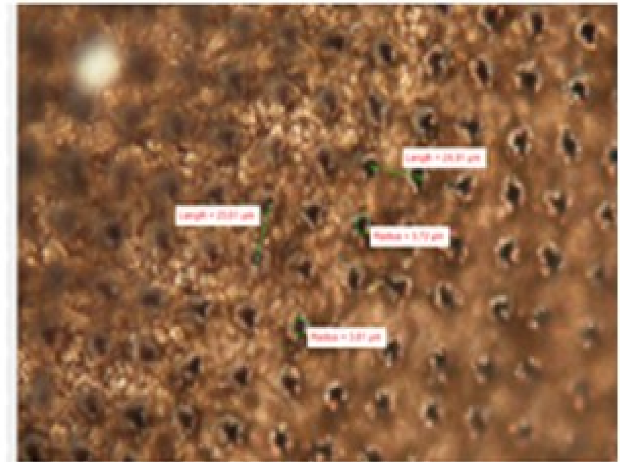
Single layer drilling



Array of 400 x 400 holes 1cm x 1 cm
(post processing 20 x 20)
Average Pitch (center to center) d = 24μm
Average size (diameter) = 13 μm
Laser Power = 500mW
Overall processing time = 2 hours and 30 mins

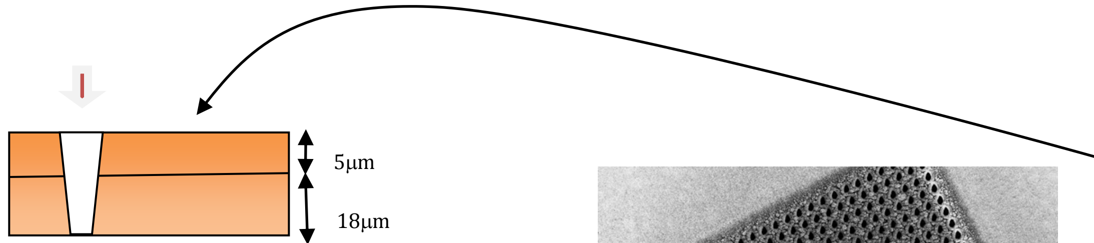


Campione 8 _5micron_ingresso

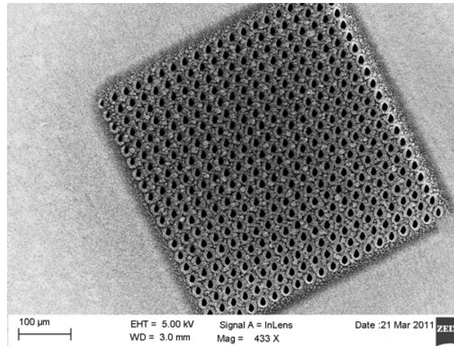


Campione 8 _18micron_uscita

Single layer drilling



	Diameter (μm)	Pitch (μm)
5μm layer	13.10 (0.8)	24.50 (1)
18 μm layer	7.50 (0.8)	23.55 (1)



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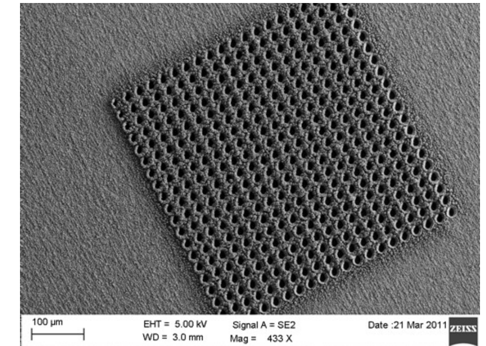

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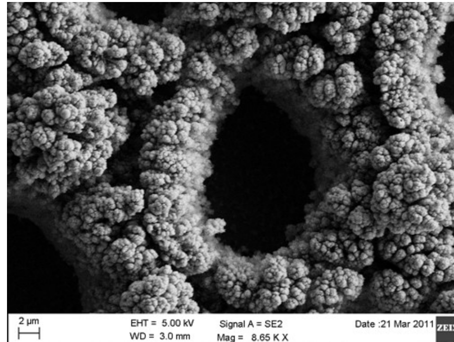

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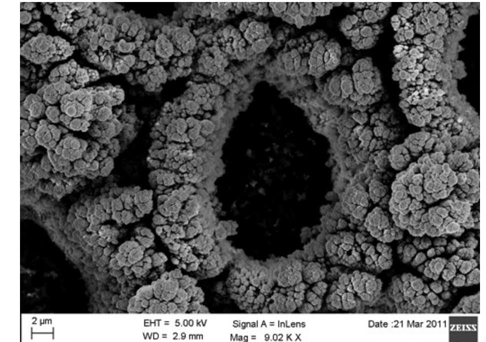

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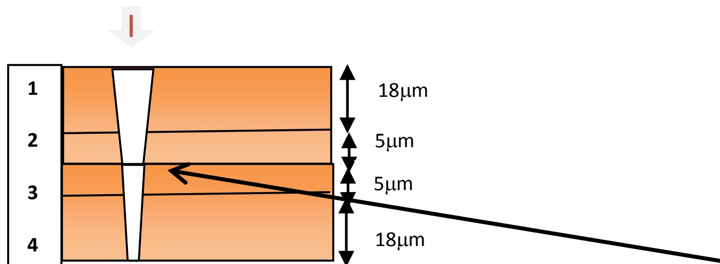
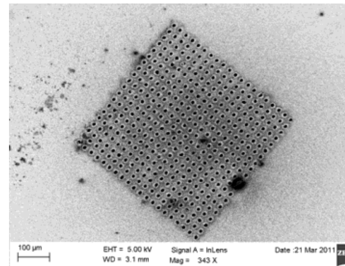
Double layer drilling





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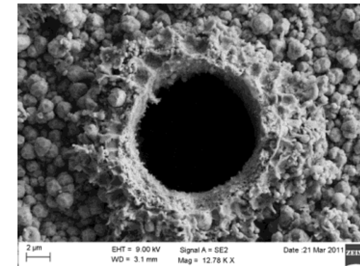

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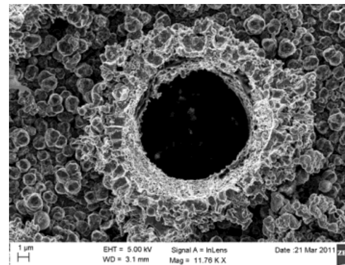

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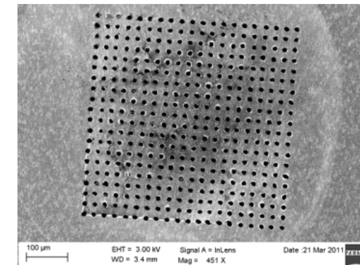

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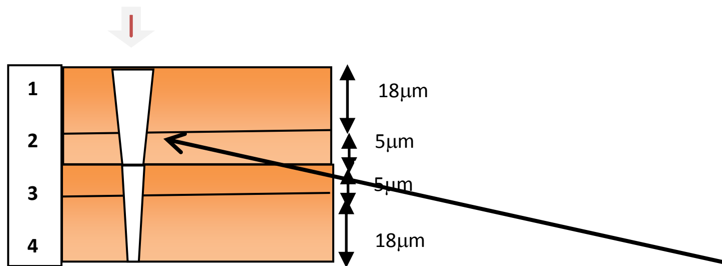
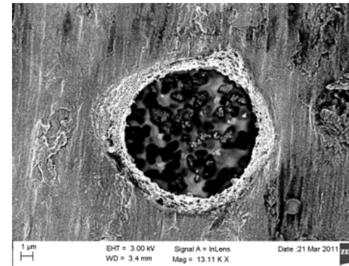
Double layer drilling





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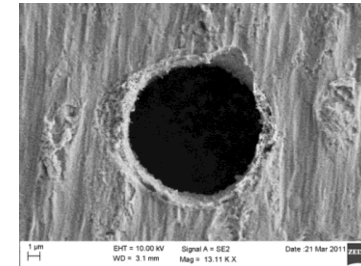

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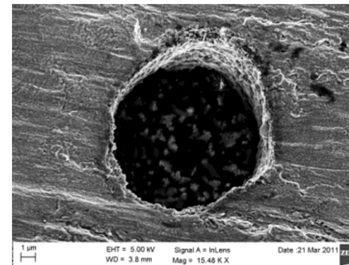

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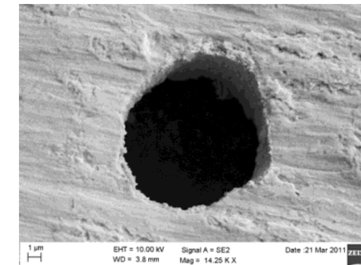

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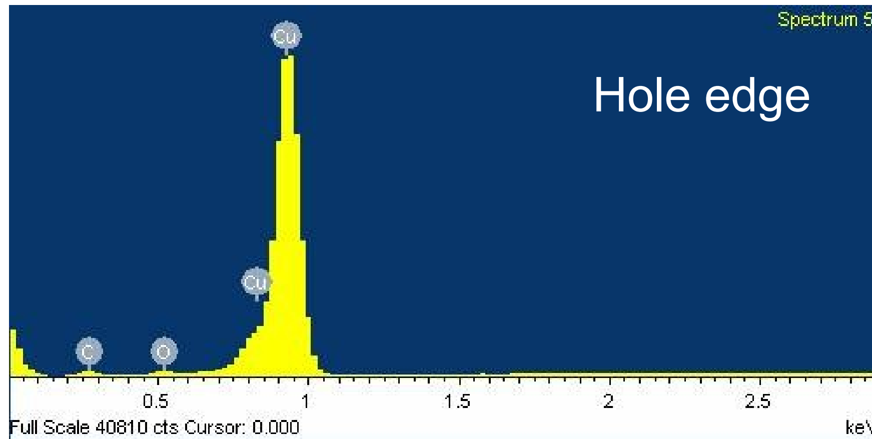
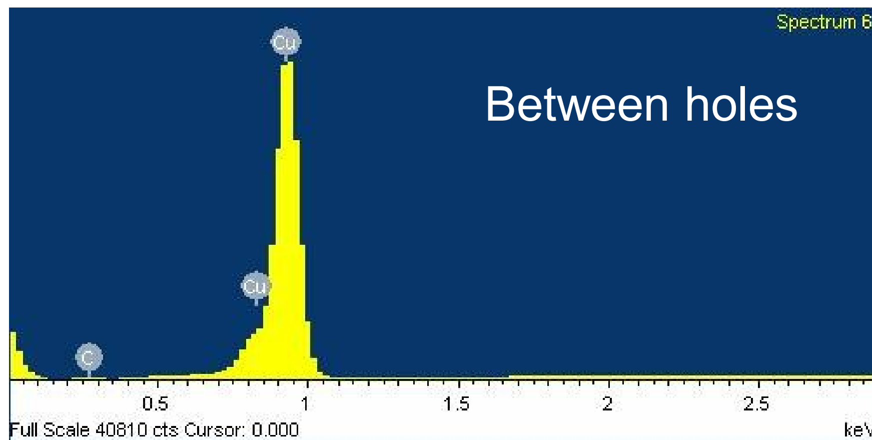
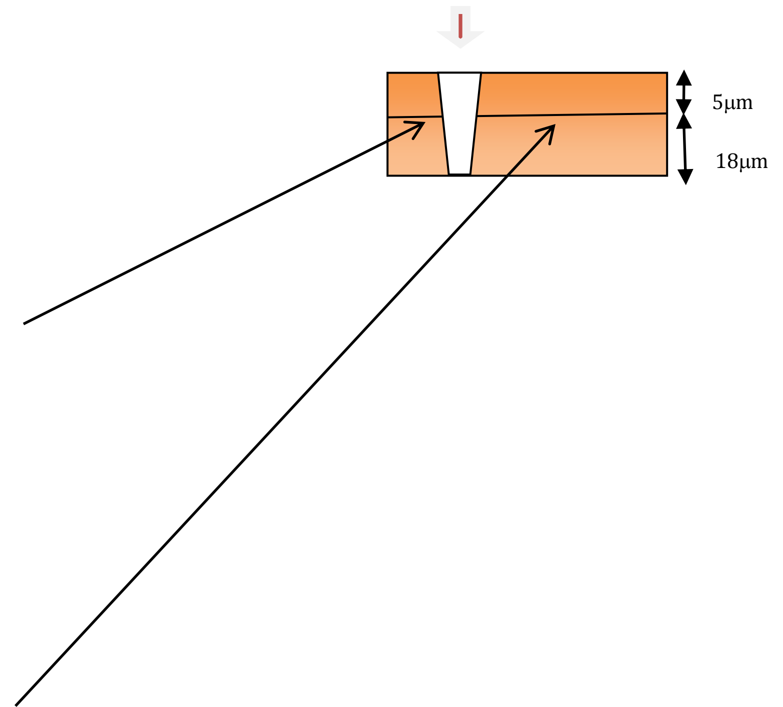
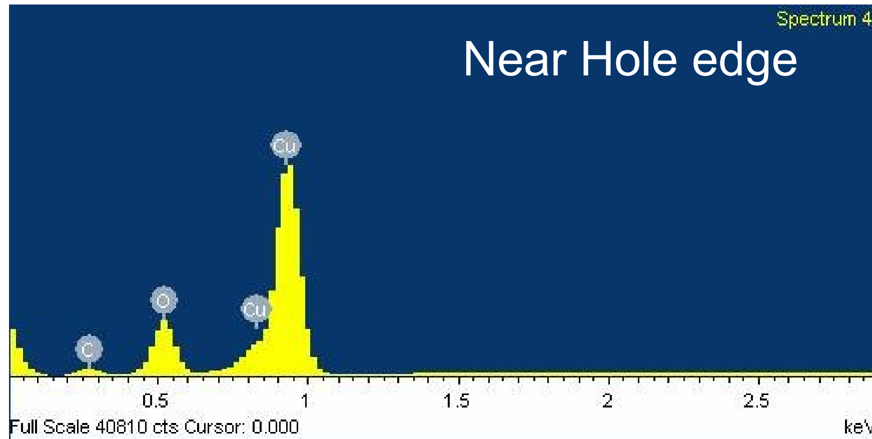
EDS

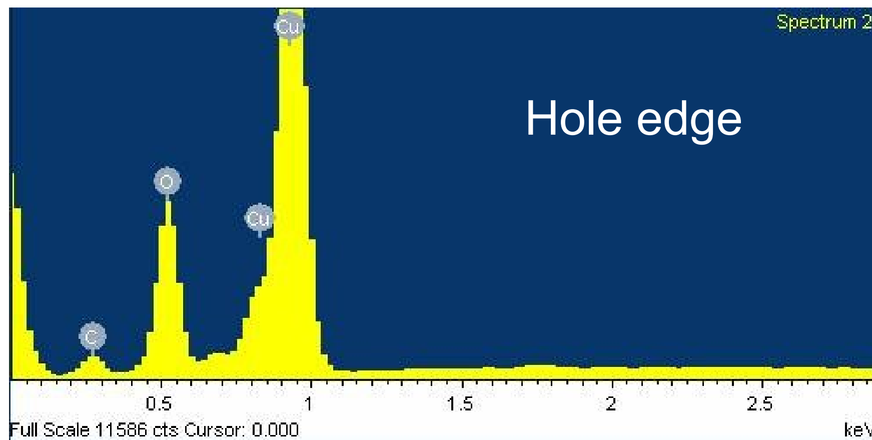


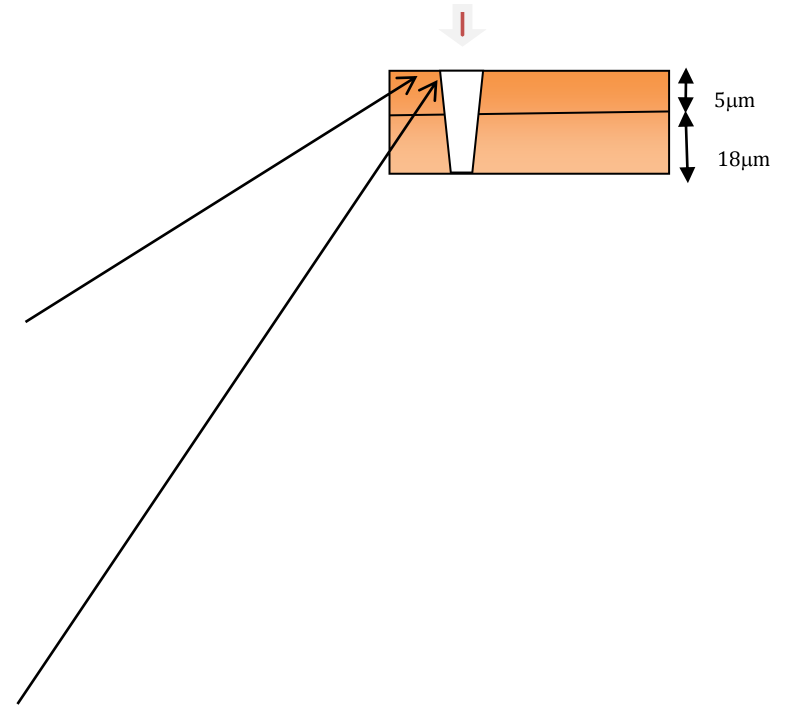




EDS

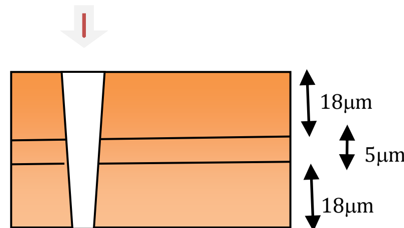






Summary

- Cu meshes can be drilled to obtain 12-14 micron diameter holes with a pitch of 20-25 microns (focusing spot down to < 10 μm)
- Only percussion drilling can be reliably used and Oxide formation can be limited but not avoided by flowing inert gas on the surface.
- Contamination can be reduced by changing the geometry as follows



IFN Group

Antonio Ancona	**CNR-IFN, Staff**
Teresa Sibillano	**CNR-IFN, Staff**
Francesca Di Niso	**Dept of Physics, PhD student**

INFN Group

Gabriella Catanesi	**INFN, Staff**
Vincenzo Berardi	**Dept of Physics, Staff**
Emilio Radicioni	**INFN, Staff**