X-ray induced modifications in materials: applications and challenges

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X-ray nanopatterning potential
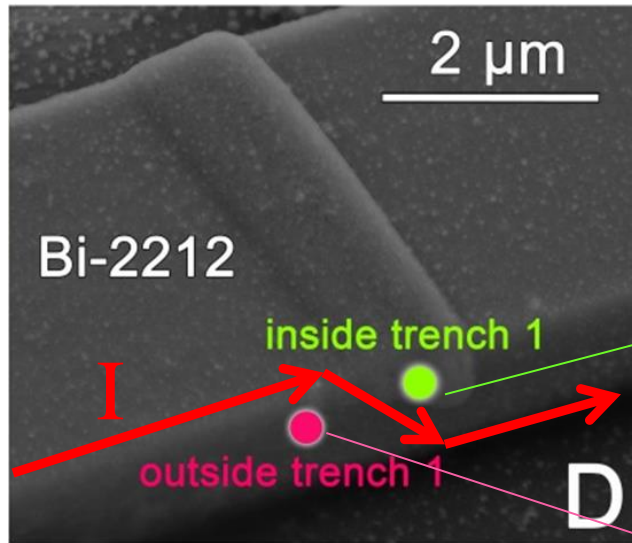
Truccato Marco

University of Torino, Italy
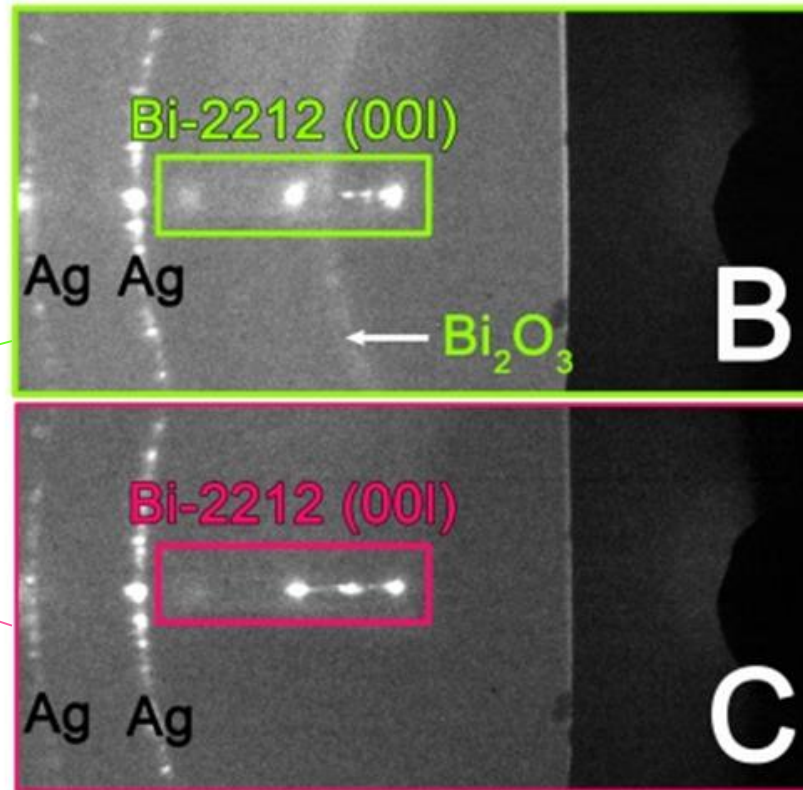
marco.truccato@unito.it

Basic feature of X-ray Nano Patterning (XNP)

SEM observation:

X-ray Nano-Diffraction:

In the trenches

Out of the trenches
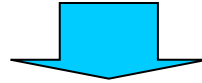
Mild and controlled perturbation of the lattice

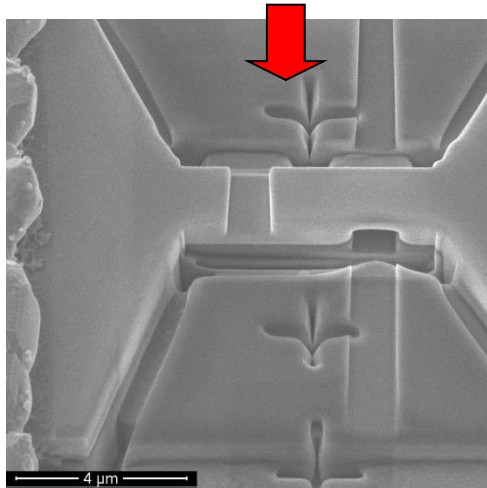BUT

large perturbation of the electrical properties

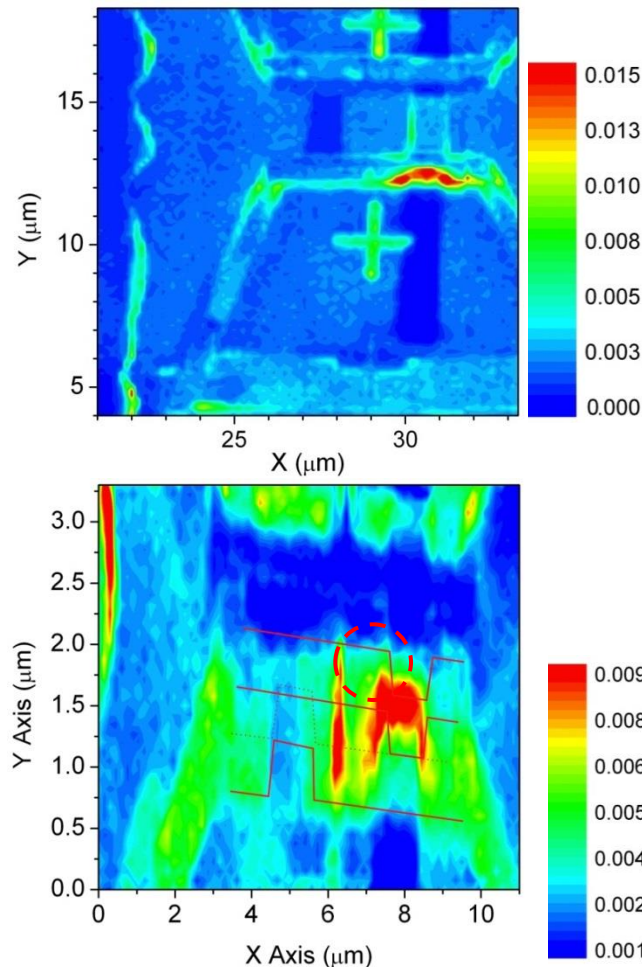# Main assets of XNP

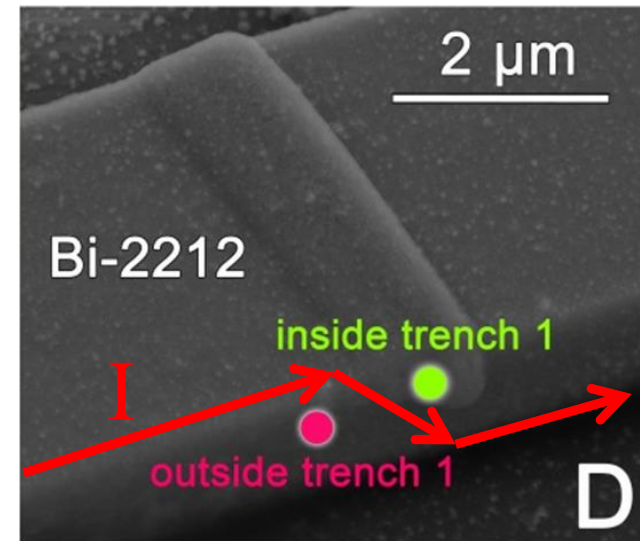1. NO USE of external chemical elements

Absence of chemical contamination

FIB:

XNP:

Ga concentration
by XRF
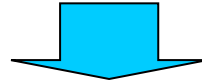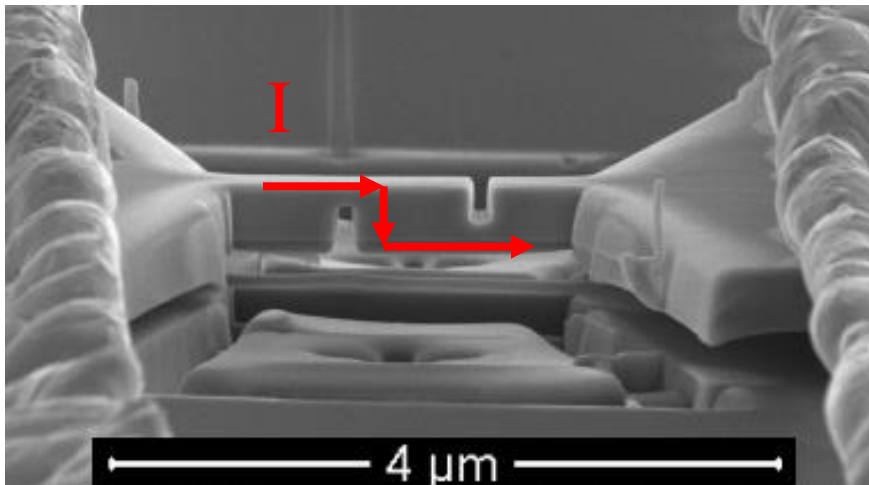
Main assets of XNP

2. NO use of MATERIAL/VACUUM interfaces
   BUT use of MATERIAL/MATERIAL interfaces,
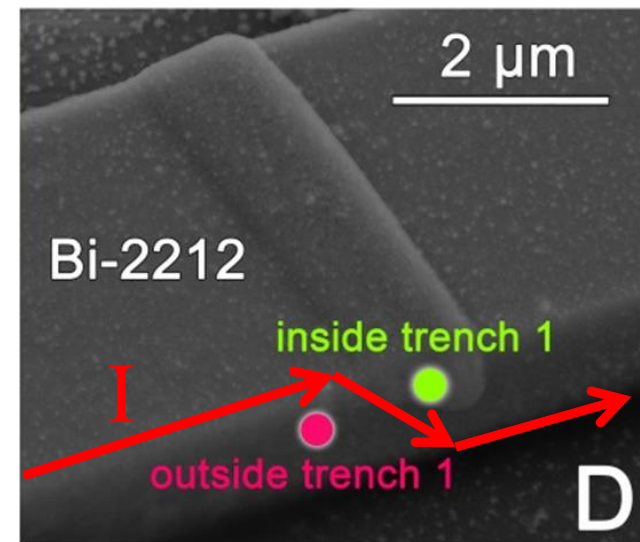
a) Higher mechanical stability
b) Higher thermal conductance and heat dissipation
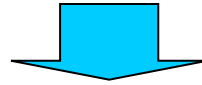c) Higher EM coupling between diffrent portions of the material
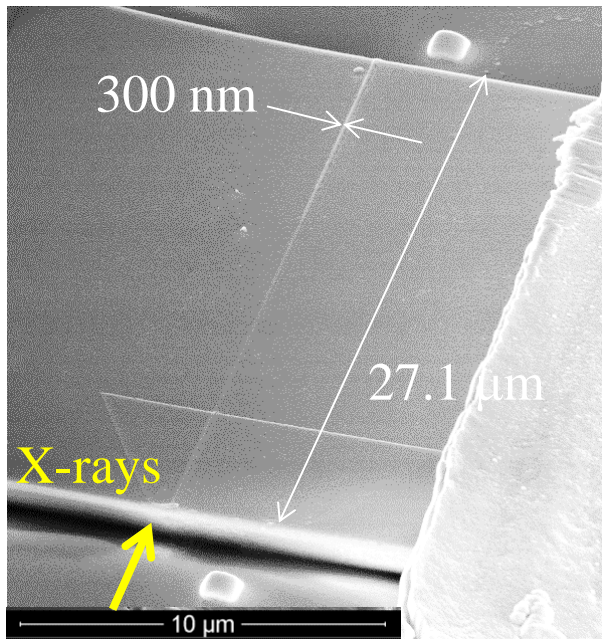
FIB:

XNP:

Main assets of XNP
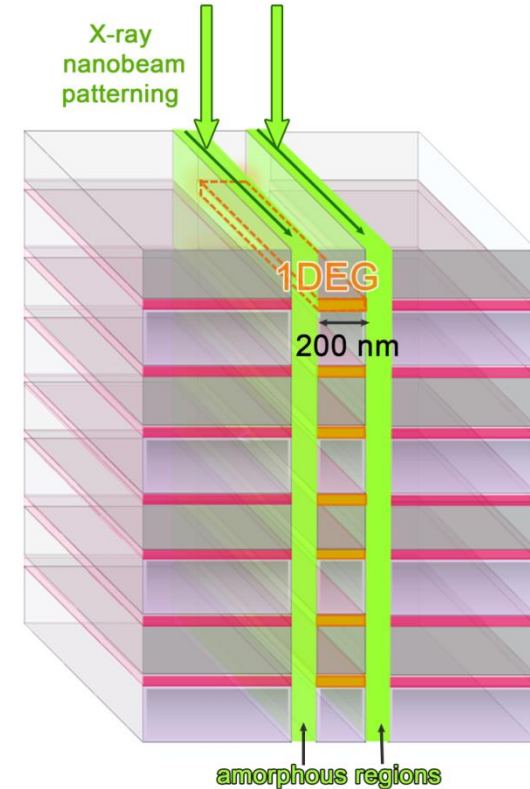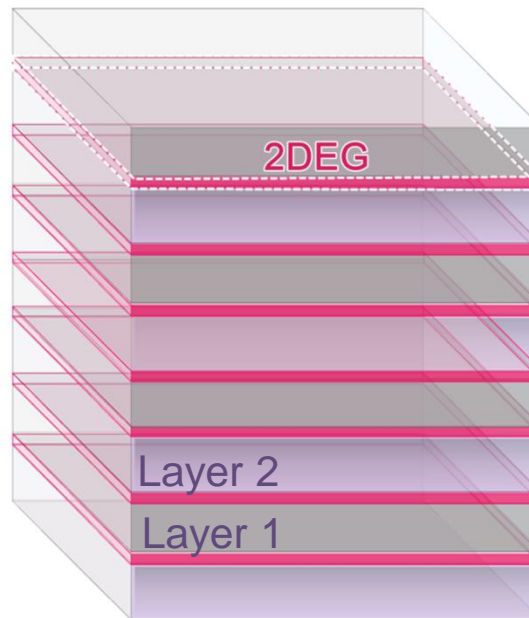
3. High penetration of X-rays

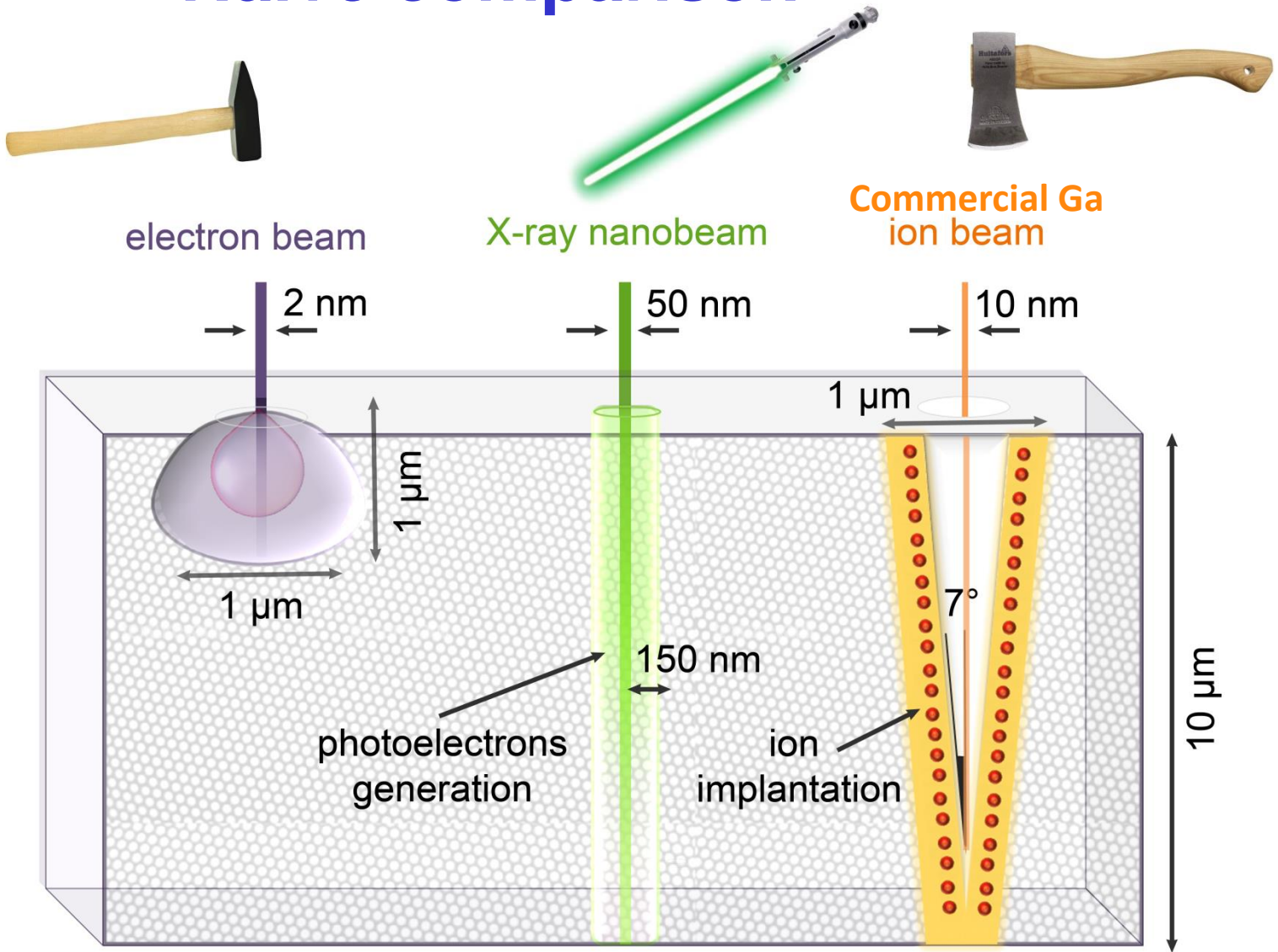Very high aspect ratio (about 100:1) between penetration depth and resolution

XNP
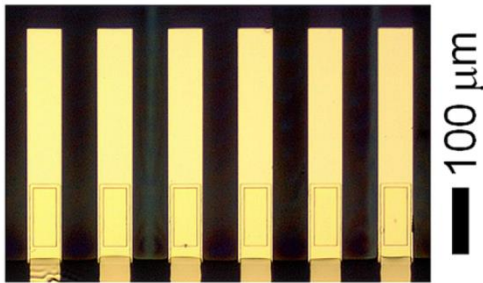
Possibility of Multilayer patterning

Naive comparison

Minimum beam size

electron beam — 2 nm

X-ray nanobeam — 50 nm

Commercial Ga ion beam — 10 nm

Minimum feature size depends on aspect ratio

1 µm

1 µm

1 µm

150 nm

photoelectrons generation

ion implantation

7°

10 µm

Possible application

➤ <u>THz emitter:</u> 6 Bi-2212 mesa (view from top)

Mesa synchronization implies emitted power $\propto N^2$

T.M. Benseman et al., Appl. Phys. Lett. **103**, 022602583 (2014)

$\dfrac{E_z}{E_{z,\,max}}$ 1 0 −1

Present record
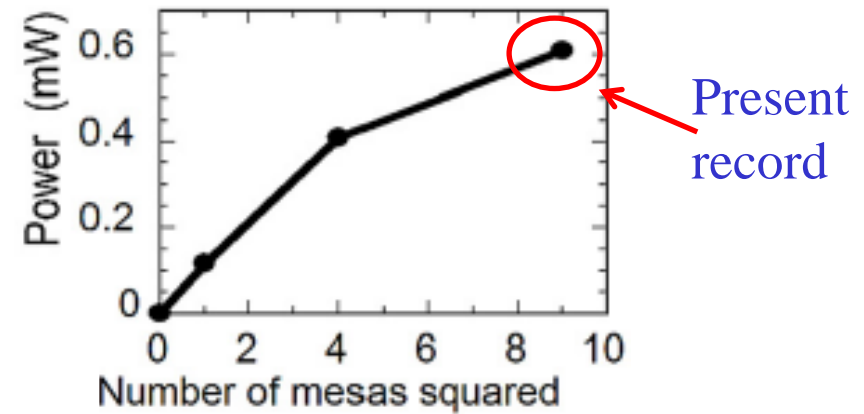
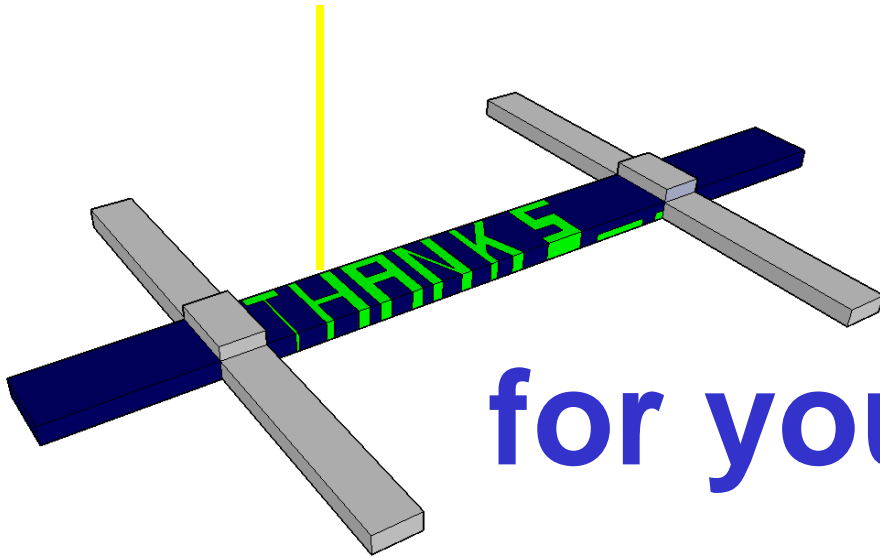➤ EM coupling supposed to take place via the crystal base.

New design: Coupling obtained through the crystal itself

Optically transparent trench

100-200 nm

oxide micro-crystal

current

150 nm

THz wave

70 µm = λ/2

X-ray nanobeam

for your attention !