INFN V^TH COMMITTEE

NEW PROJECT [NUCLEAAR] [LNF+RM1]

NEW COATINGS FOR CHALLENGING APPLICATIONS IN ACCELERATORS [2019/20]

National coordinator A. Marcelli (LNF)

RM1 coordinator S. Lupi (Sapienza)

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2 year project

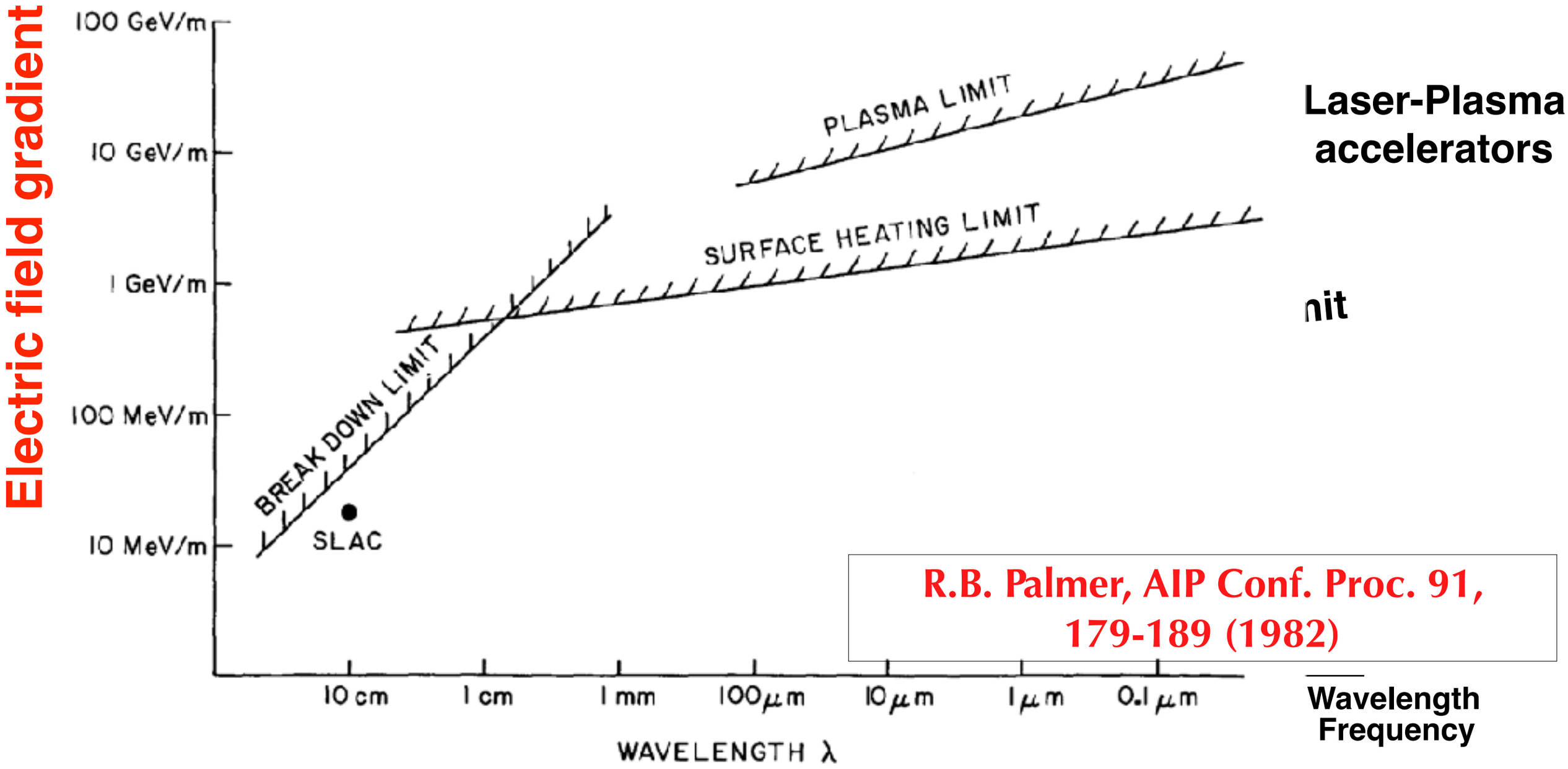
Co-funded by MAECI and Osaka university (Japan)

Italian collaborations: CNR/ISM .....

Potential international collaborations:
Diamond (UK)/SLAC (USA)/USTC (P.R.China) /Dragon Thin film Laboratory (LV)

Gruppo V – Frascati 2 luglio 2018

Accelerating field limits



Laser-Plasma accelerators

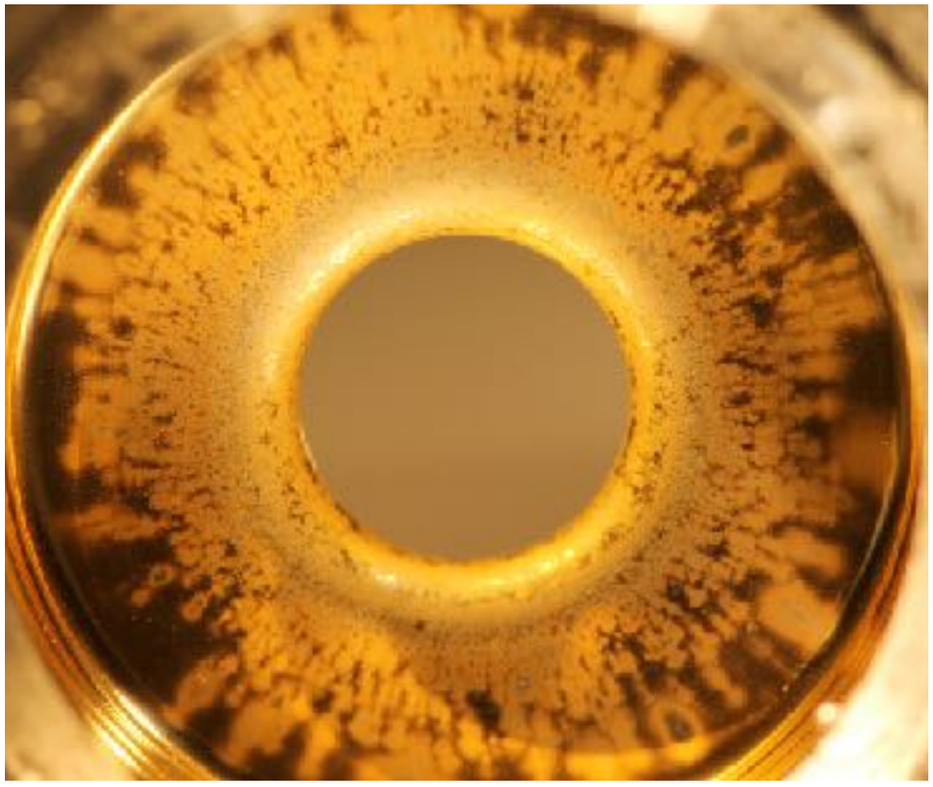
nit

R.B. Palmer, AIP Conf. Proc. 91, 179-189 (1982)

Wavelength
Frequency

Autopsy of an electroformed Au-Ni structure

High gradient side of
Center cell



High gradient side of
End cell

Au coating is removed from the high-electric field area by multiple breakdowns

Courtesy V. Dolgashev (SLAC)

Next Generation High Brightness Electron Beams From Ultra-High Field Cryogenic Radiofrequency Photocathode Sources

J.B. Rosenzweig[1], A. Cahill[1], V. Dolgashev[2], C. Emma[1], A. Fukusawa[1], R. Li[2], C. Limborg[2], J. Maxson[1], P. Musumeci[1], A. Nause[1], R. Pakter[1], R. Pompili[3], R. Roussel[1], B. Spataro[3], and S. Tantawi[2]

[1]*Department of Physics and Astronomy, University of California, Los Angeles*

[2]*Stanford Linear Accelerator Laboratory, Stanford University*

[3]*Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, Frascati, Italy*

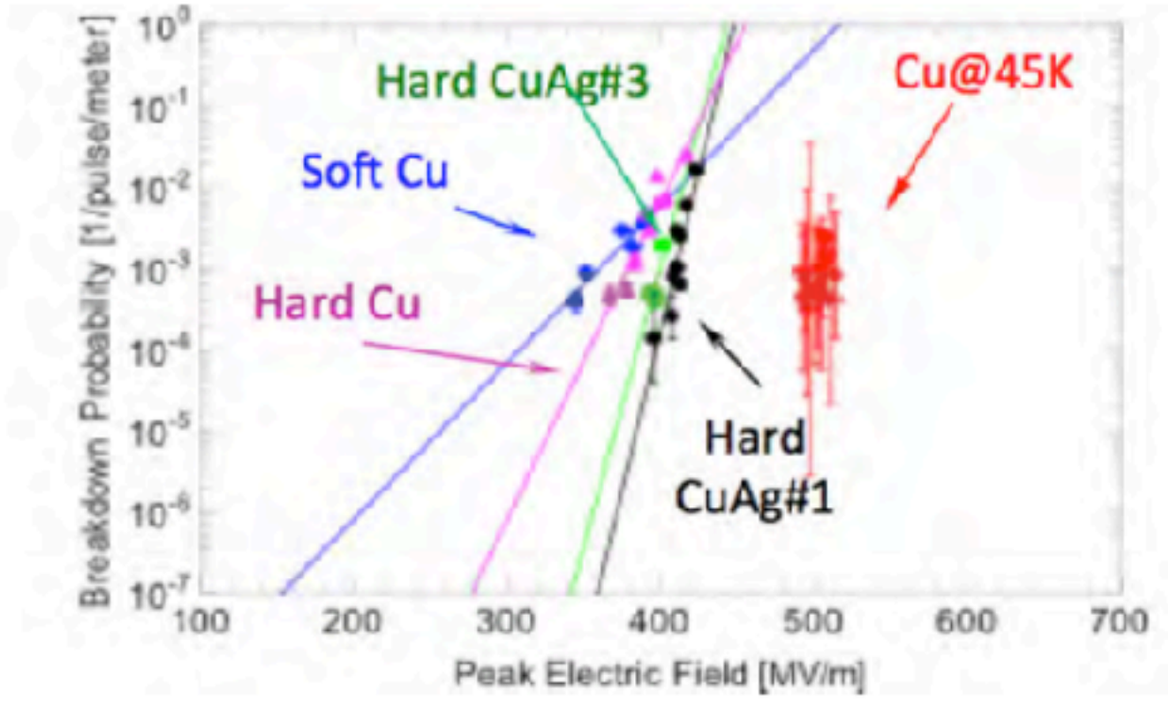
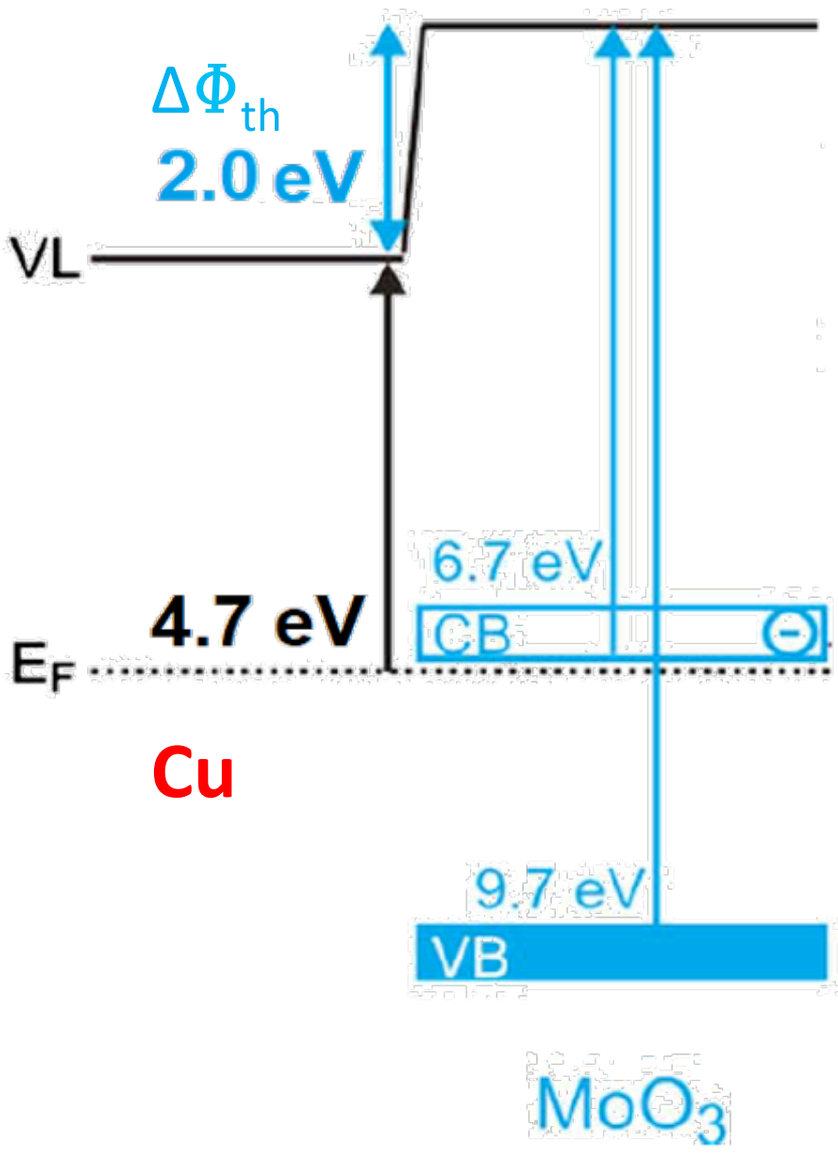
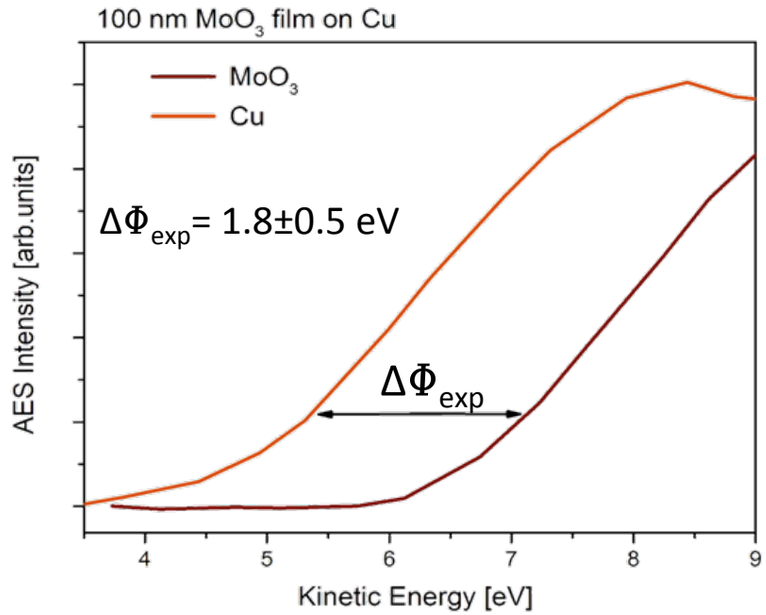


Figure 2. Breakdown probability as a function of peak electric field in single cell X-band accelerating structure tests. The introduction of a harder alloy improves the breakdown as predicted; the effect of operation at 45 deg K is more dramatic, permitting surface electric fields of 500 MV/m.

Enhancement of the WF





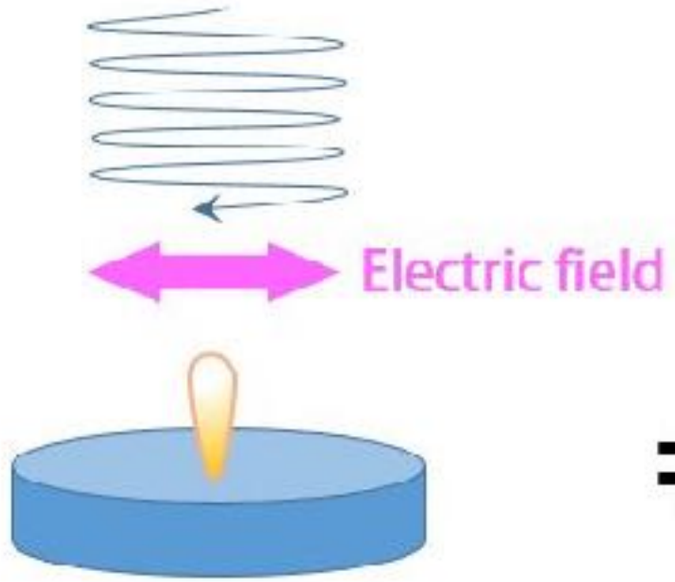
Experimental work functions for a thin film characterised with the Auger spectroscopy. Measurements were performed at normal incidence with an electron beam at 1 keV.

The measurements of this MoO_3 films show a WF ~1.8 eV higher than Cu, in agreement with the expected enhancement of ~2 eV (see left).

THz nonlinear excitation

High electric field

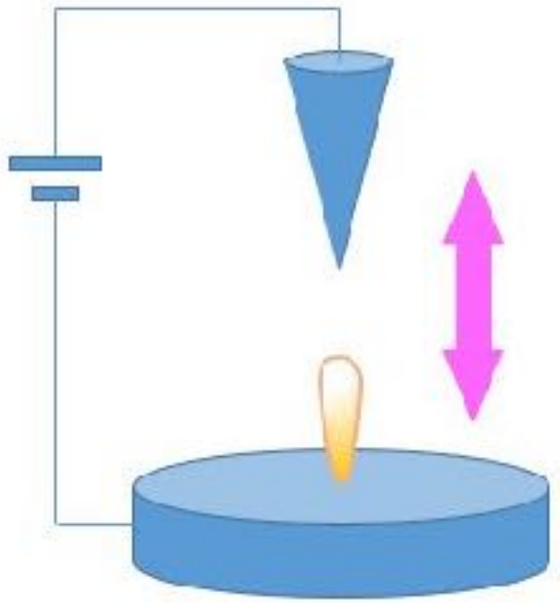
THz FEL excitation (AC)



kinetic energy
⇨ *potential energy*
⇨ *photoelectron*

≠

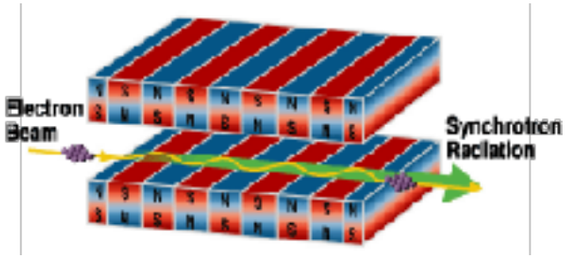
Discharge (DC)



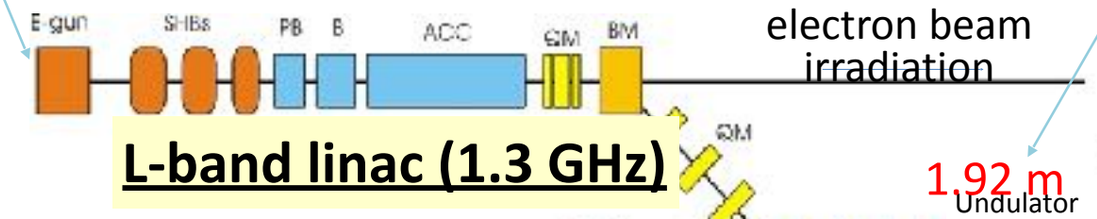
field electron emission (breakdown)

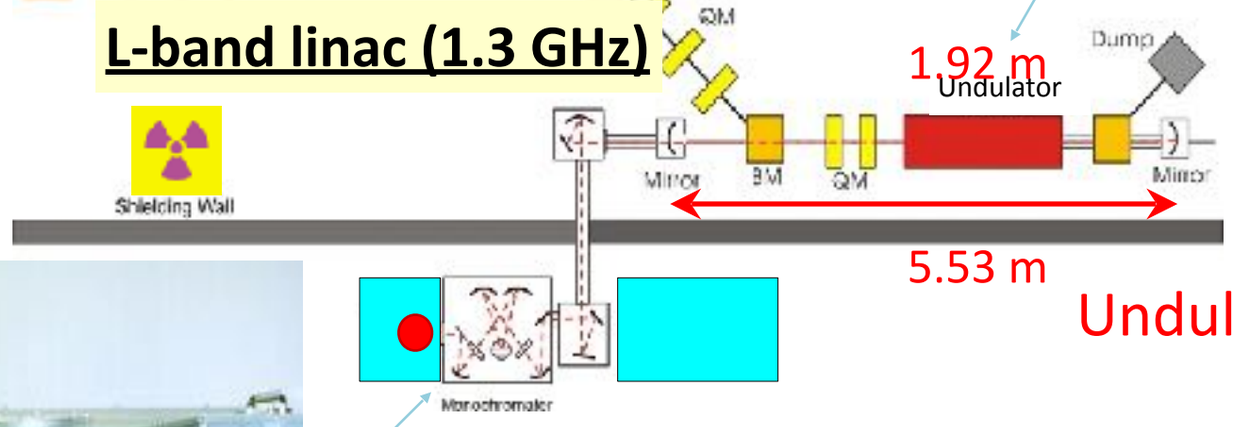
ISIR@OSAKA

Electron gun



Buncher and accelerator





Shielding wall

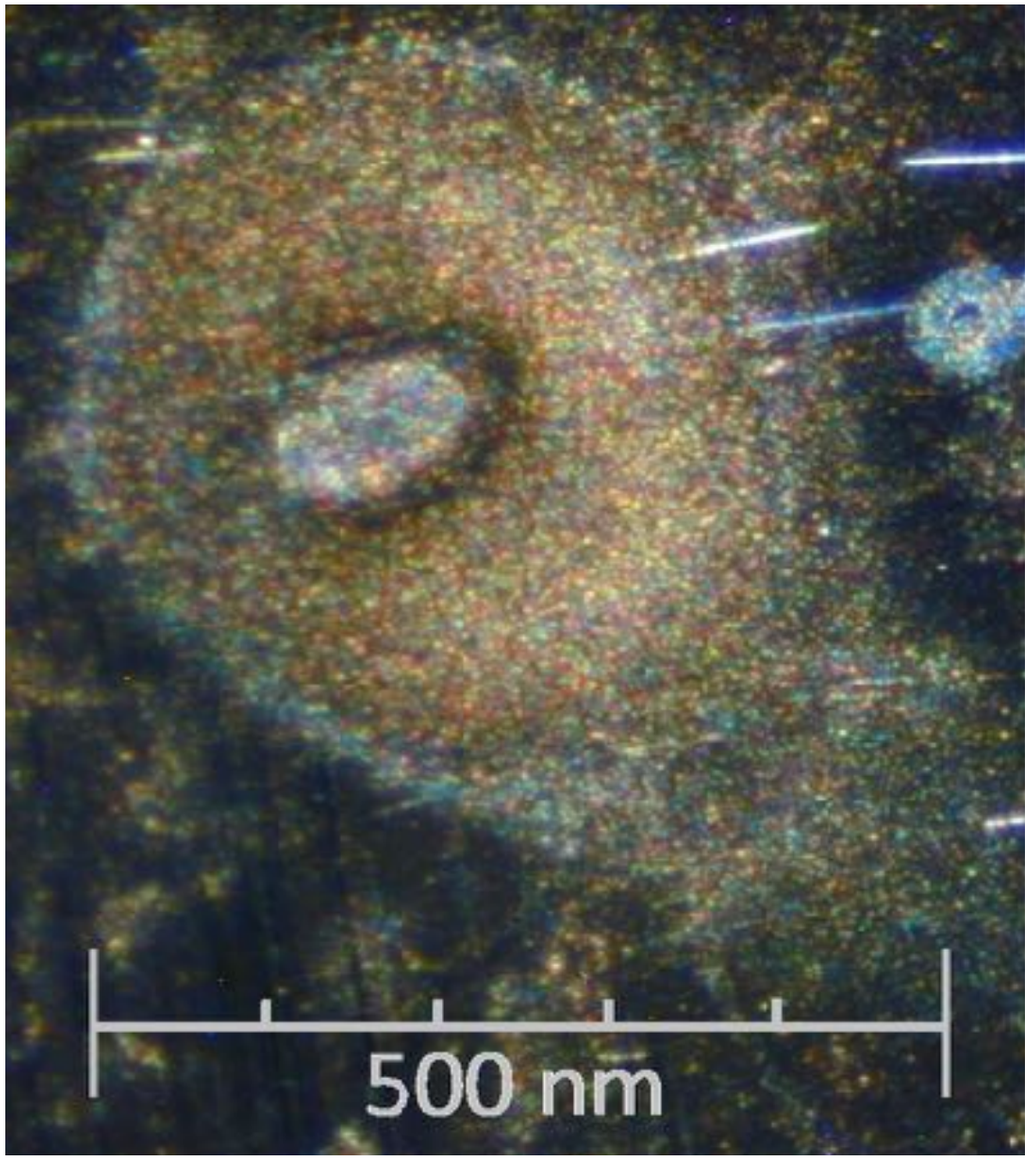
Undulator and resonator

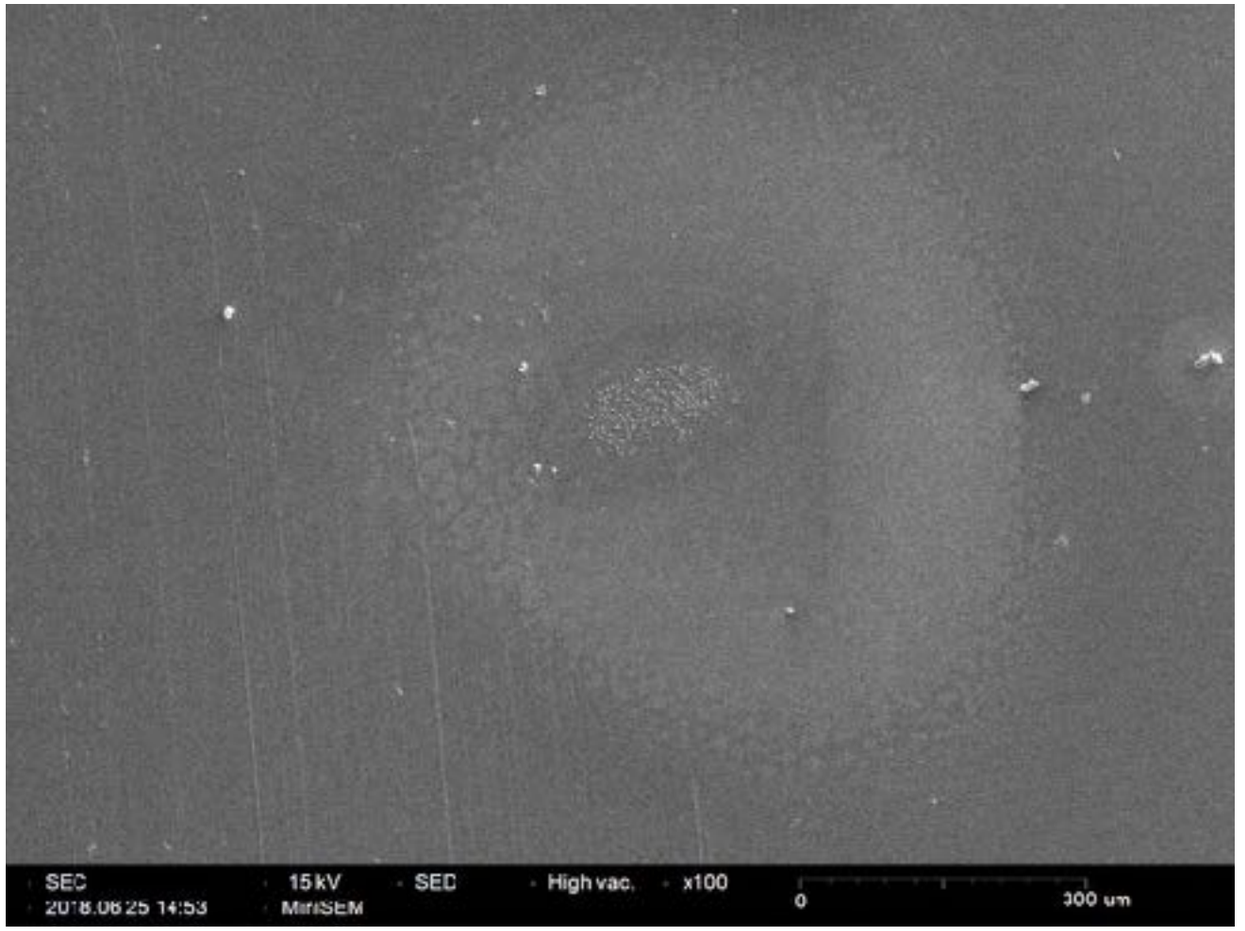
Experimental area

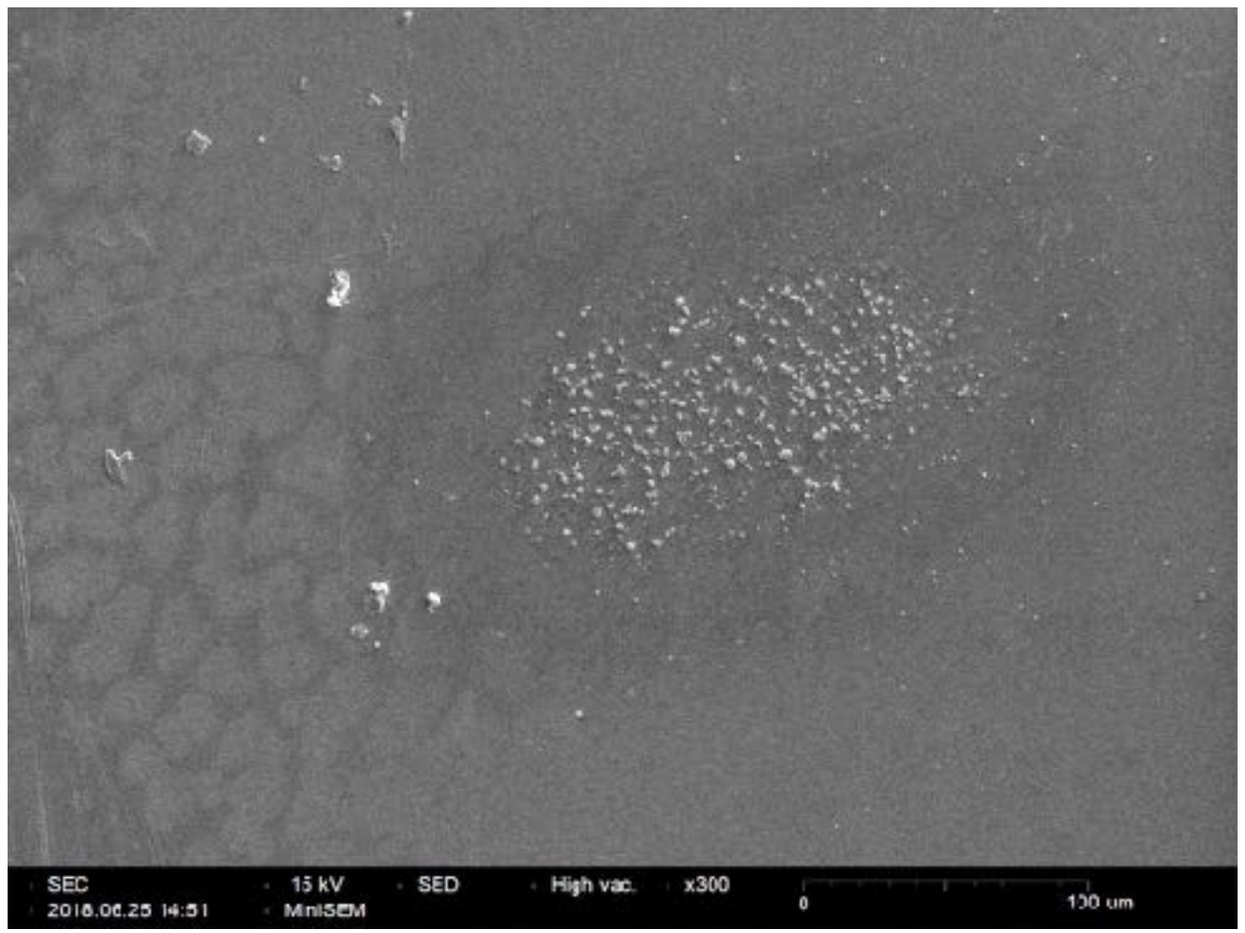
Farnesina
Ministero degli Affari Esteri
e della Cooperazione Internazionale

Courtesy A. Irizawa

Istituto Nazionale di Fisica Nucleare

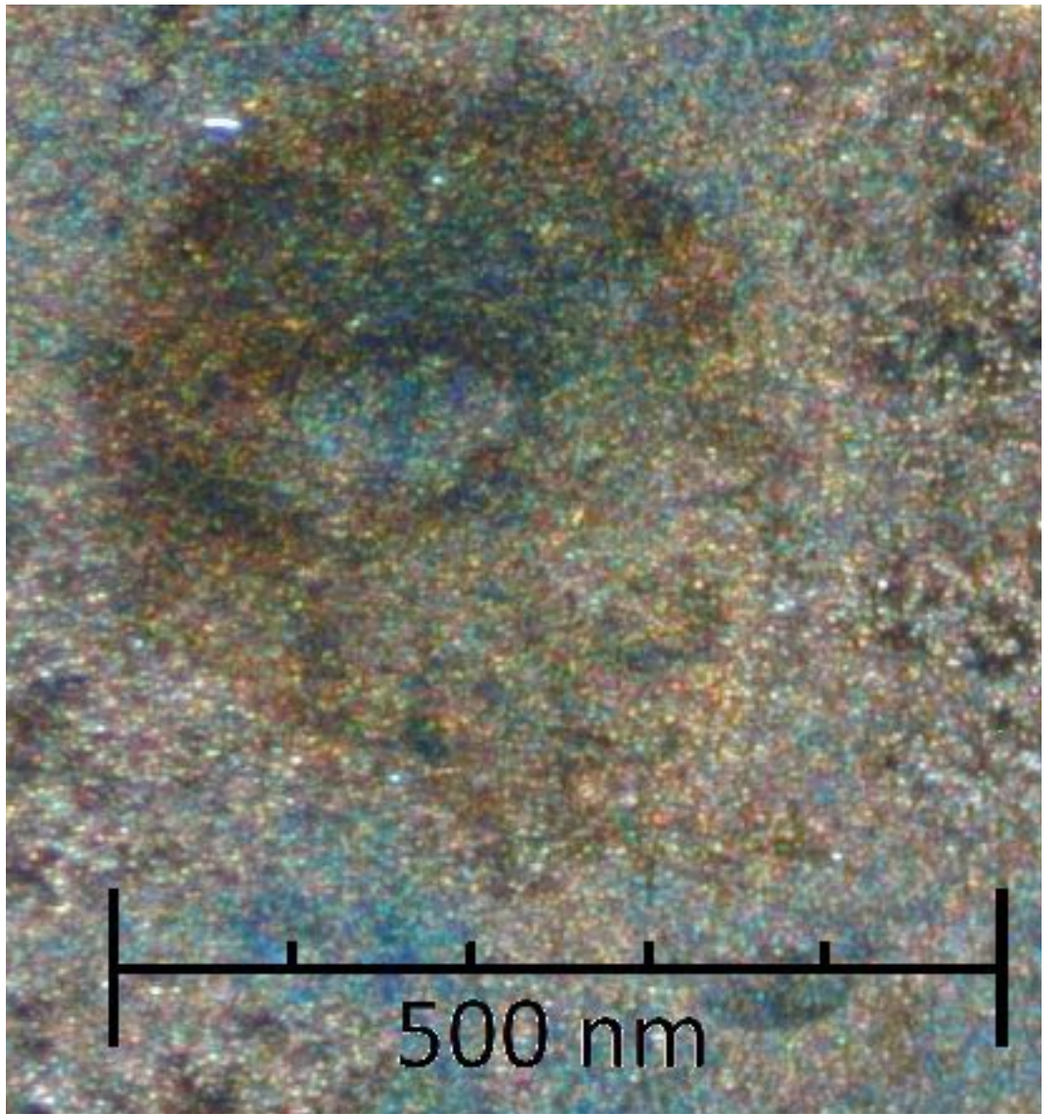


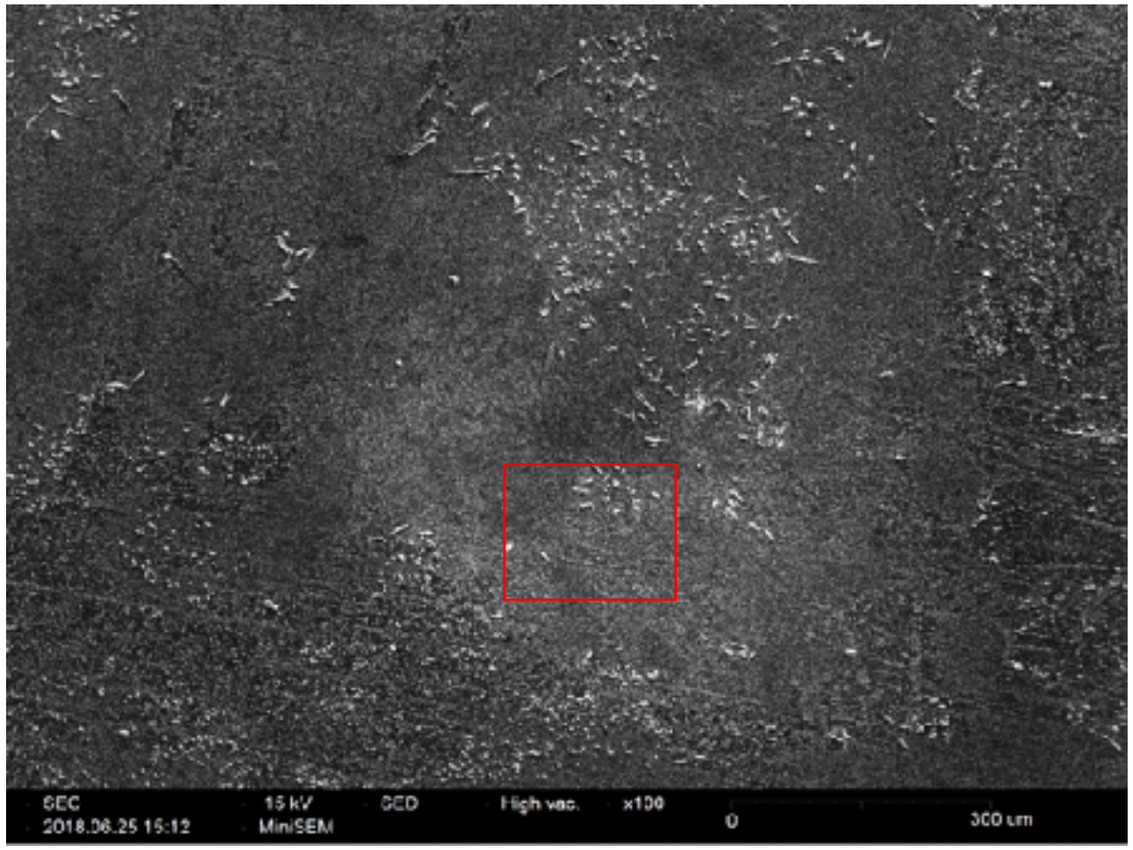


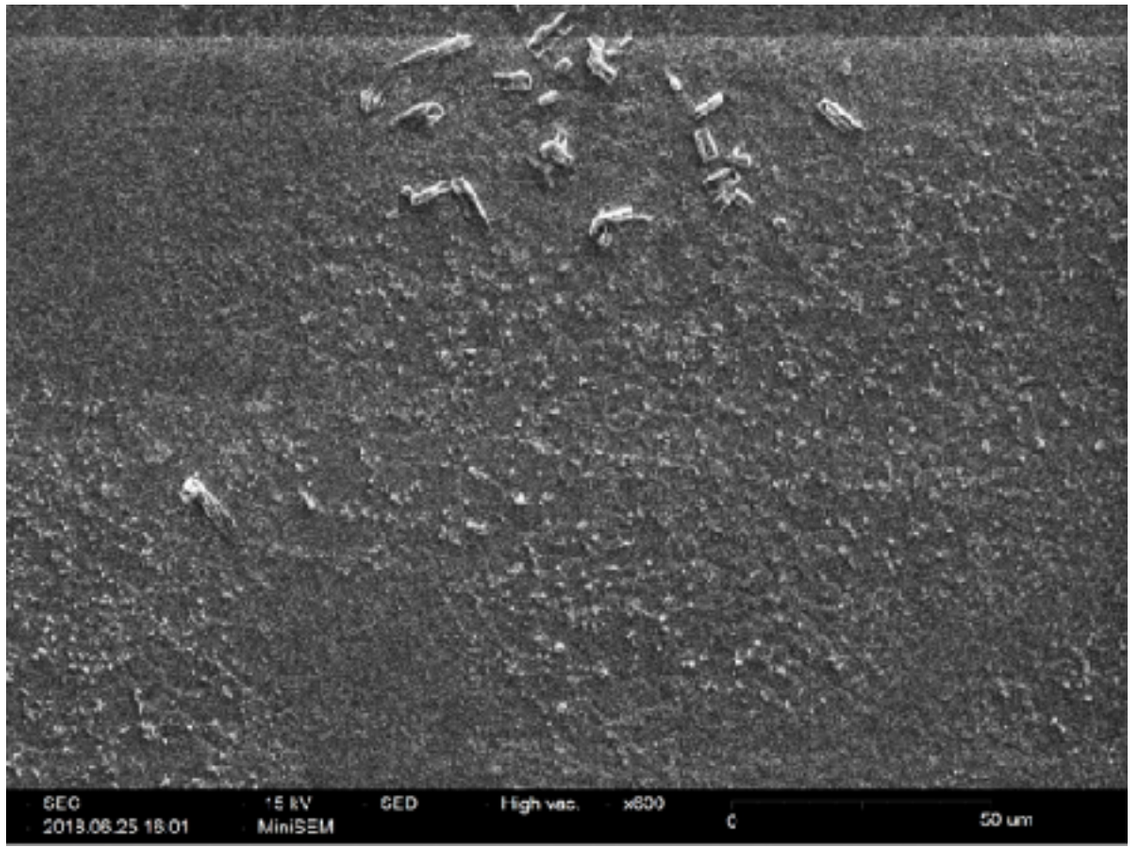


~10 GV/m

Irradiation no. 10
Sample: copper
 # shots: 5000
Angle: 45°
Center diameter: ~180 µm
Total spot diameter: ~400 µm







~10 GV/m

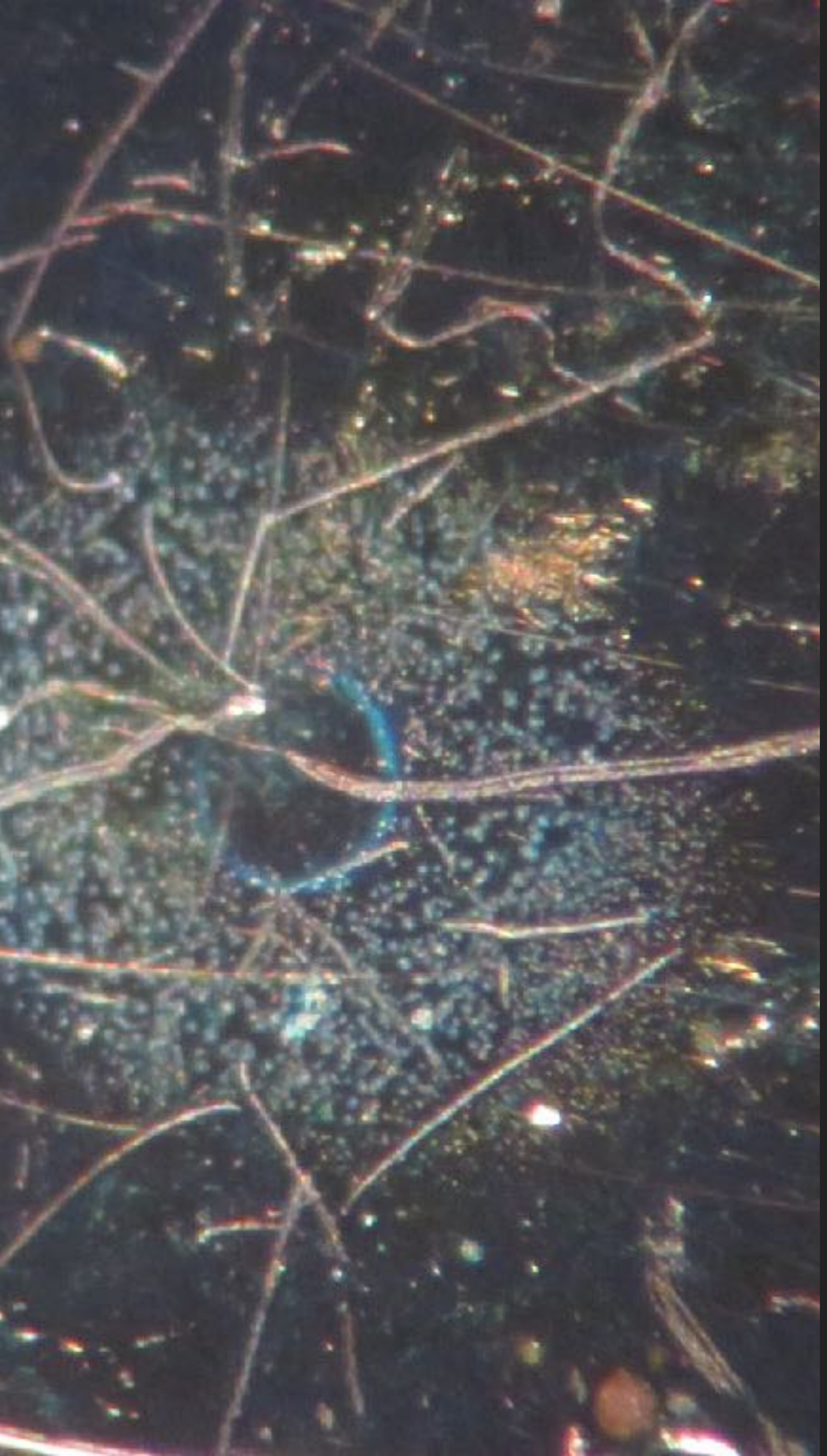
Irradiation no. 10
Sample: Annealed MoO3
 # shots: 5000
Angle: 45°
Center diameter: ~150 µm
Total spot diameter: ~370 µm

HIGHLIGHTS

- To improve the performance of RF device we propose to investigate the possibility to coat Cu materials with transition metal (TM) and TM oxides. Depositions of Mo and Mo oxides have been already obtained under vacuum and structural and electronic characterisation have been obtained with excellent results.
- The method we propose is a promising approach to obtain homogeneous coatings suitable to increase performances of RF cavities working at high frequencies. We combined FIB imaging to visualise at high spatial resolution the morphology of the films and to accurately measure the thickness. Transport experiments have been performed to measure the resistivity, while XRD and XAS techniques were used to evaluate the degree of crystallinity, identify different ordered phases and probe the local structure and their electronic properties.
- Mo and Mo oxides have been already characterised in term of conductivity properties for both ultra thin and thick films and in term of work function (WF). As an example, polycrystalline MoO_3, prepared by vacuum sublimation of MoO_3 exhibits a work function between 6.8-6.9 eV much higher then polycrystalline Cu whose WF is ~4.6 eV.
- In this project we plan to improve the adhesion and the harness characteristic of these films and apply this new technology to dedicated RF devices to be manufactured at LNF.

ACTIVITIES

- Preparation of thin and thick films on copper with TMs characterised by: Low electron field emission, high work function, high conductivity and high mechanical resistance
- Preparation of thin and thick TM/TM oxides films on curved surfaces of copper
- Damage (breakdown) tests at high electric field using FEL radiation up to several GV/m
- Manufacture of a small prototype of a RF cavity with a coating made by TMs or TMs oxides



NUCLEAAR 2019/20

LNF + RM1 FTE: 2.6

INFN/LNF FTE: 1.4

A. Marcelli (Coord. Naz.)	30 % Primo Ricer.
G. Della Ventura	40 % Associato
S. Macis	50 % Associato
J. Scifo	20 % Fellow
B. Spataro	Associato senior

INFN/RM1 FTE: 1.2

M. Petrarca (Coord. Loc.)	20 % Associato
S. Lupi	20 % Associato
S. Sarti	20 % Associato
A. D’Arco	60 % Associato