This project has received funding from the European Union’s Horizon 2020 Research and Innovation programme under GA No 101004730.

Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation.

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iFAST

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Accelerator Research and Innovation for European Science and Society (ARIES), coordinated by CERN

PROGRAMME: Horizon 2020 (Integrating Activity)
DURATION: May 2017- April 2021 (4 years)
TOTAL BUDGET: €24.8M
CONSORTIUM: 41 participants from 18 countries
WEBSITE: aries.cern.web.ch
PROJECT COORDINATOR: Maurizio Vretenar (CERN)

Fig. 3. Typical Schematic Cross-section of samples from CERN

The aim of the study is to develop laser technology for application in RF cavity.

Problems:

1. Grain size of Nb;
2. Adhesion of Nb layer to Cu substrate;
3. Pinholes.

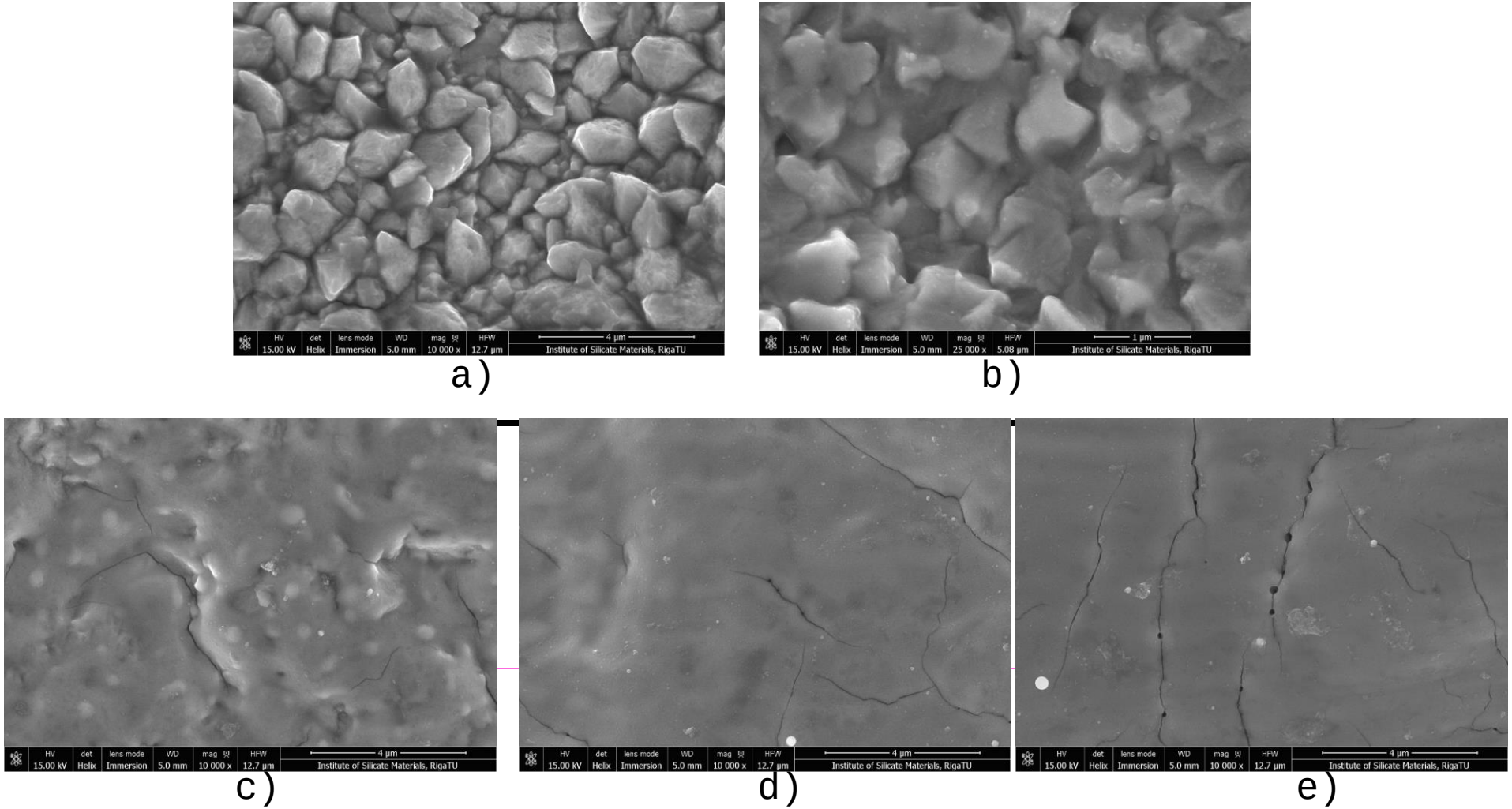


Fig.12. SEM images of Nb/Cu sample Nr.22/3/16 before irradiation (a) and after irradiation by Nd:YAG laser with
Intensities: I_1 = 140 MW/cm^2 (b); I_2 = 170 MW/cm^2 (c); I_3 = 253 MW/cm^2 (d); I_4 = 320 MW/cm^2 (e).

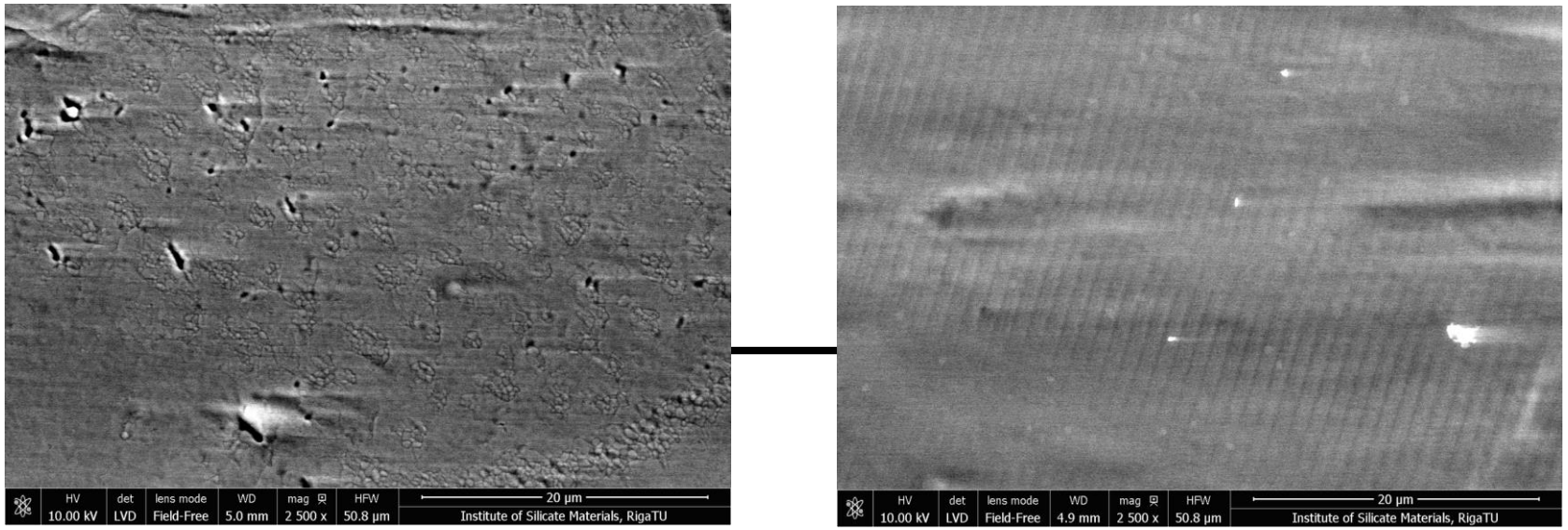


Fig.13. SEM images of Nb/Cu sample L16 , non-irradiated and irradiated by laser.

ARIES samples, before and after Laser-irradiation at RTU

deposited at INFN Legnaro

Magnetization measurements in Prependicular applied field, planar samples ~2x2 mm2

4.22 K	Field of 1st entry of mag. flux, 2% criterion		Δ/Ben, %	Field of maximum mag. moment		Δ/Bp, %	Cu Surface prep.
Sample:	Original	after-Laser		Original	after-Laser		
	Ben [Oe]	Ben [Oe]		Bp [Oe]	Bp [Oe]		
L8	180	191	6	465	465	0	Tumbling
C10	120	170	30	315	352	11	CERN subu
L16	140	155	10	320	322	1	EP+SUBU
L20	200	237	16	825	787	5	SUBU
L21	180	188	4	445	437	2	EP

Table 1. The flux entry field B_{en} (left), determined applying the 2% relative difference criterion, and the field of maximum magnetic moment B_p (right) before and after irradiation by laser depending on Cu surface preparation methods at 4.22 K.

[1]Medvids, A. Onufrijevs, P., Kaupuzs, Ja, Grase, L., Malyshev, O.B., Valizadeh, R., Žunda, A., Padgurskas, J. «Improvement of Nb/Cu adhesion and increase of Nb crystal size by laser radiation» **Applied Surface Science,** Vol. 525(2020)146528.

[2]

Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation.

Partners:

1.Riga Technical University(RTU),Dr.A.Medvids;
2.United Kingdom Research and Innovation (UKRI),Dr.R.Valizadeh;
3.Institute of Electrical Enginering (IEE),Dr.E.Seiler;
4.Helmholz-Zentrum Berlin (HZB),Dr.O.Kugeler;
5.Instituto Nazionale di Fisica Nucleare(INFN), Dr.C.Pira.

Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation.

- 1. **Transfer of laser technology from flat surface to the inner surface of Nb/Cu based RF cavities.**

- 2. **Define laser parameters for complex shape 3D irradiation in order to increase superconducting properties of RF cavities.**

Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation.

- 1. **Transfer of laser technology from flat surface to the inner surface of Nb/Cu based RF cavities.**
- This Task will develop laser technology to improve mechanical and superconducting properties of Nb/Cu based RF cavities. The inner surface of the cavities will be irradiated by a Nd:YAG laser in order to improve the Nb adhesion to Cu, to increase the grain size of Nb, and to perform laser polishing of the Nb surface. These changes may lead to an increase of the first magnetic flux entry field B_{en} up to 20%, due to the increase of the Nb crystals size up to 20 % and the improvement of adhesion (the critical delamination force increased up to 36 %), opening the way to larger accelerating fields.

Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation.

- 2. **Define laser parameters for complex shape 3D irradiation in order to increase superconducting properties of RF cavities.**
- The goal of this Task is a fully developed laser technology ready for the irradiation of the inner surface of the 1.3 GHz RF cavities used in many particle accelerators. In the first step of testing on simple copper tubes;
- 1. INFN will polish 80mm and 200 mm diameter and 200 mm long cylindrical Cu tubes;
- 2. UKRI will coat the tubes with Nb thick film of a few microns;
- 3. RTU will treat them with a Nd:YAG laser in Ag atmosphere and perform a full surface characterization:
- a. The AC/DC superconducting properties will be evaluated at IEE;
- b. deposited with a Nb film and RF tested at UKRI and/or INFN.

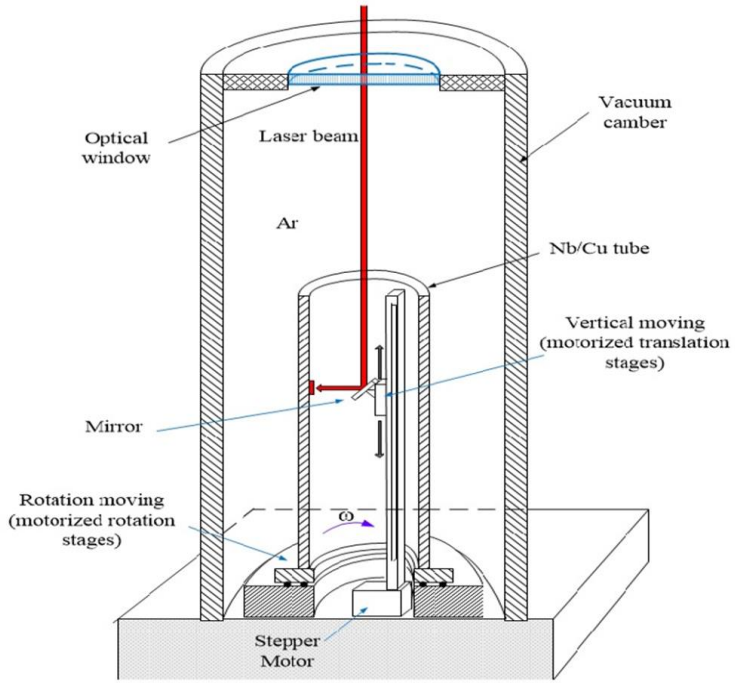
c. HZB will perform additional testing.

In the second step, the procedure will be applied to a complex 1.3 GHz Cu cavities coated with Nb film.

IFAST WP9.5 Milestone 41:
A facility for laser operation for complex 3D treatment is tested on 1.3 GHz cavity (Report)

- **IFAST WP9 Deliverable 9.5:**
- 1.3 GHz Nb coated cavity irradiated by laser in Ar atmosphere and RF tested.
- *Increasing of the field of magnetic flux entry in Nb coated 1.3 GHz cavity irradiated by laser in Ag atmosphere. Standard RF testing.*

Cross-section of the laser facility for irradiation inner surface of RF cavity



Laser facility:

L=300mm, D=250mm, Ar gas atmosphere 1.5 atm pressure.

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Thank you very much for your attention!

MS41: A facility for laser operation for complex 3D treatment is tested on 1.3 GHz cavity (Report)

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