



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

Developing laser treatment facility for tubes/cavities at RTU (Task 9.5)

Arturs Medvids, Pavels Onufrijevs, Aleksandr Mychko

Laboratory of Semiconductor Physics, Institute of Technical Physics, Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena 3/7, Riga, LV-1048, Latvia

iFAST

18.04.2023.



The aim of 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. UK Research and Innovation (UKRI), Dr.R.Valizadeh;
3. Institute of Electrical Engineering (IEE), Dr.E.Seiler;
4. Helmholtz-Zentrum Berlin (HZB), Dr.O.Kugeler;
5. Istituto Nazionale di Fisica Nucleare(INFN), Dr.C.Pira.

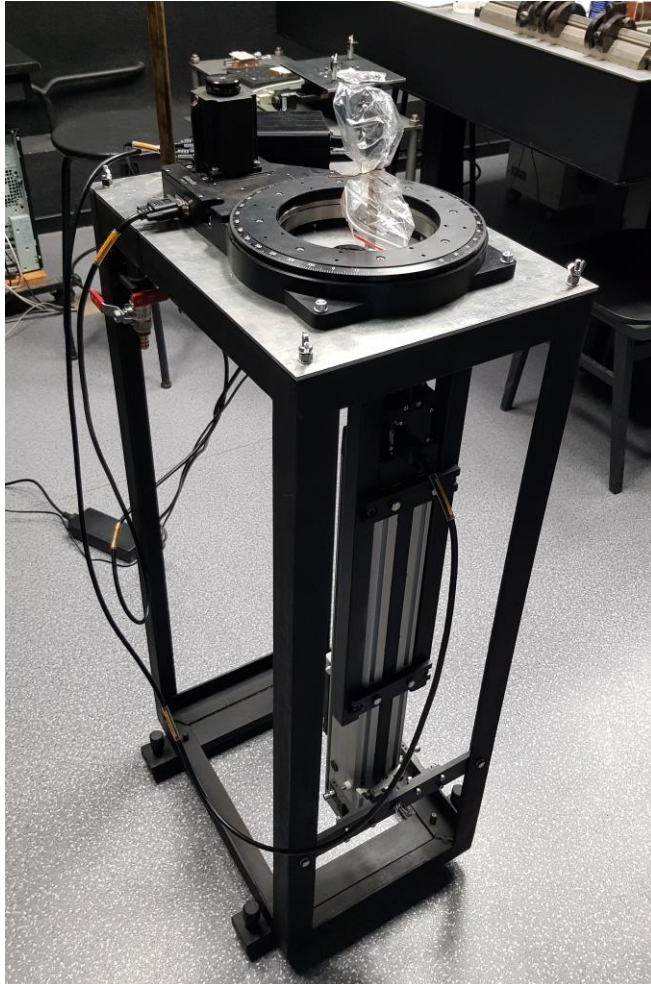


Fig. 1. Scanning system for cylindrical copper tubes Nd:YAG laser.

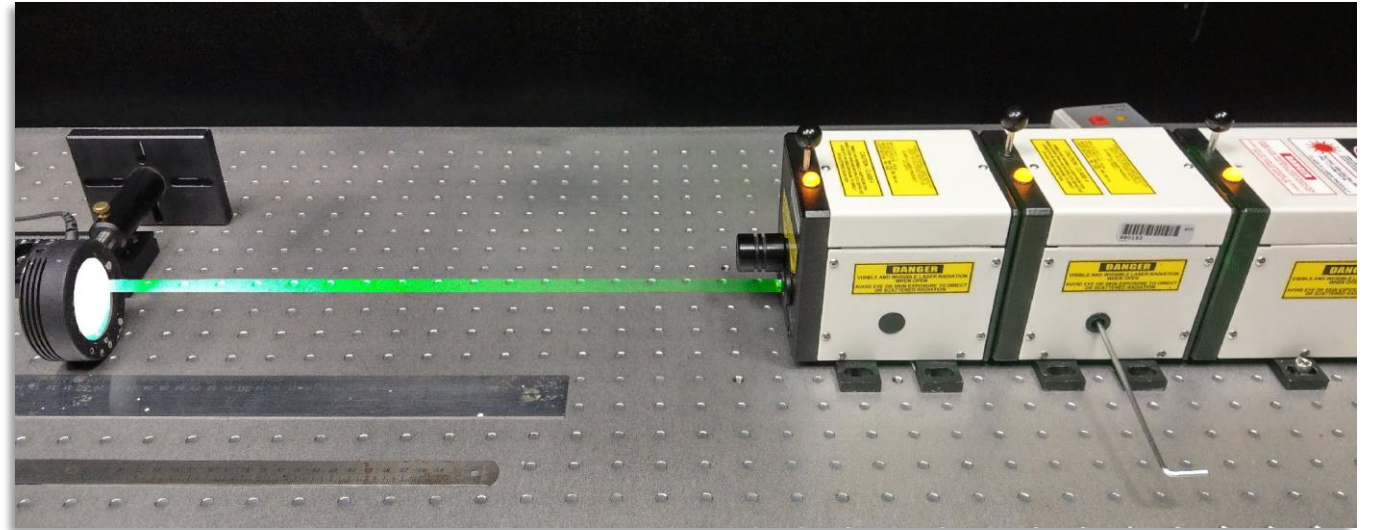


Fig.2. Nanosecond Nd:YAG laser,

- wavelength 1064 nm,
- pulse duration 6 ns,
- repetition rate of 10 Hz
- beam diameter of 0.5 mm.
- Scanning of the laser beam was performed normally to the surface with a speed of 1.2 mm/s and hatch of 0.4 mm.
- The irradiation of the samples was carried out at room temperature in Ar chamber to prevent oxidation.

Optical microscope image

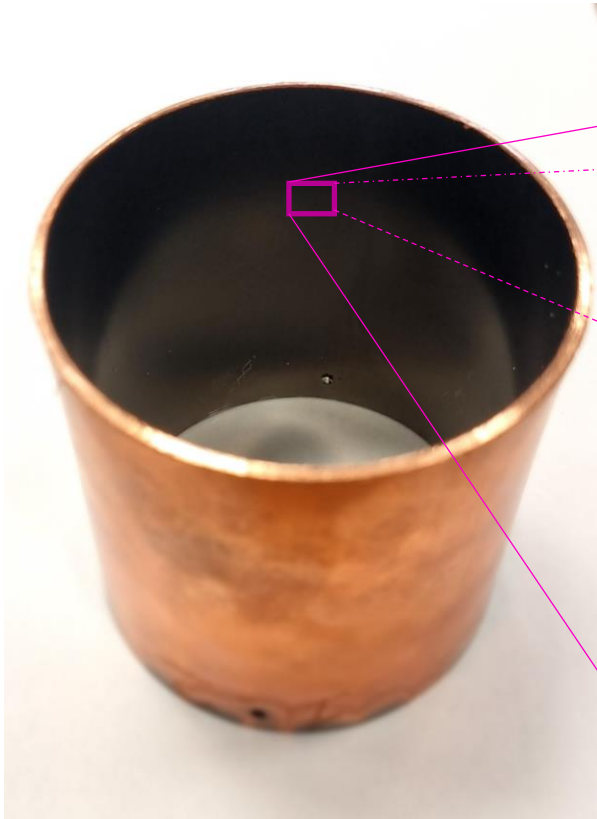
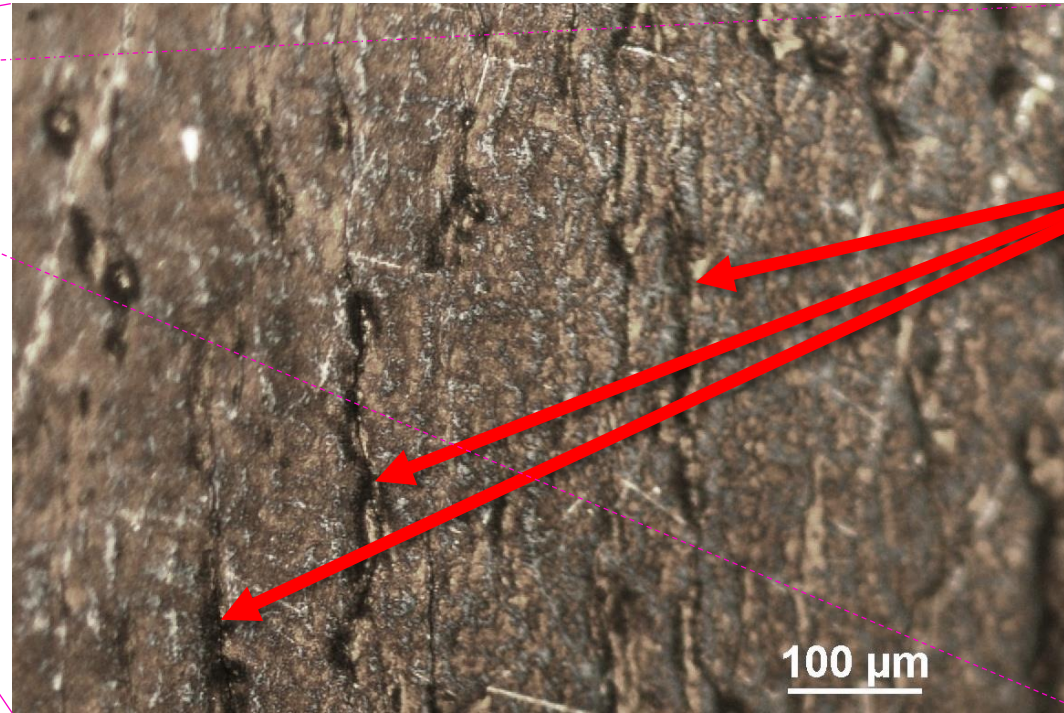


Fig. 3. Samples were prepared by coating a cylindrical copper tube with a thin layer of Nb film.



Cracks

The samples were sent to Dr Reza Valizadeh for determination of reasons of cracks.

Fig.4. Optical microscope image of the surface of a cylindrical copper tube with a thin film of niobium (Nb) before laser processing.

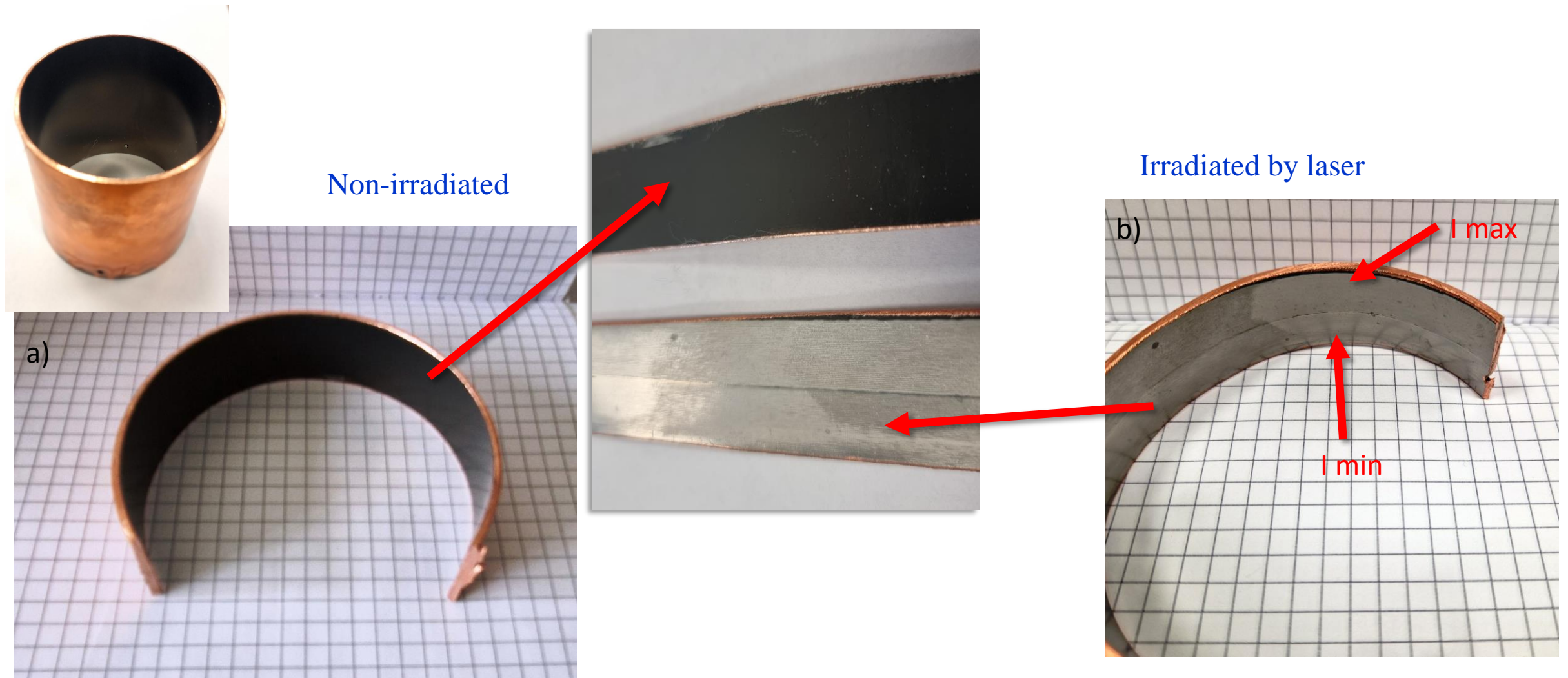


Fig.5. Samples formed from cylindrical copper tube with Nb film: (a) non-irradiated; (b) irradiated in Ar chamber by ns laser radiation.

XRD pattern of Nb/Cu

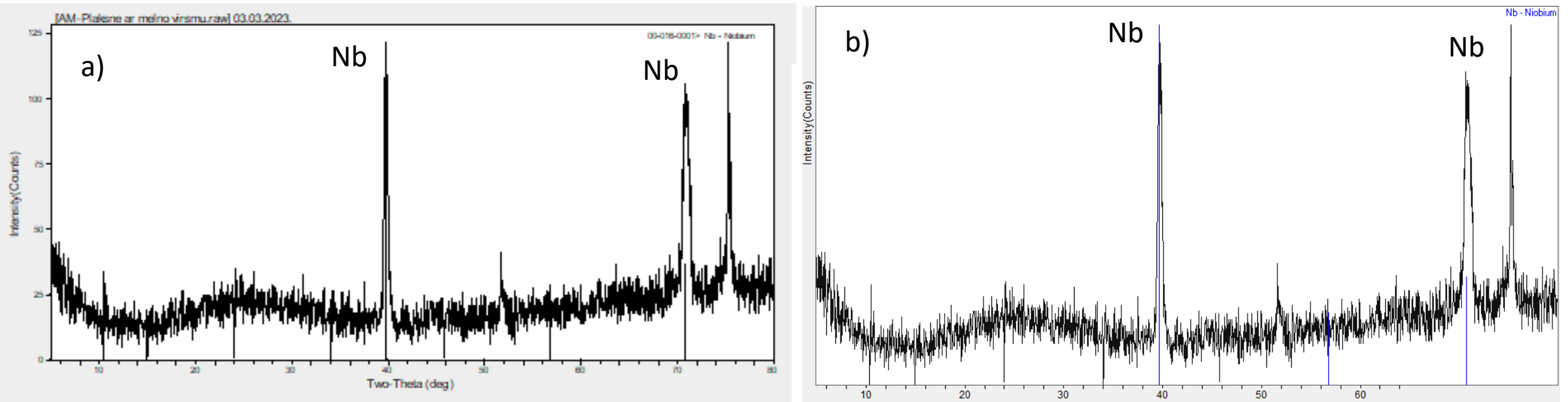


Fig.6. XRD pattern of cylindrical copper tube with Nb film: (a) non-irradiated; (b) irradiated by laser.

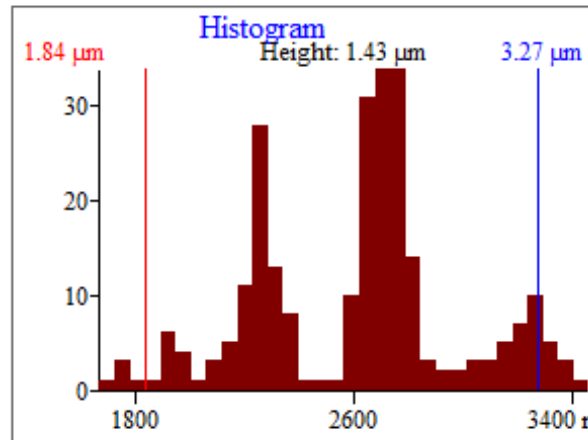
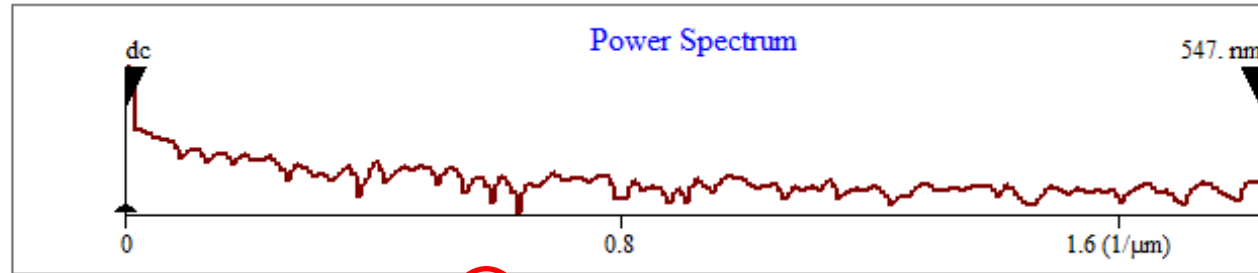
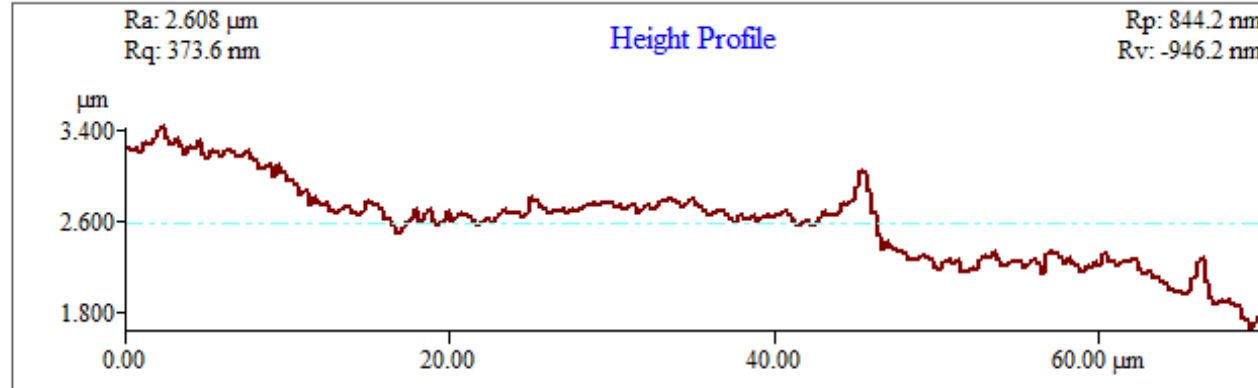
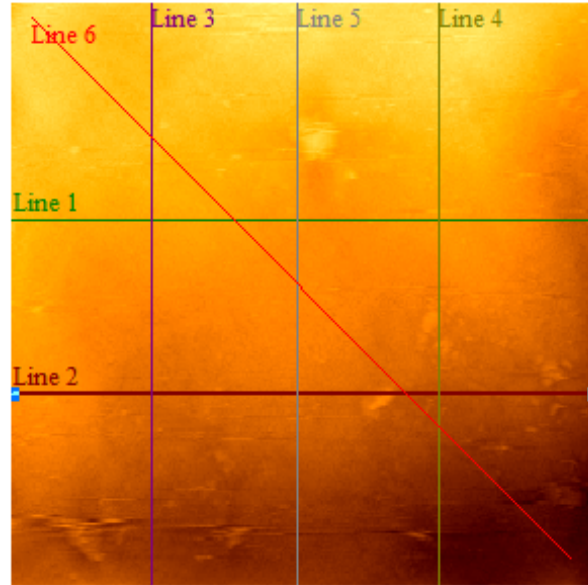
The surface of the sample does not contain black crystals of NbO_2 [1].

The surface appears black due to its uniform absorption of all visible wavelengths of light.

XPS should be preformed.

Non irradiated surface texture parameters

(255,8) x: 69.7 μm y: 2.188 μm z: 0.6491 μm



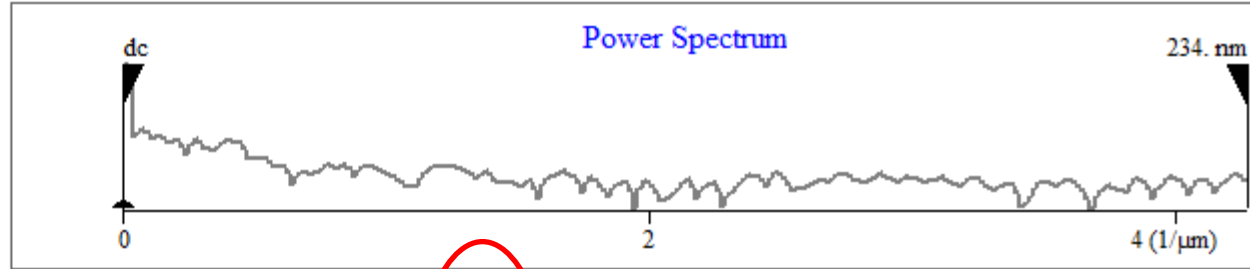
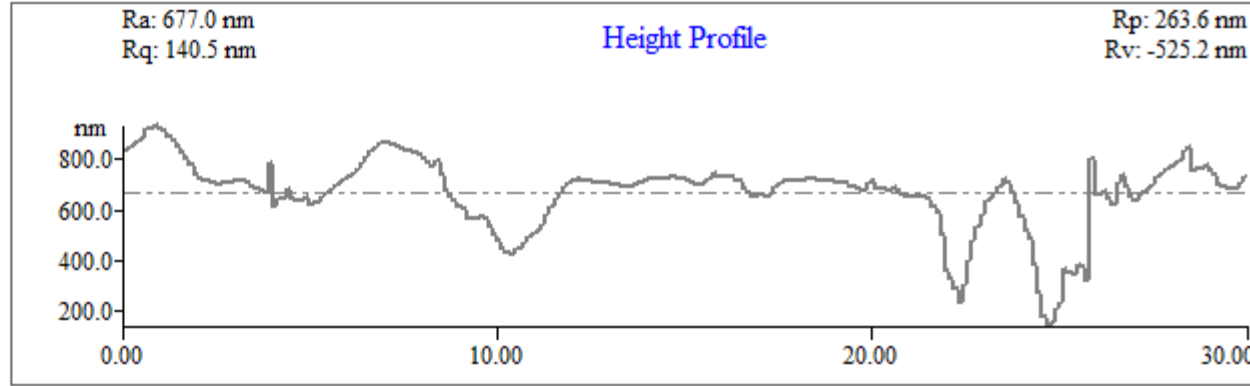
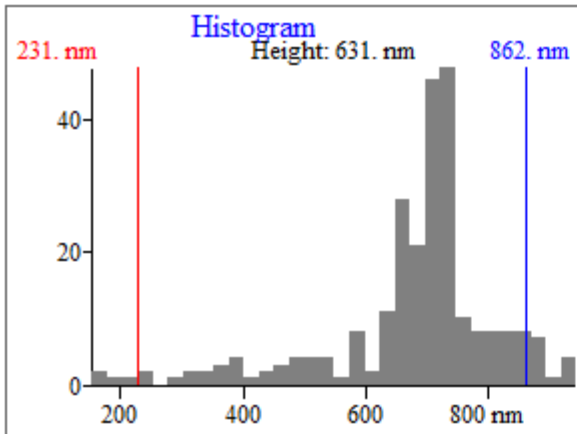
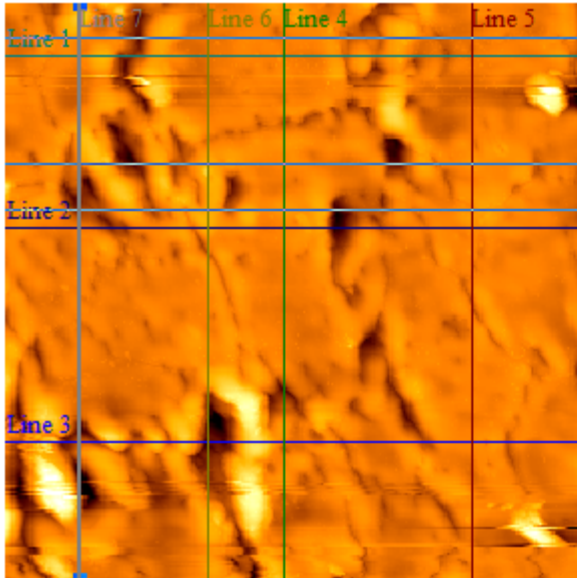
	Rp-v	Rms Rough (Rq)	Ave Rough (Ra)	Mean Ht	Median Ht	Arc length	Bearing Ratio
Line 2	1.790 μm	373.6 nm	292.3 nm	2.608 μm	2.668 μm	78.81 μm	@30.0% 2.75 μm
Line 3	2.652 μm	845.8 nm	753.0 nm	3.158 μm	3.167 μm	79.07 μm	@30.0% 3.98 μm
Line 4	3.908 μm	1.196 μm	1.026 μm	2.951 μm	3.005 μm	80.92 μm	@30.0% 3.79 μm
Line 5	3.523 μm	913.4 nm	733.2 nm	3.118 μm	3.148 μm	80.02 μm	@30.0% 3.55 μm
Line 6	3.760 μm	1.132 μm	962.2 nm	2.972 μm	3.171 μm	101.3 μm	@30.0% 3.82 μm
Delta [.]							

Ra -average, or arithmetic average of profile height deviations from the mean line.

The roughness parameters Ra are in the range of a few microns from about 1 to 5.

Irradiated surface texture parameters

(236,240) x: 27.7 μm y: 28.13 μm z: 0.7189 μm



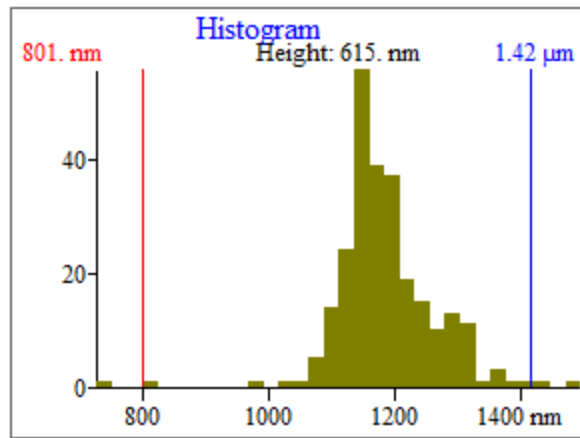
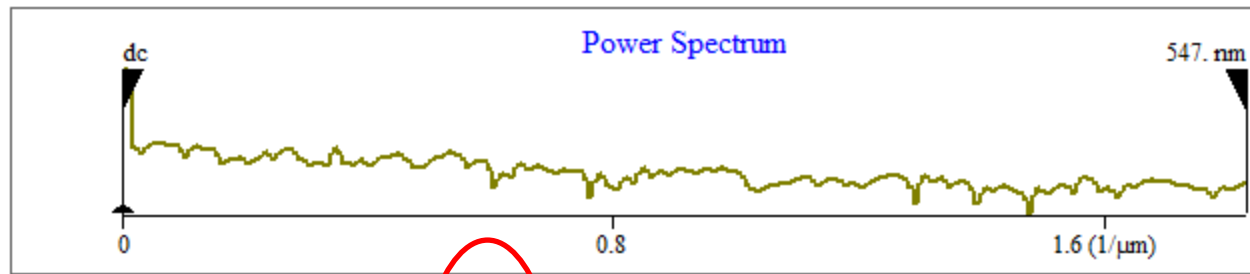
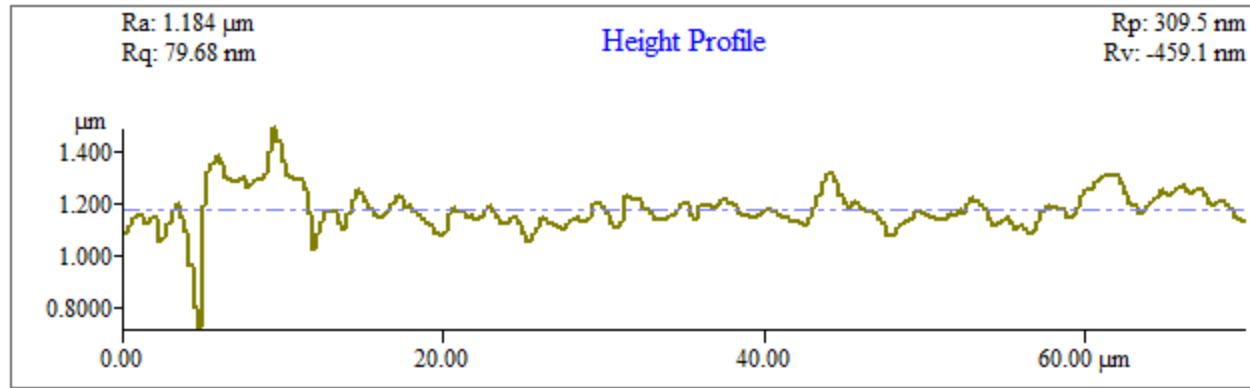
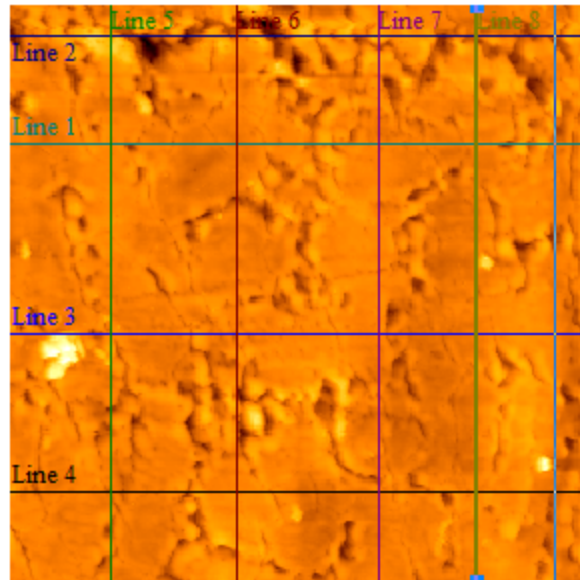
	Rp-v	Rms Rough (Rq)	Ave Rough (Ra)	Mean Ht	Median Ht	Arc length	Bearing Ratio
Line 3	685.5 nm	132.0 nm	94.28 nm	714.7 nm	710.0 nm	34.69 μm	@30.0% 756.16
Line 4	486.0 nm	65.70 nm	44.87 nm	709.3 nm	715.5 nm	33.62 μm	@30.0% 745.07
Line 5	218.1 nm	37.35 nm	29.11 nm	722.7 nm	729.8 nm	33.46 μm	@30.0% 741.88
Line 6	654.8 nm	143.1 nm	107.6 nm	698.8 nm	728.5 nm	33.68 μm	@30.0% 783.49
Line 7	788.8 nm	140.5 nm	95.93 nm	677.0 nm	710.1 nm	34.58 μm	@30.0% 728.16
Delta [.]							



After laser exposure, the roughness parameters *Ra* decreased by about *two* orders of magnitude.

Irradiated surface texture parameters

(242,129) x: 66.2 μm y: 35.27 μm z: 1.138 μm



	Rp-v	Rms Rough (Rq)	Ave Rough (Ra)	Mean Ht	Median Ht	Arc length	Bearing Ratio
Line 4	552.4 nm	76.41 nm	57.55 nm	1.184 μm	1.184 μm	73.61 μm	@30.0% 1.22 μ
Line 5	974.5 nm	121.0 nm	79.45 nm	1.213 μm	1.215 μm	73.81 μm	@30.0% 1.25 μ
Line 6	696.4 nm	112.7 nm	80.01 nm	1.181 μm	1.181 μm	74.14 μm	@30.0% 1.23 μ
Line 7	651.0 nm	90.05 nm	66.90 nm	1.195 μm	1.194 μm	73.61 μm	@30.0% 1.23 μ
Line 8	768.5 nm	79.68 nm	55.43 nm	1.184 μm	1.172 μm	73.40 μm	@30.0% 1.20 μ
Delta [.]							

Summary

1. The cylindrical copper tubes with Nb were effectively scanned using laser radiation in an Ar chamber.
2. X-ray diffraction (XRD) analysis showed that there were no traces of niobium oxide present in either the non-irradiated or irradiated samples treated with the Nd:YAG laser.
3. The irradiated samples' surface roughness (Ra) decreased by more than ten times compared to the non-irradiated samples.
4. The number of cracks on the irradiated samples increased, they became smaller in size after laser processing.

iFAST

Thank you very much for your attention!



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