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

Task 9.5: Laser treatment of Nb/Cu films for RF cavity

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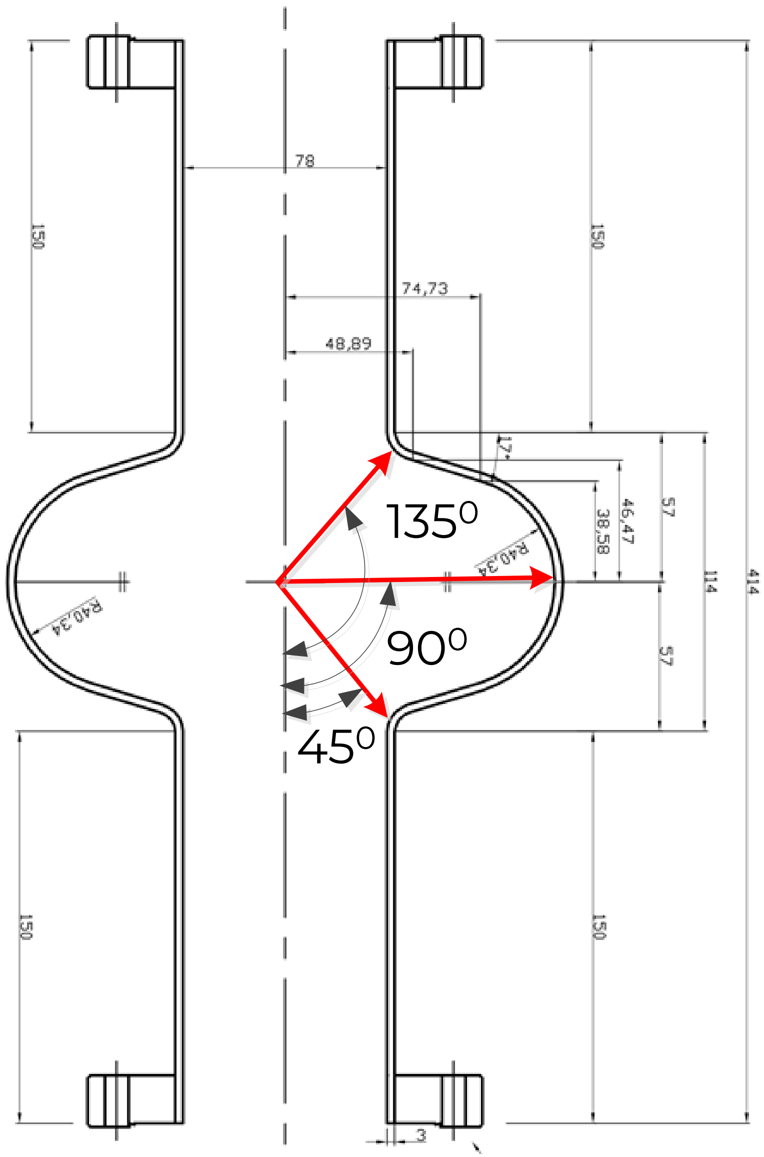
19.01.2024.

I- 3D Laser Scanning system for irradiation of RF cavity.



1.At this stage, a control device along the third coordinate is being designed. The device consists of a miniature motorized rotating table with an attached mirror. The rotating mirror is mounted on a vertically moving platform . At a certain height, simultaneously with the movement of the platform, the angle of inclination of the mirror changes so as to ensure an angle of incidence of the laser beam on the surface equal to 90^0 with an error of $\pm 10^0$.

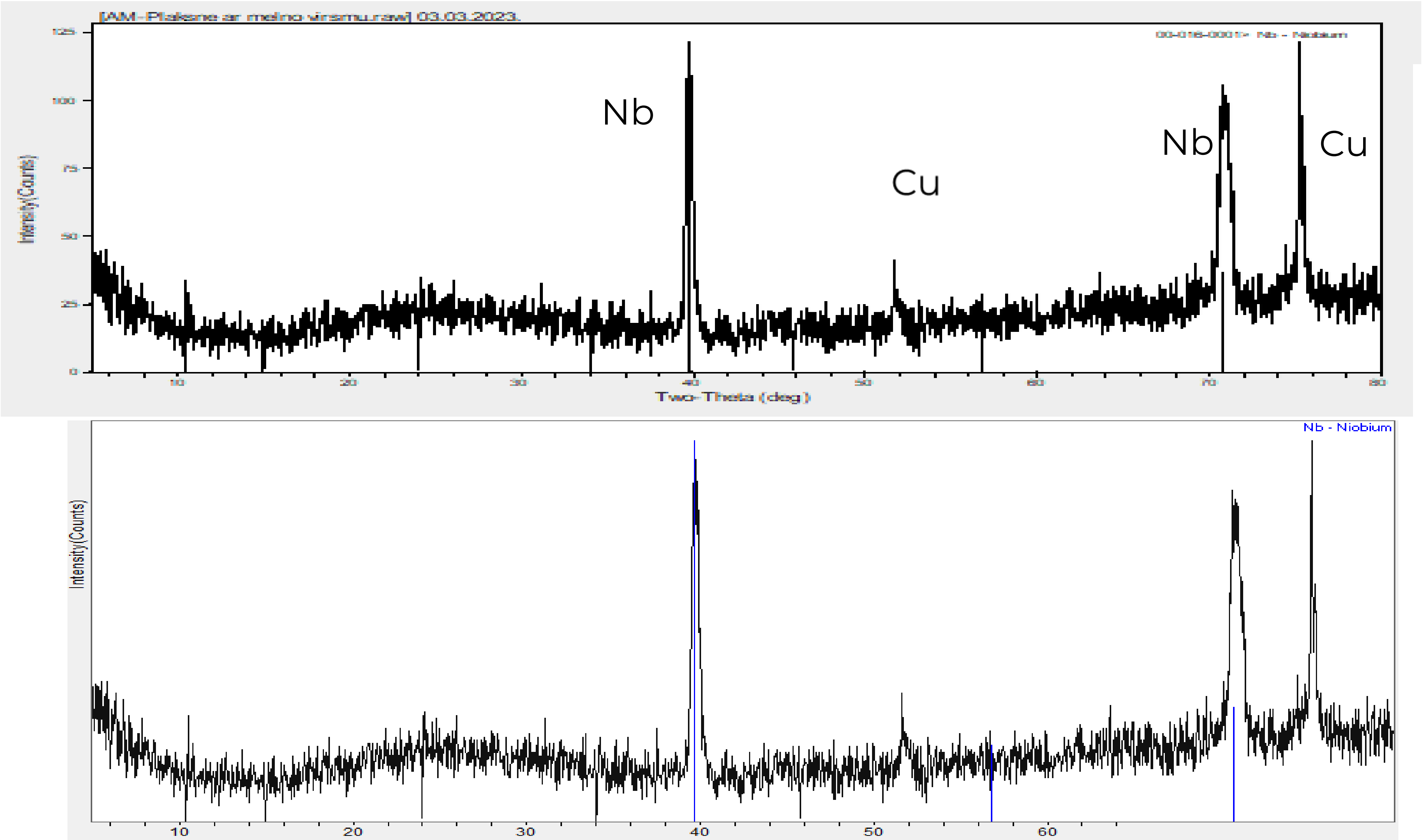
2.To implement this irradiation mode, work is underway to create software that synchronizes the work on the 2nd and 3rd coordinates.

II-Mechanical properties of Nb/Cu

Fig.1. a-XRD pattern of non-irradiated, and b-irradiated by laser Nb/Cu structure

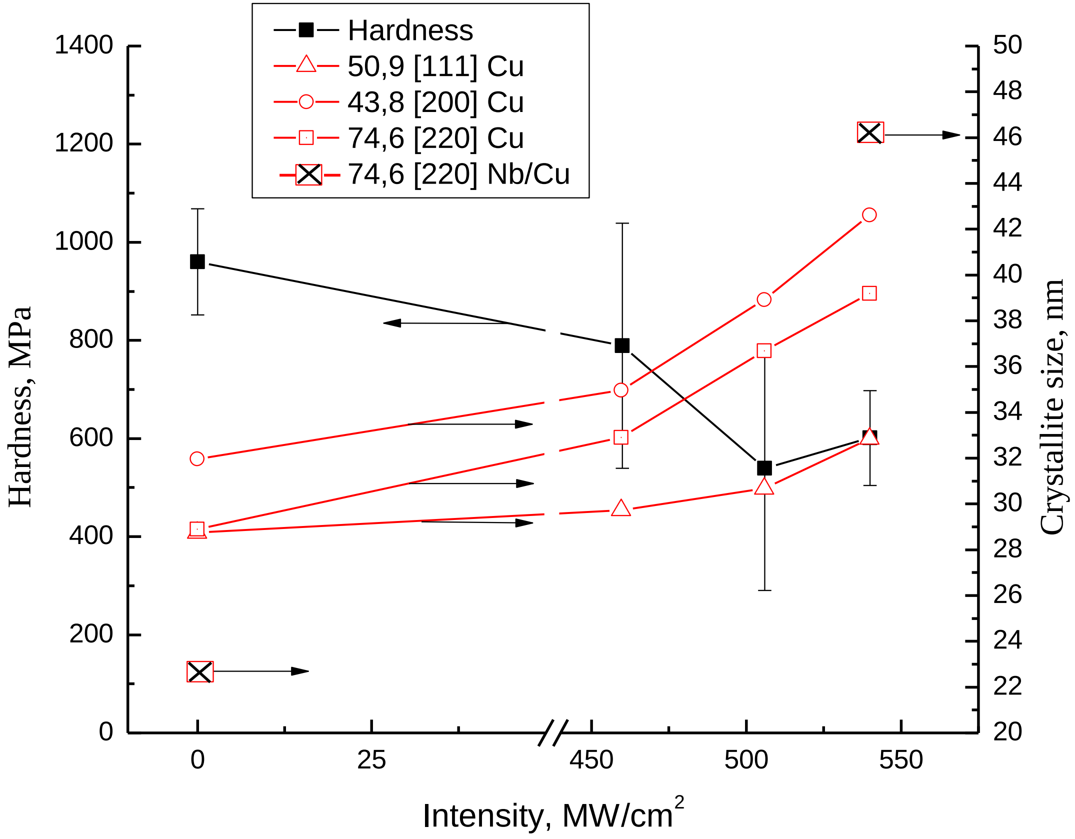
a)

b)



We can see from Fif.1 that irradiation of the structure by the laser leads to a decrease in the width of XRD lines. It means the size of the crystals of both Nb and Cu increase. Therefore, we studied the influence of laser radiation intensity on Cu crystals size, hardness, and thermal conductivity.

Fig.2. Dependence of Hardness and Crystallite size of Cu substrate on the Nd:YAG laser radiation intensity.



Diffusivity non-irradiated Cu is α= 59 mm^2/s and, after irradiation by the laser, is independent of laser intensity and is α= 62 mm^2/s. From Fig.2. we can see that the size of Cu crystal, using Sherer's formula, increases more on 25 % for [220] direction and from Fig.1a and b 2 times increases up to twice. At the same time, the hardness of Cu decreases twice, too.

Calculation of temperature distribution in Cu wafer after the irradiation by laser

The temperature distribution in the irradiated Cu wafer was calculated by solving the Stefan problem. The heat conduction equation is written as

$$c\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(\kappa\frac{\partial T}{\partial x}\right)+g(x,t)$$

where T is the temperature, which depends on coordinate x and time t, c is the heat capacity, k is the thermal conductivity and $g(x,t)$ is the heat source due to the absorption of laser irradiation. The initial condition is $T=T_0$ for all x, where $T_0=300K$ is the room temperature. The boundary condition $\partial T/\partial x=0$

is used at the surface, implying the absence of heat exchange with the ambient. The equation was solved numerically by the well known implicit Crank-Nicolson difference scheme.

For estimation of thermal diffusion length $L=\sqrt{(\alpha\cdot\tau)}$, where α is diffusivity, τ is pulse duration, for example, for Nd:YAG laser radiation L=6 nm and for flash lamp up to 1mm.

Conclusion

Irradiation of Nb/Cu system leads to 6 μm soft Cu layer formation between Nb and Cu.

In the case of longer pulse duration, for example, a flash lamp with pulse duration up to 1 ms or longer, the complete Cu substrate becomes soft and unsteady.

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Thank you very much for your attention!

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