Contribution ID: **47** Type: **not specified**

Improvement of Nb thin film on Cu substrate by Nd:YAG laser radiation

Tuesday, 9 October 2018 15:55 (25 minutes)

The properties of Nb thin films deposited on planar Cu substrate were studied after its laser annealing. Five samples were prepared employing different substrate preparation techniques and were subsequently coated with 3-μm thick Nb film with the same deposition parameters. Afterwards, the Nb films were irradiated using Nd:YAG laser in order to increase crystallinity and improve adhesion of the Nb layer. The non-irradiated and irradiated surfaces were studied employing SEM, EDS, XRD and optical microscopy. It was found that the non-irradiated Nb film is delaminated in some places. This effect probably occurs due to mechanical stresses after the deposition of a very thick Nb film on Cu substrate. This is suggested by the observed Nb presence under the delamination layer according to EDS measurements. Irradiation of the structure by the Nd:YAG laser leads to increase of the Nb grain size according to SEM measurements. The study of the irradiated structure by XRD method revealed decrease of mechanical strain by a factor of two.

Typical for the Nb/Cu samples studied is the presence of pinholes with size up to 500 nm. Only for one of the samples the surface is characterized by chaotically distributed scratches with lengths up to 10 μm. In one case the pinholes are longitudinal and orientated with length up to 5 μm. After irradiation by pulsed Nd:YAG laser (λ= 1064 nm, τ =6 ns and intensity up to I=200 MW/cm2) in scanning mode with step 5μm in Ar atmosphere, the longitudinal pinholes fully disappeared and a periodical structure - Laser-Induced Periodic Surface Structures (LIPSS) appeared, with period 1 μm and amplitude up to 5 nm. The surfaces became smoother, but with some cracks up to 5 μm length. The surface roughness decreased by a factor 10 for all the samples.
To study the impact of laser annealing on superconducting properties, the samples were measured at VSM/PPMS in a perpendicular magnetic field before and after laser irradiation
The authors would like to acknowledge the support provided by European Union's ARIES collaboration H2020 Research and Innovation Programme under Grant Agreement no. 730871.

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Session Classification: Advanced cleaning of substrates

Track Classification: Advanced preparation of substrates and atmospheric plasmas