10.6 Works in INFN-Roma Tor Vergata: Generation of Nb Superconducting Layers

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In 2007 upgrading of superconducting parameters of niobium layers obtained by vacuum arc deposition was carried out at Roma Tor Vergata University by using negative pulsed bias of a coated substrate [1]. A series of Nb coatings on sapphire samples have been performed in a planar vacuum arc device at both constant and pulsed negative substrate bias. The pulsed bias was reached by using a dc power supply connected in series with a keying module (designed and delivered by the Dept. of Plasma Physics and Technology, SINS) controlled by a pulse generator. Constant bias voltage was varied between ~40V and ~80V respectively to the grounded anode of the arc system. Pulsed bias with ~60V amplitude was applied at pulse frequencies of 1 kHz, 10 kHz, 40 kHz and 100 kHz and duty factor values of 10%, 30% and 50%. The layers generated were tested for RRR. The samples coated at dc bias showed RRR values not larger than 50. The RRR for the samples treated with pulsed bias exhibited up to RRR=80 at pulse frequencies 1 or 10 kHz and duty cycle of 30%. The same pulse parameters were responsible for an increased deposition rate which was up to 900 nm/min, while the layer growth rate at dc bias ranged from 300 to 500 nm/min.

Microstructures of some of the deposited layers were studied using scanning electron microscope (SEM) and X-ray diffraction (XRD). SEM micrographs of selected layers obtained at low pressure of residual gas (below $5 \cdot 10^{-7}$mbar) and high substrate temperature (ca 150^{o} C) showed large (1-5 μm), randomly oriented grains (Fig. 1) with very low concentration of impurities and defects. Their average size grew with layer thickness. XRD tests revealed that niobium lattice parameter in the layer (0.3304 nm) is very close to that of bulk Nb (0.3303-0.3306 nm).

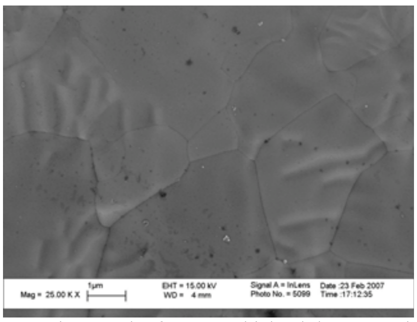

Fig. 1 SEM micrograph of a 10μm thick Nb layer reached by using pulsed substrate biasing. Grain size up to 5 μm.

Preparation for Nb coating of a single-cell 1.3 GHz copper cavity was the priority in 2007. The cavity coating system reported in [2] has been modified in 2007 so as to increase the arc plasma transmission between the plasma source and the cavity centre. A system of three rectangular coils was installed around the cavity on a rotating platform in order to reach an axially symmetric layer distribution with a sufficiently thick layer in the equator region. Preliminary tests leading to deposition optimization were done using a "dummy cavity" of stainless steel, the shape of which was a replica of a real 1.3 GHz TESLA cavity. The position of the arc plasma beam was monitored on-line by using a set of isolated plasma ion collectors or by observing "hot areas" on the cavity wall with an infrared photo-camera (Fig. 2). Layer thickness distribution has been measured (using a profile-meter) on sapphire samples that were strategically positioned on the inner cavity wall during deposition. The tests revealed that the layer thickness ratio between the central and equatorial cavity regions is acceptable (3:1).

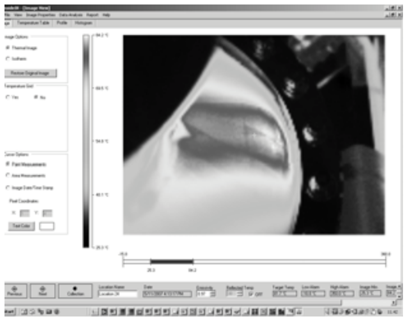

Fig. 2 Nb coated area identified on the external cavity surface by using thermo-graphic camera.

Two copper, 1.3 GHz, one-cell cavities were delivered by Orsay: the first cavity after chemical etching and electropolishing and the second - just after etching. They were both Nb deposited up to a thickness of 2μm on the equator. The layer on the first cavity suffered heavy peeling inside the cut-off tubes and at the equator region after a subsequent high pressure rinsing with ultra-pure water under a pressure of 100 bar. The layer on the second cavity survived a rinsing under 40 bar pressure and the rinsing under 100 bar caused lesser damage than in the case of the first cavity. The improvement of layer adhesion to the underlying copper surface is now our main task.

[1] L.Catani, A.Cianchi, D.Digiovenale, R.Polini, S.Tazzari, J.Lorkiewicz, M.J.Sadowski, P.Strzyżewski, B.Ruggiero and R.Russo, Recent Achievements in Ultra High Vacuum Arc Deposition of Superconducting Nb layers, Proceedings of SPIE, Volume 6937 (Dec. 28, 2007), p. 69370R.

[2] J. Lorkiewicz et al., Annual Report 2006, p.174.

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