Microstructural changes observed in the near-surface of SRF cavity cutouts using Gl-synchrotron XRD

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MOPFDV010

Introduction
Niobium is the metal superconductor of choice for SRF cavity technology by its superconducting properties, and formability, which facilitates the cavities manufacture. Nb is a highly reactive metal, particularly for hydrogen, nitrogen, oxygen, and carbon, and these elements can be found in the near-surface region forming hydrides, nitrides, oxides, carbides, or forming solid solutions. During the manufacture, the cavity undergoes to several surface treatments, both mechanical and chemical, which remove the oxide layer, mainly formed by NbO2/NbO. The oxide layer passivates the surface and behaves as a barrier for hydrogen absorption. When it is removed, the resulting naked metal surface facilitates the uptake of hydrogen, which is finally found occupying the tetrahedral or octahedral interstitial sites in the Nb bcc crystal structure and precipitates as hydrides upon cooling, which has a detrimental effect on the quality factor, Q0, known as HFQS. This contribution reports a phase analysis for the near-surface region of cutouts extracted from cavities treated with state-of-the-art RF surface treatments. The results herein discussed contribute to understanding the mechanism by which N and O as atoms occupying the interstitials sites in the Nb matrix minimize the detrimental effect of hydrogen at the operational temperatures of the SRF cavities.

Motivation

Motivation - variation of the lattice parameter, a, of Nb matrix upon thermal cycle from 300 to 30 K recorded on SRF Nb cavities cutouts. Increase of the lattice parameter at Tc of hydrides formation.

Experimental

Experimental - Grazing incidence synchrotron X-ray diffraction. The evaluated depth penetration for a glancing angle of 1° is ~1 μm, covering the London penetration, J, where the superconductivity takes place.

Conclusions

Conclusions - We have performed a structural and phase composition study on cutouts from cavities processed with state-of-the-art RF surface treatments: N-doping, low-T (75/120 °C) baking, and standard-T EP using Gl-synchrotron XRD. 1) For N-doping, Nb is found forming a Nb(NHx) solid solution, where the N atoms occupy the interstitial octahedral sites of Nb, trapping hydrogen atoms located in the tetrahedral sites. This avoids the formation of Nb-hydrides upon cooling. 2) A similar effect has the presence of oxygen as Nb(OHx), particularly in the low-T baking cutout. 3) Exclusively, in the standard T-EP cutout, the hydride formation was detected, related with hydrogen forming an ordered solid solution with Nb, α-Nb(H).

Acknowledgments

Acknowledgments - The author(s) would like to thank Prof. E. Reguera, M. Avila and J. Rodriguez-Rodriguez from LNCAE for the discussions and helpful suggestions in the XRD data analysis.

References

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