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Surface evolution of Nb(100) during thermal and gas-treatments

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Superconducting radio frequency (SRF) niobium cavities are the basic building blocks of linear accelerators present in modern x-ray free electron lasers, such as the European X-Ray Free-Electron Laser. The final surface treatment steps of Nb cavities impose a subtle change in their performance to obtain high quality factors at high accelerating field gradients; however, the underlying physical phenomenon is not fully understood yet. Here we report on the surface analysis of cavity-grade and high purity single-crystal Nb samples subjected to various thermal and gas exposure protocols together with the cavities and how the findings correlate with observed SRF properties. Surface characterization was performed by means of x-ray photoelectron spectroscopy, electron microscopy, energy dispersive X-ray spectroscopy and time-of-flight secondary ion mass spectroscopy. By in-situ monitoring of elemental composition in the near surface region before and after the N-infusion of Nb(100) model system, in ultra-high vacuum and much lower nitrogen partial pressures, a clear evidence of the formation of Nb-N bond is obtained together with the already known phases of Nb2O5, NbC, NbO2 and NbO. These results give a deeper insight of the surface composition changes occurring during the thermal cycles of Nb - including or excluding nitrogen in the low temperature bake step, and thus help us to correlate this to the improved RF cavity performance.

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