Tunneling Study of SRF Cavity-grade Niobium

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Abstract—Niobium, with its very high HC1, has been used in superconducting radio frequency (SRF) cavities for accelerator systems for 40 years with continuous improvement. The quality of cavities (Q) is governed by the surface impedance RBCS, which depends on the quasiparticle gap, delta, and the superfluid density. Both of these parameters are seriously affected by surface imperfections (metallic phases, dissolved oxygen, magnetic impurities). Loss mechanism and Surface treatments of Nb cavities found to improve the Q factor are still unsolved mysteries. We present here an overview of the capabilities of the point contact tunneling spectroscopy method and how it can help understanding SRF cavity performances. Tunneling spectroscopy was performed on Nb pieces from the same processed material used to fabricate SRF cavities. Air exposed, electropolished Nb exhibited a surface superconducting gap delta=1.55 meV, characteristic of clean, bulk Nb, however the tunneling density of states (DOS) was broadened significantly. Nb pieces treated with the same mild baking used to improve the Q-slope in SRF cavities revealed a much sharper DOS. Good fits to the DOS are obtained using Shiba theory suggesting that magnetic scattering of quasiparticles is the origin of the degraded surface superconductivity and the Q-slope problem of Nb SRF cavities.

Index Terms—Tunneling spectroscopy, niobium, RF cavity, magnetism.

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