PHYSICS AND ASTRONOMY SEMINAR

(Online)

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TRIUMF

"Measurement of the magnetic field profile in superconducting multilayers for the application of SRF cavity using LEμ-SR and β-NMR"

Abstract

Superconducting radio frequency (SRF) cavities made of bulk Nb are extensively used in particle accelerators for numerous challenging applications since several decades. However, the demands for higher accelerating gradients, Eaccs (i.e., energy gain per unit length) and increased efficiency have pushed the capabilities of bulk Nb close to its fundamental limits. In terms of Eacc performance close to the so-called superheating field, Bsh has been achieved for some prototype cavities. To overcome this limitation, material engineering of the near surface region is necessary to enable the development of future particle accelerators that are more cost-effective and energy-efficient. One proposed solution is to coat Nb with single or multilayer superconductors of higher penetration depth, including alternating insulating layers. Heterostructures with such coatings can maximize the Bsh by modifying the Meissner screening of each layer, which depends on the other layers through boundary conditions since Bsh $\propto$ J (i.e., the screening current density). We used low energy muon spin rotation (LEμ-SR) technique to measure the depth-resolved Meissner screening profile in superconductor-superconductor (SS) Nb1–xTixN/Nb samples, and found evidence for reduced Meissner screening in the surface Nb1–xTixN layer. We fit the screening profile with the London model with appropriate boundary and continuity conditions at the material interfaces to determine the penetration depths of Nb1–xTixN and Nb and found a good agreement with literature values. Using these penetration depths the maximum field Bmax (i.e., > Bsh of both the layers), that can sustain by an SS sample in the flux free Meissner state was predicted. The results suggest that due to the strong suppression of the Meissner currents multilayered structures of several superconducting and insulating layers are necessary to reach maximum accelerating gradients. The general trend in sample studies is that heterostructures increase the DC field of first vortex penetration but give a weak RF performance (high surface resistance). Our hypothesis is that the limitation is dissipative premature flux entry in the outermost surface layer. To test this hypothesis we will perform an experiment using β-detected nuclear magnetic resonance (β-NMR) at TRIUMF. Thanks to the recent facility upgrade, TRIUMF is now the only place in the world capable of performing this challenging experiment.

Wednesday, March 8, 2023

2:30 p.m. PST

Zoom: https://uvic.zoom.us/j/7082082094?pwd=UGc5UWxvZ2dvT25BaEp3MU1MRUQ1Zz09

Meeting ID: 708 208 2094

Password: 3t9Cmg