RF Surface Impedance Measurement of Polycrystalline and Large Grain Nb Disk Sample at 7.5GHz

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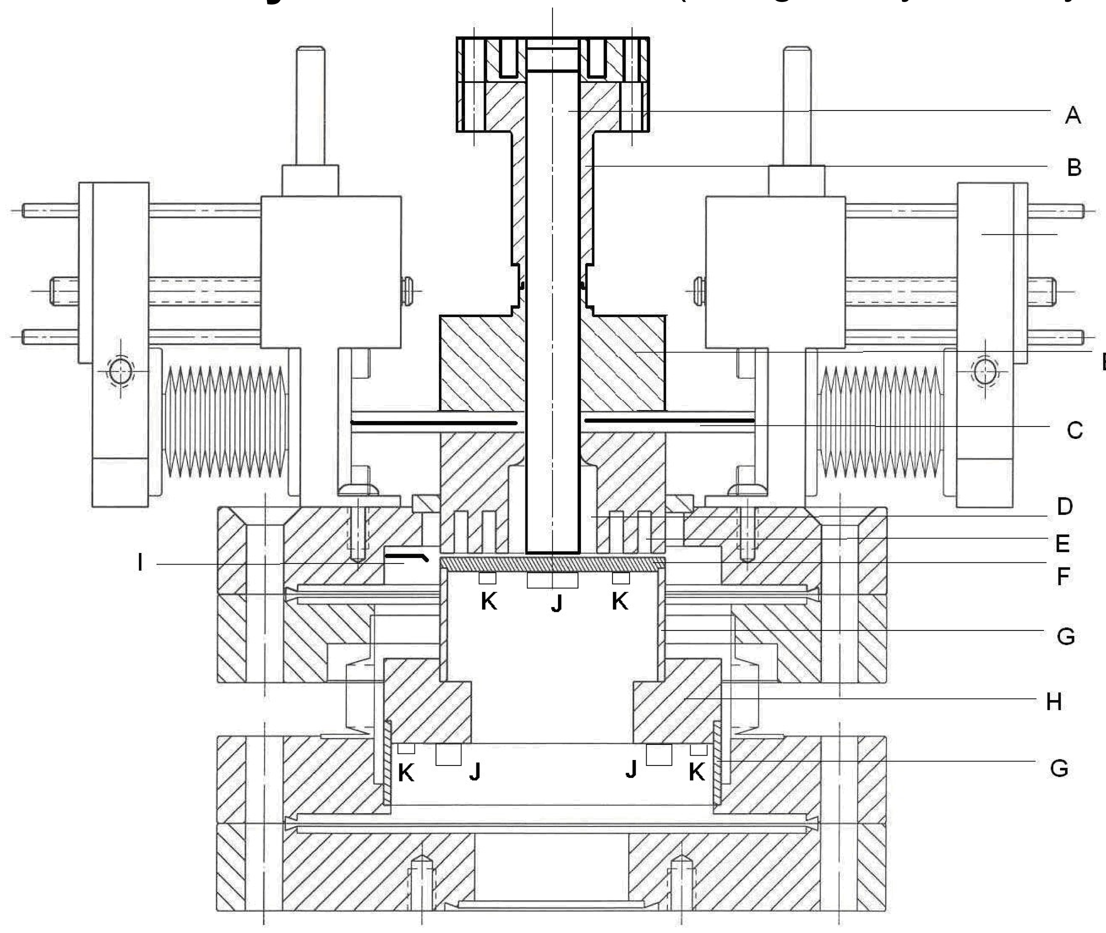
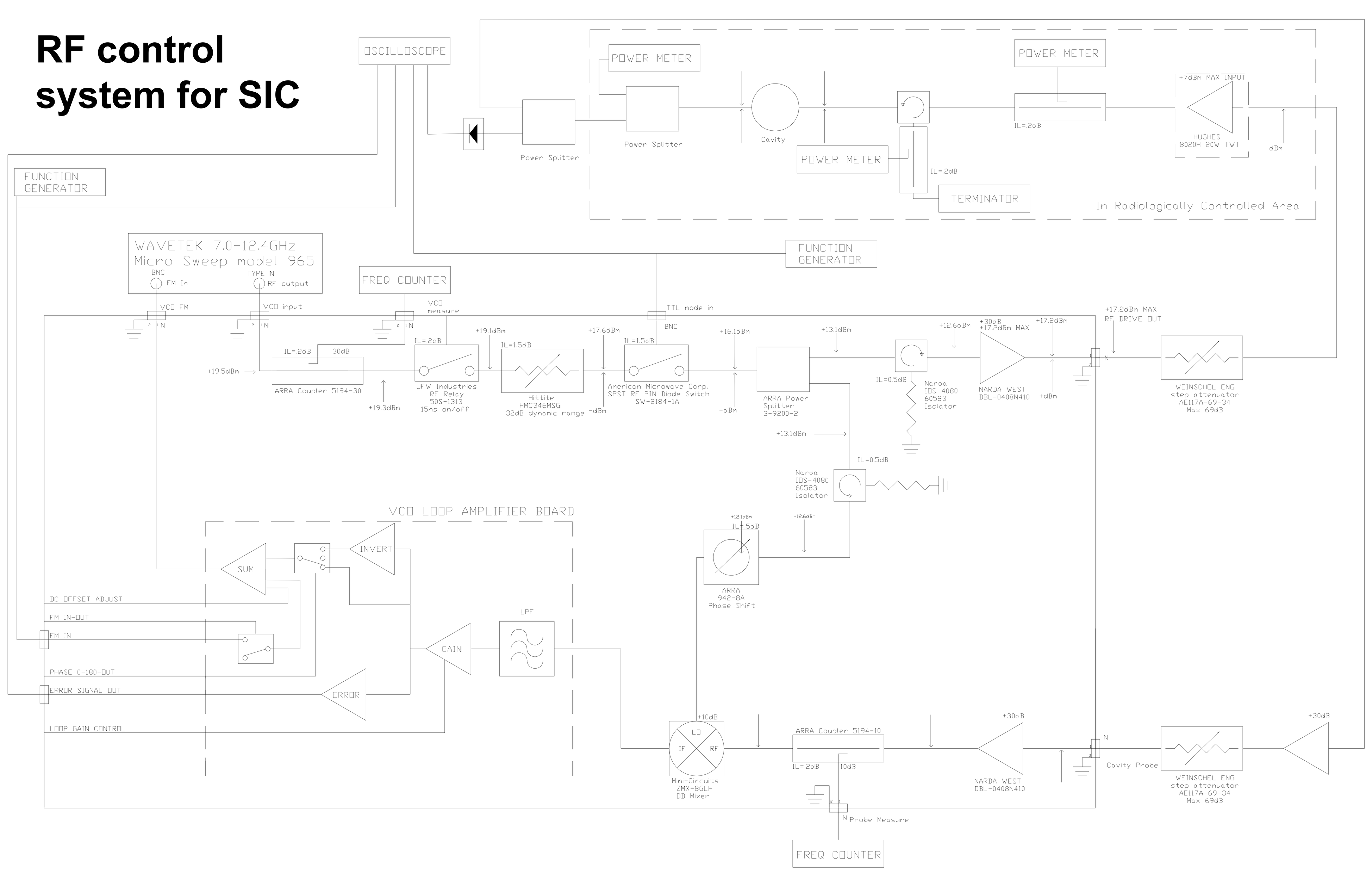
SIC system overview (Designed by J. Delayen, H. L. Phillips, H. Wang and B. Xiao)



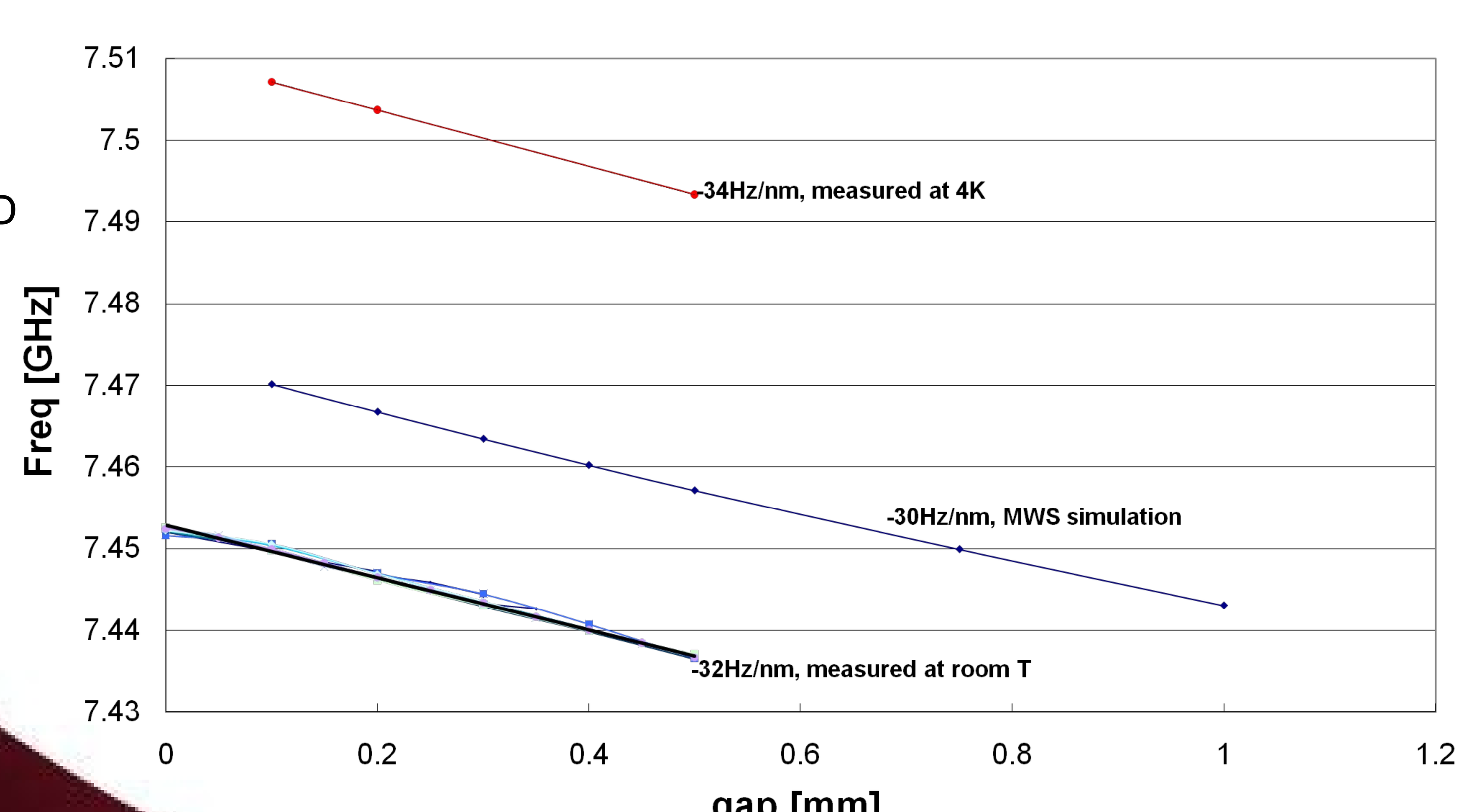
A. Sapphire rod
B. Nb
C. Coupler
D. TE011 cavity
E. Choke joint
F. Nb sample on copper plate
G. Stainless steel thermal insulator
H. Copper ring
I. Pickup coupler near the choke joint to monitor the RF leaking from the open gap
J. Heater
K. Thermal sensor

RF control system for SIC



Tuning sensitivity of TE_{011} mode with 0.2 mm gap

Confident mode ID



Abstract:

A Surface Impedance Characterization (SIC) system was first proposed at the 2005 SRF workshop, and its commissioning was detailed at the 2009 PAC conference.

Currently, the SIC system can make direct calorimetric R_s measurements on 50 mm samples in the temperature range from 2–20K exposed to a 7.5 GHz RF magnetic flux density of less than 3 mT.

We report on new results of a BCP etched large grain Nb sample measured with this system as compared with previous results of a BCP etched polycrystalline Nb sample.

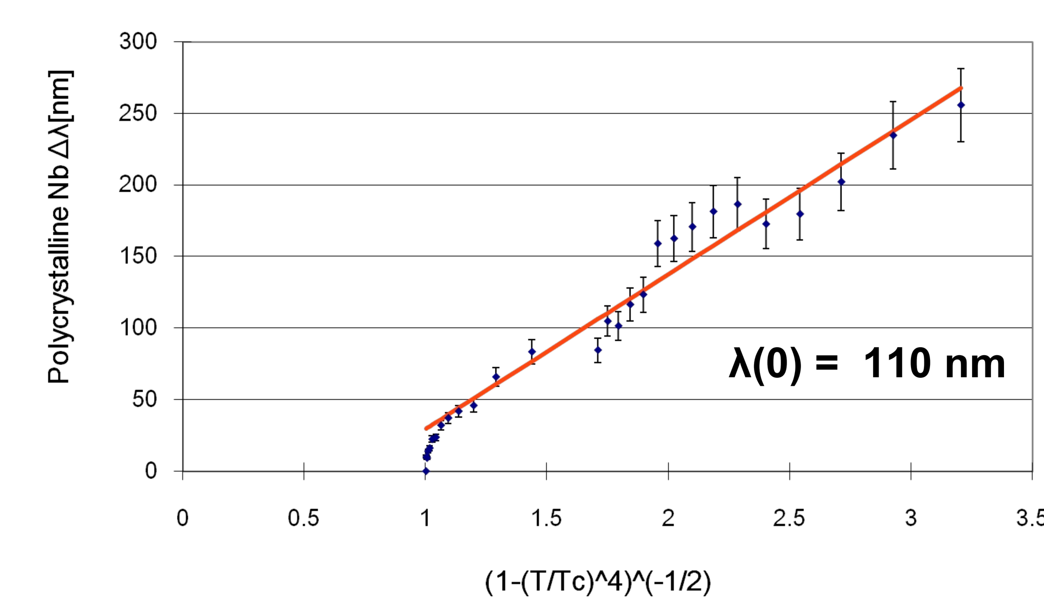
The design of an upgraded SIC system for use at higher magnetic flux densities is on the way to more efficiently investigate correlations between local material characteristics and associated SRF properties, both for preparation studies of bulk niobium and also new thin film SRF developments.

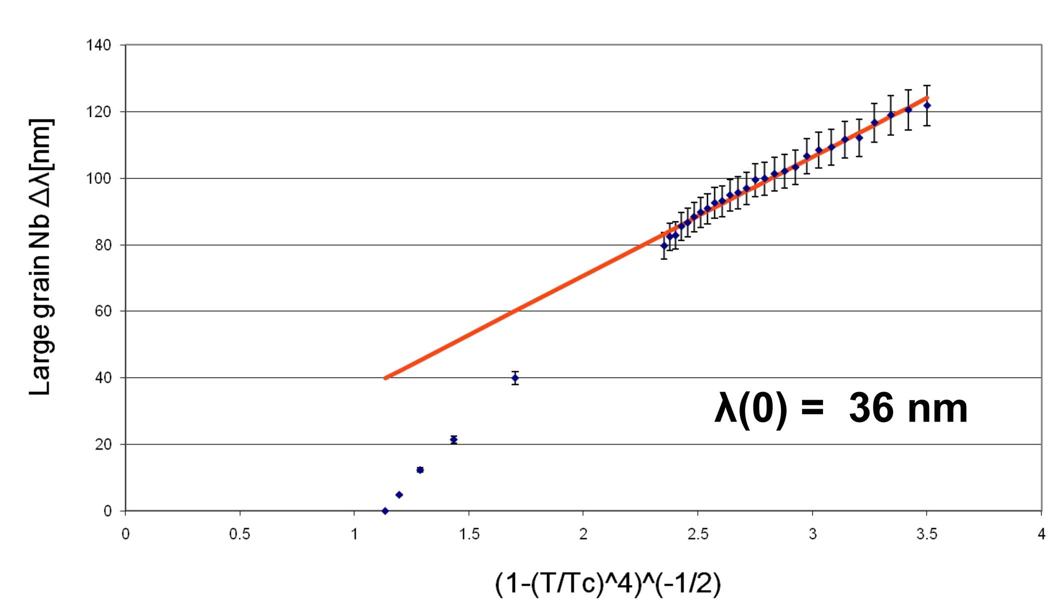
Key parameters to derive surface impedance

Simulation	Tuning Sensitivity M [Hz/nm]	$k\ \left[\frac{W}{\Omega T^2}\right]$	$\frac{H_{pk}}{\sqrt{U}}\ \left[\frac{T}{\sqrt{J}}\right]$
Closed gap MAFIA	-30		
Closed gap MathCAD		3.70×10^7	0.530
Closed gap MWS			0.503
0.2 mm gap MWS	-30	3.62×10^7	0.336

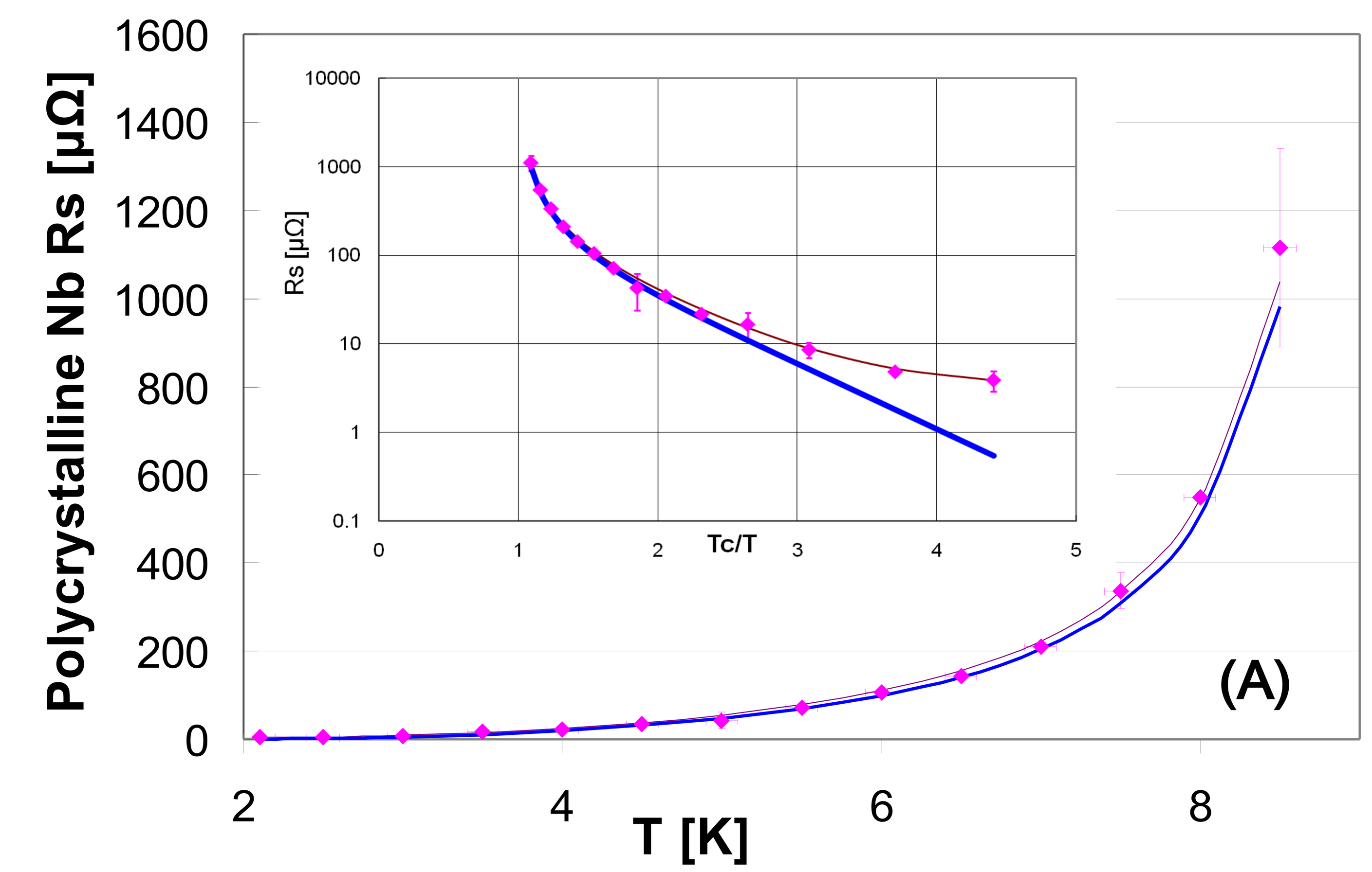
Surface Impedance
$$Z_s = \frac{P_{rf}}{kH_{pk}^2} + i\omega\mu_0\left(\lambda_{ref} + \frac{f - f_{ref}}{M}\right)$$

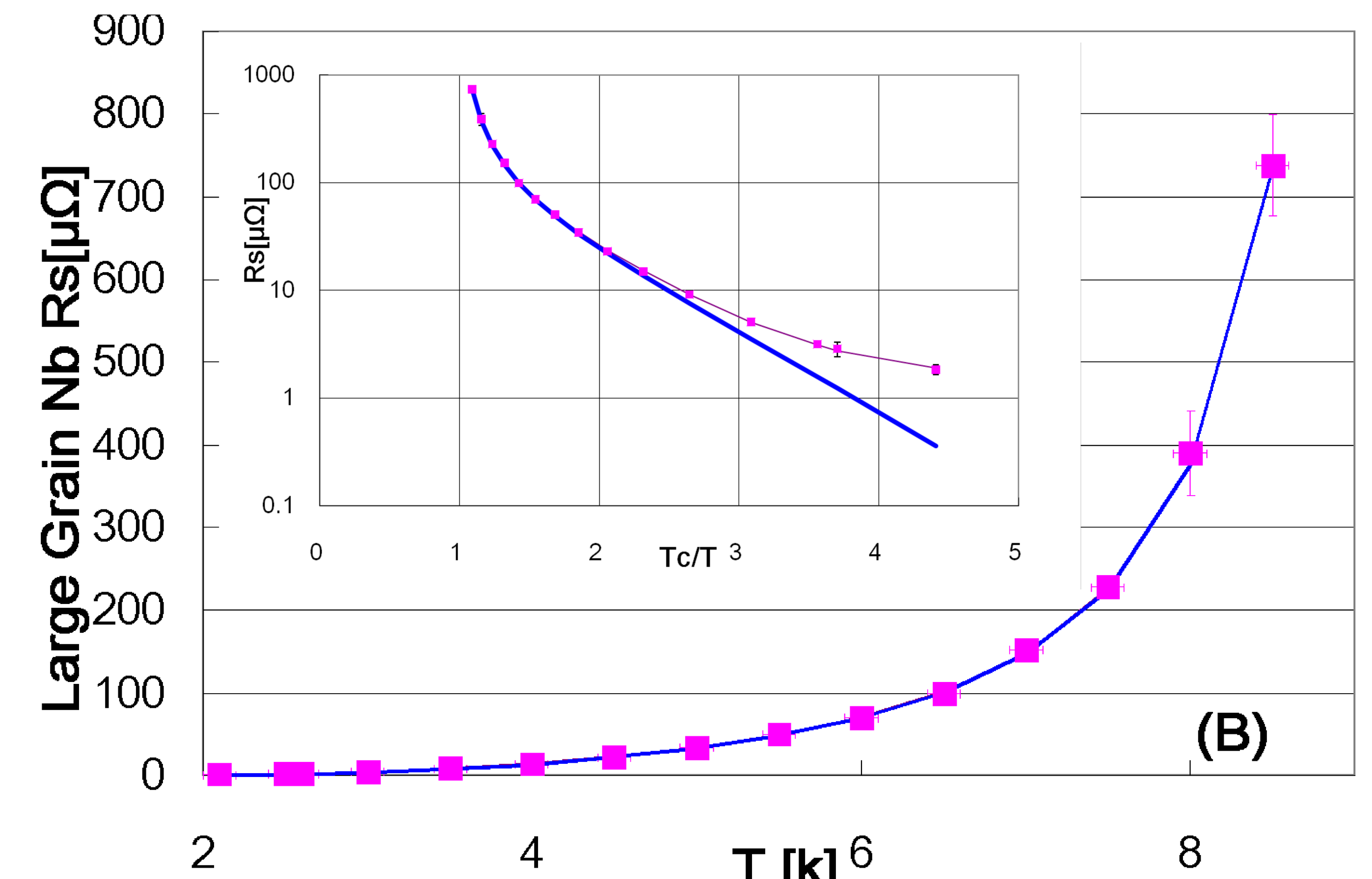
Penetration depth for polycrystalline/large grain Nb brazed on Cu





Surface resistance changes with sample temperature for polycrystalline/large grain Nb brazed on Cu





■ Measured R_s

— Theoretical value with

(A) Δ/kT_c = 1.85, T_c = 9.25 K, London penetration depth = 43.8 nm, Coherence length = 22.4 nm, Mean free path = 99.3 nm and Residual Resistance = 3.27 μΩ for polycrystalline Nb sample

(B) Δ/kT_c = 1.87, T_c = 9.26 K, London penetration depth = 39.8 nm, Coherence length = 89.7 nm, Mean free path = 826.4 nm and Residual Resistance = 1.54 μΩ for large grain Nb sample

— BCS resistance.

Summary:

RF surface impedance measurements have been completed at low field (<3 mT) under different sample temperature conditions for polycrystalline and large grain Nb brazed on Cu with the current SIC system. Least-square multi-parameter fits have been performed for polycrystalline and large grain Nb surface resistance. 12 mT peak magnetic field has been achieved in a preliminary pulse mode test. A second-generation calorimeter will be ready soon to achieve 20 mT fields in CW mode. It is anticipated that use of the SIC system will enable valuable and efficient correlation of local material characteristics with associated SRF properties, both for preparation studies of bulk niobium and also new thin film SRF developments.

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