RF Properties at 6 GHz of Cathodic Arc Films up to 450 Oe

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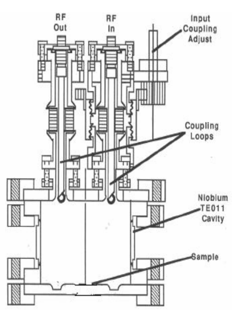
Abstract

We received several Nb films deposited on copper plates via the cathodic arc deposition method under development by R.Russo et al.
We attached these end-plates to a 6 GHz cavity operating in the TE_{011} mode. At low field, the Q values obtained were (1-2)*10^8 corresponding to a surface resistance of 3-6 μΩ as compared to the BCS Q of 0.23 μΩ at 2.2 K and small mean free path. The Q remained constant up to a field of 450 Oe. A baseline Q of 3.5*10^8 was determined for the host cavity by attaching a bulk Nb end-plate. We expect the BCS resistance to be 0.5 μΩ for the higher mean free path end-plate and cavity material. Therefore the host cavity has 1.5 μΩ of residual losses. The film resistance appears to be higher than the residual resistance of the host cavity. Future efforts will focus on reducing the residual resistance of the host cavity.

Experimental Setup

Niobum cavity operating in TE_{011} mode at the frequency of f=5.963 GHz was used as a host cavity. Geometric constanf corresponding to the field distribution was found to be G=750 Ω. The bottom plate of the cavity can be replaced by the Nb/Cu end-plate for the evaluation of the film RF properties. RF power was provided by the sweep oscillator and a 20 W TWT amplifier. CST Microwave Studio was used to model the field distribution and therefore to calculate the peak magnetic field at a given stored energy value.



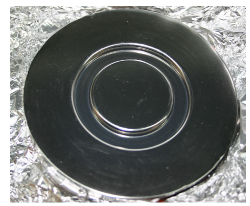
TE cavity design.

TE cavity.

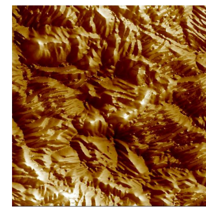
G = 757 Ω

Results

Four films of Nb deposited on electropolished copper plates via cathodic arc deposition method were tested. SEM and AFM analyses of the samples was made too.



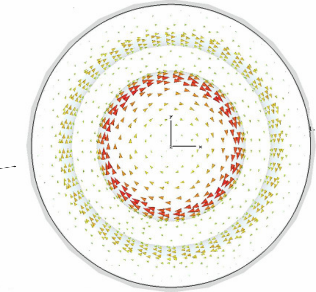
Nb/Cu end-plate sample.

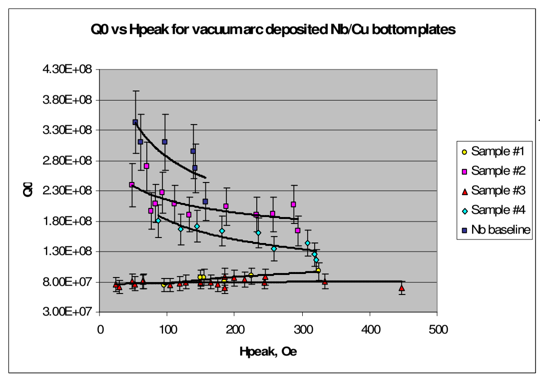


AFM picture of the film surface

2 x 2 μm area

Surface currents at the bottom plate surface when the cavity is operated in TE_{011} mode





The results of the RF measurements are summarized in the graph on the left.. We didn't observe any Q-slope at the peak magnetic field level up to 450 Oe. The slight Q decrease at higher fields for some samples might be attributed to the heating of the cavity resulting from limited heat transfer capacity of the helium vessel.

Theoretically calculated BCS values at T = 2 K:

Low mean free path niobium: R_s = 0.23 μΩ, Q_0 = 3.3*10^9

High mean free path niobium: R_s = 0.5 μΩ, Q_0 = 1.5*10^9

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