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NOTES ON TALK GIVEN 12 FEBRUARY AT THE INITIAL MEETING OF THE SEMINAR ON SUPERCONDUCTING SEPARATORS

A. TOPICS TO BE COVERED DURING SEMINAR SERIES

1. Theory
   Basic principles of RF superconductivity.
   Electric breakdown effects.
   RF critical magnetic field for Type II superconductors.

2. Cavity Measurements
   Superconducting cavity measurements at CERN.
   Progress at other laboratories - Stanford, SLAC, Karlsuhe, Rutherford, Brookhaven, Orsay.

3. Structure Design
   Measurement of shunt impedance and peak electric and magnetic fields (E_p/E_0, H_p/E_0) for bi-periodic structures.
   Traveling-wave resonators.
   Tuning, perturbations, and π-mode for superconducting structures.

4. Technology
   Refrigeration and cryogenic designs.
   Fabrication techniques for niobium structures.

5. Systems
   Optimization of the parameters for a superconducting separator.
   Stability and phasing for superconducting structures.

6. Physics
   Application of superconducting separators to counter physics experiments.

B. RESULTS OF RECENT NIOBIUM CAVITY MEASUREMENTS

Cavity type	Mode	Freq. GHz.	T °K	Q	Q/Q(300°K)	Hp,Ep(1)	Type of break-down
Solid-Stanford(2)	TE_{011}	11.2	1.2	3×10^{10}	1×10^{6}	260G	H
Solid-Stanford(2)	TE_{011}	11.2	1.2	1×10^{10}	3×10^{5}	440G	H
Electroformed-Stanford(2)	TE_{011}	11.2	1.2	$\{2\times10^{10}$ 5×10^{9}	6×10^{5} 1.5×10^{5}	Low 500G(4)	None
Sputtered-CERN	TE_{011}	2.8	1.5	$\{4.5\times10^{8}$ 1.5×10^{8}	1.3×10^{4} 4×10^{3}	Low 60G	H ?
Solid-Stanford(2)	TM_{010}	8.5	1.2	$\{5\times10^{9}$ 1×10^{9}	4×10^{5} 8×10^{4}	Low 300G, 25MV/m	H
Solid-electron beam welded-Stanford(2) (before vac. firing)	TM_{010}	8.5	1.2	2×10^{9} (2×10^{8})	1.5×10^{5}	600G,(4) 40MV/m (60G)	E (H)
Solid-CERN	TM_{011}	2.8	1.5	4×10^{7}	2×10^{3}.	Low	(3)
Sputtered-CERN	TM_{011}	2.8	1.5	$\{1.4\times10^{7}$ 1×10^{7}	7×10^{2} 5×10^{2}	Low 45G, 1.8MV/m	H ?

NOTES

(1) Hp = peak magnetic field , Ep = peak electric field.

(2) Outgassed and annealed at T ≈ 2100°C, p ≈ 10^{-8} Torr, t ≈ 15 hrs.

(3) To be measured soon.

(4) Limited by other factors.

C. SOME REQUIREMENTS FOR A SUPERCONDUCTING SEPARATOR

Preliminary measurements at CERN indicate that values of $E_p/E_0 \approx 3.5$ and $H_p/E_0 \approx 130\ \mathrm{G(MV/m)}^{-1}$ are typical for a bi-periodic separator structure with a disk aperture dismeter $2a/\lambda \approx 0.35$. For an effective deflecting field strength of 7.5 MV/m, these ratios indicate that a peak electric field of about 25 MV/m and a peak magnetic field of about 1000 G must be tolerated in the structure. The required magnetic field is greater than that yet reached experimentally (600 G). There is no reason in principal why fields on the order of 1000 G cannot eventually be attained for niobium, or why structures with lower values of H_p/E_0 cannot be designed. However, until either alternative has been demonstrated experimentally, the peak magnetic field must be considered as the primary limitation on the gradient in a superconducting separator.

The required refrigeration power is determined by the Q improvement factor using the relation

$$P = \frac{E_0^2\, L}{r_{300}\ (Q/Q_{300})}$$

where L is the length of the structure and r_{300} is the room temperature shunt impedance for a copper structure. From the preceding table it is seen that a Q improvement factor on the order of 1.5×10^5 has been attained under high field conditions at 8.5 GHz (Note that the theoretical improvement factor for niobium at 2.8 GHz and 1.85°K is 3×10^5). For $E_0 = 7.5$ MV/m, $L = 6$ m (total for two cavities) and $r_{300} = 1.0 \times 10^5$ (measured for a standing-wave bi-periodic structure with $2a/\lambda = 0.35$), a peak power dissipation of 375 W is calculated. If the separator operates at a duty factor of 400 msec/ 2 sec, the average power dissipation is 75 W. Making an allowance for heat leaks and other possible sources of loss, a refrigerator with a power handling capability of about 100 W is needed for this example.

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