deflecting mode with a phase shift of $2\pi/3$ radians per cell.

The test structures were made of OFHC copper and electroplated with about 0.1 mil of lead. The lead was deposited onto the test pieces from a lead fluoborate bath. The lead anode material was all 99.999% pure. After the pieces were plated, they were rinsed in distilled water and quickly dried with N$_2$ gas after a final alcohol bath. The quality of the lead plating was then visually examined for the appearance of copper spots or "poor" plating. The "good" pieces were stored under vacuum until assembly. The plated pieces were assembled in a nitrogen atmosphere dry box.

The iris-loaded structure was plated by using a rotatable support structure which allowed the axis of the 5-cell assembly to rotate from the vertical to the horizontal plane. The lead anode had 6 cantilevered blades spaced according to the periodicity of the structure supported on a long rod. The anode was moved through the iris hole and dropped carefully into position with the support rod on axis. The blades went about halfway down into the iris slots. The structure was first put into the plating bath vertical and moved from side to side to remove all trapped air pockets. Then it was rotated horizontally and plating begun. The anode was held fixed while the structure was slowly rotated. With this technique we were able to plate the inside of the iris-loaded structure without any visible copper or "bad" plating spots.

**Measuring Techniques and Results**

The low power Q measurements were performed using a frequency sweep technique. The input coupling loop of the test structure is excited by a frequency swept RF signal near a resonance. The output signal is diode detected after amplification and displayed on an oscilloscope. The loaded Q is given by the power decay time ($\tau$) of the output signal by $Q = \omega_0 \tau$. The unloaded $Q_0$ is given by $Q_0 = Q(1 + 2\beta)$ where $\beta$ is the RF coupling coefficient.

The high power measurements were performed by connecting the structure as a resonant ring, Fig. 2. The phase shifter was adjusted until the circuit went into self-oscillation when the diode switch was turned "on". By making measurements of the input reflected and incident power, it was possible to determine $Q$, $\beta$ and $E_q$, the equivalent RF deflecting field. $\beta$ is equal to $(1 + z \pm \sqrt{1/2})/(1 - z)$ where $z$ is the power reflection coefficient (+ sign overcoupled; - sign undercoupled). The power absorbed by the structure, $P_o$, can be shown to equal $4\beta/(1 + \beta)^2$ times incident power and $E_q$ is equal to $P_o R_{sh}/L$ where $I$ is improvement factor, $R_{sh}$ is shunt impedance, and $L$ is length of structure.

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We achieved a $Q_0$ of $7.4 \times 10^9$ for the $TE_{011}$ cylindrical cavity mode at 2.856 GHz and at a temperature of 1.04°K. The $Q$ improved by a factor of 29 as the temperature was changed from 4.2°K to 1.04°K. In addition we measured the $Q$s of most of the resonant modes in our measuring RF band of 2 to 4 GHz. The $Q$s of these resonances were all in the $10^8$ range. For example, at 1.04°K the $Q$ of the $TM_{011}$ mode resonance at 1.98 GHz was $2.5 \times 10^8$, the $Q$ of the $TM_{012}$ mode at 2.721 GHz was $1.3 \times 10^9$, and the $Q$ of the $TE_{012}$ mode at 3.406 GHz was $3.6 \times 10^9$.

We have performed a number of test runs on the iris-loaded deflecting structure. Our best results for the deflecting $2\pi/3$ mode has been a $Q_0$ of $2.2 \times 10^8$. The $Q_0$ increased by a factor of 20 as the temperature was changed from 4.2°K to 1.8°K. The highest equivalent deflecting field that we have been able to achieve has been 500 kV/m. However, this is really equivalent to an $E_0$ of 1 MV/m for a standing wave deflector ending with full end cells. Operation of the structure at these gradients has produced small dark spots on the end plates. The spots were random which makes us believe they were due to enhancement of electric field at "dirty" surface spots.

Efforts are continuing with the lead-plated, iris-loaded structure to determine if higher gradients and $Q$s are feasible. We also are currently studying the possibility of building a niobium iris-loaded test structure.

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References


