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High-Power Test of Iris Coating in the *S*-Band Linear Collider *

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Abstract The excitation of Higher, Order Modes (HOM) in an accelerator can lead to cumulative beam break up, therefore, these modes have to be suppressed. For the *S*-Band Linear Collider (SBLC), it has been suggested to cover the disk loaded structure at the iris with an appropriate loss material. For the high-power test of the iris coating a resonator consisting of two cells of the SBLC is used. This paper describes the high-power test and gives some preliminary results.

Key words high order mode (HOM), loss material, *Q* quality, high-power test

1 Introduction

The excitation of Higher Order Modes (HOM) in an accelerator can lead to cumulative beam break up, therefore, these modes have to be suppressed. For the *S*- Band Linear Collider (SBLC), it has been suggested to cover the disk loaded structure at the iris with an appropriate loss material[1,2]. Due to the iris coating, the Q of HOM is decreased by a factor of 5 while the Q corresponding to the fundamental mode stays nearly unchanged[3]. Three materials are considered for the iris coating, namely, stainless steel, kanthal and a galvanic coating which has material properties similar to those of kanthal. For the high-power test of the iris coating a resonator consisting of two cells of the SBLC is used. This paper describes the high-power test and gives some preliminary results.

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2 Basic Principle

In a travelling weve structure, the time averaged energy per cell W_{tr} and the corresponding power flow P_{tr} are related by

$$W_{tr} = \frac{D}{v_{gr}} \cdot P_{tr} , \qquad (1)$$

where v_{gr} and D denote the group velocity and the length of a cell, respectively. On the other hand, the test resonator is a standing wave structure which consists of two cells operated in the $\pi / 2$ mode. Let Q_0 be the unloaded quality factor of the resonator, then we have to supply the power P_{loss} which is given by

$$P_{loss} = \frac{\omega W_{res}}{Q_0} \qquad (2)$$

in order to sustain an oscillation with an energy W_{res}. The quantity ω is the angular frequency of the electromagnetic field. Let us assume that the resonator consists of two cells and let W_{cell} denote the energy stored in one single cell. Thus we obtain for the total energy W_{res} inside the test resonator

$$W_{res} = 2W_{cell}. \qquad (3)$$

If we require that the peak electric field in the travelling wave structure and the test resonator are the same, this yields

$$W_{cell} = W_{tr}. \qquad (4)$$

One has to keep in mind that the above relation holds only if the principal field configurations in the travelling wave structure and the test resonator are approximately the same which is the case in our structure. Combining (1)—(4), we get

$$P_{loss} = \frac{2\omega D}{Q_0 v_{gr}} P_{tr} . \qquad (5)$$

For the test tesonator the 25th cell of SBLC is chosen. The characteristic data of this cell are:

$$v_{gr} = 3.7\% ,$$
$$D = 33.34\text{mm},$$
$$Q_0 = 10820,$$
$$f_{\pi/2} = 2.978\text{GHz},$$

The quantity c_0 denote the velocity of light in vacuum. With $\omega = 2\pi f_{\pi/2}$, the relation between P_{loss} and P_{tr} reads

$$P_{loss} = 1.04\% \cdot P_{tr} . \qquad (6)$$

Consequently, we need 0.78MW rf power to arrive at the same electric field strength inside the test resonator as in the case of feeding 75MW into the travelling wave structure.

3 Experimental Set-up

Fig.1 schematically shows the test set-up. The klystron is coupled to the test resonator via a 10dB directional coupler in order to keep the reflected power at the klystron output port sufficiently small if the test resonator is not matched. The peak rf power of the klystron is about 10MW. Consequently, approximately 1MW rf power is available at the input port of the test resonator. For the measurement of the incident and the reflected

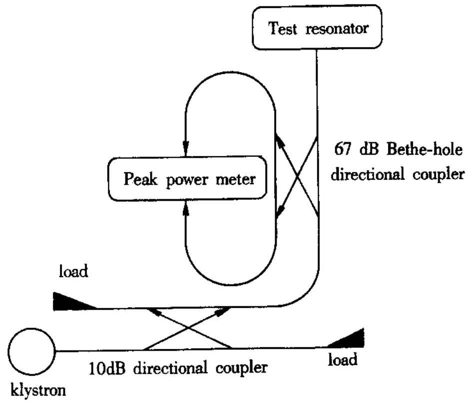

Fig.1. Schematic representation of the test set-up.

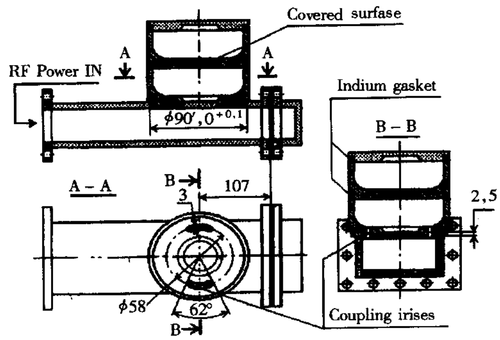

Fig.2. The test resonator and its coupling to the feeding waveguide.

power at the test resonator a peak power meter is used which is coupled to the feeding waveguide by a 67dB Bethe-hole coupler.

Fig. 2 presents the drawing of the test resonator and its coupling to the feeding waveguide. The power from the klystron is coupled into the resonator by two kidney-shaped slots. A voltage standing wave ratio $\leqslant 1.2$ is obtained with this coupling which guarantees that more than 99% of the input power is transmitted into the resonator.

4 Measurements

For the measurements, rf pulses with a width of 2μs and a repetition rate of 50Hz are used. During conditioning the rf power level has to be increased step by step. Fig. 3 shows the incident (rectangular pulse, 0.7MW) and reflected signal (spiky signal) in a case where electric discharge accompanied by out-gassing occurs. Note that during operation the pressure increases from 3×10^{-8} Torr without rf power up to 2×10^{-7} Torr. After conditioning electric discharge stops and consequently no spikes are observed (see Fig.4, the incident power of 0.8MW).

The SBLC is designed for an unloaded gradient of 21MV / m. If we assume the same gradient in the test resonator which corresponds to an input power of 0.78MW, this leads to a maximum overall voltage of 1.4MV. Consequently, we have to provide sufficient shielding against radiation. Therefore a small house of lead bricks has been built all around the test resonator. Table 1 gives some measured radiation data. Keeping in

Table 1. Radiation as a function of the rf power with and without lead shielding.

Incident power in MW	Radiation in μSv/h With lead shielding	Radiation in μSv/h Without lead shielding
0.25	1	8
0.30	1	40
0.60	1	1500
0.70	2	>3000

mind that the upper radiation limit which is tolerable is 300μSv / h, the radiation is well-below this value for small power levels. Nevertheless, for more than 0.70MW of rf power a shielding is required. With the lead bricks the radiation is small(≤2μSv / h).

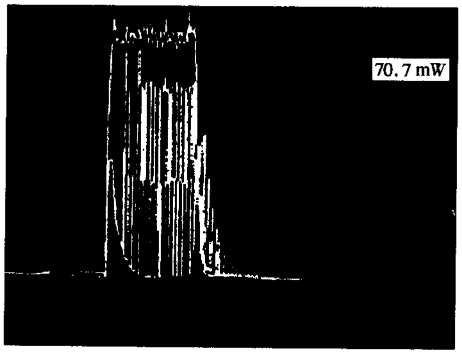

Fig.3. Incident and reflected signal with electric discharge during conditioning.

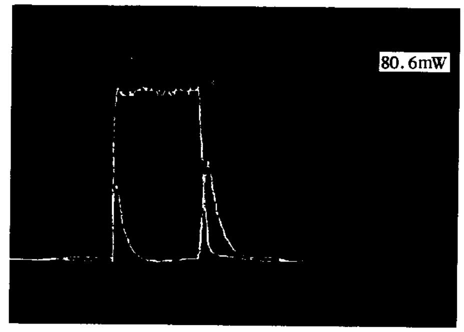

Fig.4. Incident and reflected signal after conditioning.

5 Experimental results

Up to now four cells have been tested, namely, a cell without coating, two sputtered cells (stainless steel and kanthal) and a cell with a kanthal-like galvanic coating. After conditioning, all cells have been continuously operated at a power level of at least 0.75MW for six hours. It has been checked that none of the cups has been damaged by the high-power test, which means that all three iris coatings are technically feasible.

6 Conclusions and outlook

The test facility for the high-power test of the iris coating in the SBLC has been described. All of the coating which have been investigated have passed the high-power test without damage and can consequently be used in the SBLC. For an upgrade of the SBLC based on the "SLED option"[4] the high-power test have to be repeated with a gradient of more 40MV/m on axis. This gradient cannot be obtained with the present set-up due to electric discharge in the coupling slots between the test resonator and the feeding waveguide. Therefore an improved test resonator will be designed which is suitable for the required gradient.

Reference

1 Dohlus M et al. Higher Order Mode Damping by Artificially Increased Surface Losses, DESY Report, to be published

2 Haimson J. Collinear Termination for High-Energy Particle Accelerators, PATENT-US-3264515, Aug. 1966

3 Holtkamp N. For the SBLC Study Group, The S-Band Linear Collider Test Facility, PAC 95, Dallas, May 1th-5th, 1995

4 Wilson P B. SLED: A Method for Doubling SLAC's Energy, Technical Note SLAC-TN-73-15, Stanford Linear Accelerator Center, Stanford University, Stanford, California, 1973

S 波段直线对撞机中具有膜片涂层加速腔的高功率实验*

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摘要　加速管中的高次模(HOM)能导至累积束流崩溃，因此这些模式必须被抑制．在 *S* 波段直线对撞机中(SBLC)，采用了在束流孔膜片上复盖适当的损耗材料的方式．HOM 的 *Q* 值被减小了5倍，而基模的 *Q* 值几乎保持不变．3 种材料被考虑，即：stainless steel, kanthal 和 galvanic 为了对具有这种涂层的加速腔进行高功率测试，一个两腔的谐振器结构被设计．本文描述了高功率测试的原理，过程以及初步的结果．

关键词　高次模　损耗材料　*Q* 值　高功率测试

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