HIGH GRADIENT EXPERIMENT
ON X-BAND ACCELERATING STRUCTURE

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ABSTRACT

High gradient performance of a travelling wave X-band accelerating structure of 20cm long was examined. Various observables were measured such as RF pulse waveform at various positions, dark current versus accelerating field level, energy spectra of emitted electrons toward downstream and so on. The field level of 80MV/m at input coupler cell was obtained after 500 hours conditioning. This field level is equivalent to 70MV/m accelerating field in 20cm long structure. Peak dark current decreased down to 1μA level at 50MV/m at input coupler cell.

INTRODUCTION

In the Japan Linear Collider (JLC), an acceleration with a high frequency accelerating structure is needed to save wall plug power while obtaining a very high energy. Furthermore, the accelerating field should be reasonably high to preserve the emittance through the linac. In the JLC, the accelerating field of several tens MV/m and possibly up to 100MV/m is considered.

The breakdown limit of the accelerating structure in S to X band frequency range was examined.[1] Though the results show much higher field level than stated above, it is not clear whether such a field can be stable obtained in a long travelling wave structure, because the experiments were performed only in standing wave condition for a few cell. The high field experiment for travelling wave structure at S-band was performed and showed the possibility of nearly 100MV/m at S-band but also observed a large amount of dark current of the order of mA.[2]

Following these background, a high gradient experiment on X-band accelerating structure was comissioned to examine the possible field level for stable operation. Various physical aspects such as the amount of the dark current, the energy spectra of the dark current, breakdown mechanism in a long structure, vacuum characteristics and so on were also examined. In this paper, the results of the experiment were briefly described.

EXPERIMENTAL SETUP

The parameters of the examined accelerating structure were summarized in the following Table 1. The cells in the structure were machined in a usual lathe and brazed in a hydrogen furnace. The thin iris in the coupler cells were squeezed after brazing for matching. The experimental setup is shown in Fig. 1.

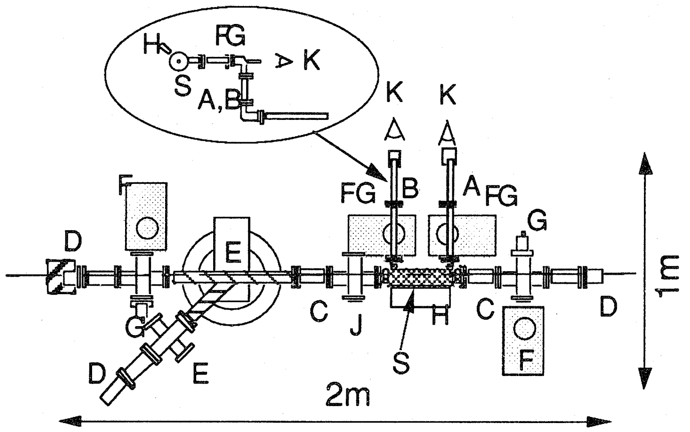
Table 1. Parameters of the examined accelerating structure.

Constant impedance, 20 cell + 2 coupler cell, operated at $2\pi/3$ mode at 11.4GHz.

Aperture	a	3	[mm]
Group velocity	vg/c	0.01177	
Shunt impedance	r	103.6	[MΩ/m]
Surface field in TW	Ep/Eacc	3.91 / 2	
Total attenuation parameter	τ	0.284	[neper]

RESULTS

The RF power generated by a klystron "XB50K" [3] was fed to the structure through 4.9m long waveguide. typical RF waveform are shown in Fig. 2. Most of the conditioning were performed with 50ns pulse length and at 10pps. The input power was shut off in case of a large reflected power from the structure or when the vacuum at the pumping port exceeds 10^{-6} Torr.



A,B: RF monitors
C: Current transformer
D: Faraday cup
E: Analyser magnet and slits
F: 20 *l* /sec ion pump
G: Cold cathod gauge
H: Plastic scintillator
J: Profile monitor
K: TV camera
S: Accelerating structure

Fig. 1. Experimental setup of X-band High Gradient Experiment

Typical RF waveforms, current transformer output and scintillator output are shown in Fig. 2. Note that the scintillator output signals were delayed compared to the other pulse by about 70ns due to the time delay in photomultiplier tubes.

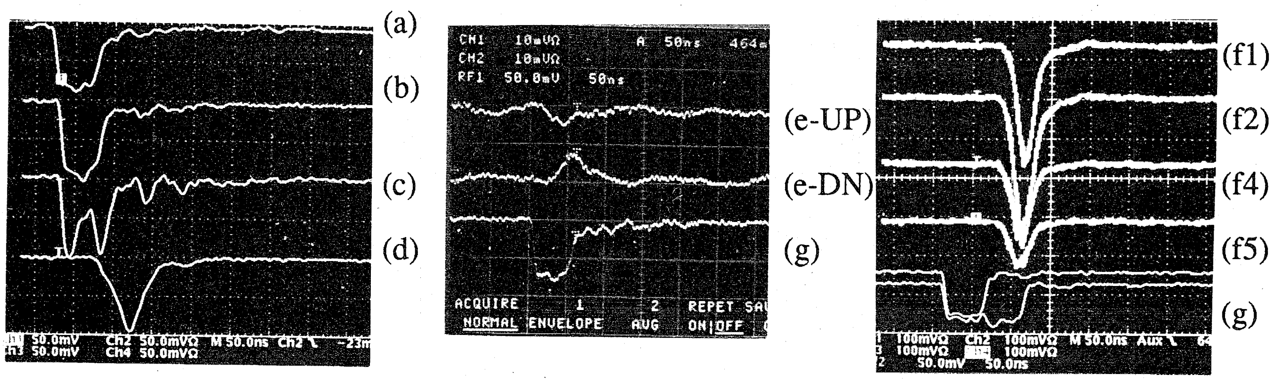


Fig. 2 Typical waveforms at E_{IN}=75MV/m. (a) Klystron RF output, (b) input RF to structure, (c) reflected RF from structure, (d) transmitted RF from structure, (e-UP),(e-DN): current transformer output at upstream and downstream side, respectively, (fi) i=1 to 5: scintillator output aligned from i=1 at input to i=5 at output coupler cell (envelope of a number of shots) and (g): input RF to structure to show the time reference. All the scope were triggered by the rise of this signal. Horizontal sclale is 50ns/div.

(1) Conditioning history

Obtained accelerating field at input cell versus conditioning time was shown in Fig. 3. Further conditioning above 80MV/m seems difficult due to frequent breakdown and/or sudden jump of the vacuum level. Fig. 4 shows a decrease of dark current during the conditioning down to 1μA at 50MV/m, though the decrease stopped after 500 hours, which coincides with the stop of increase of maximum field level.

(2) FN plot and energy spectra

In Fig. 5 are shown the modified Fowler-Northeim plots for dark currents to both directions. The dark current to upstream and Ein>65MV/m and that to downstream in full energy range show a similar field enhancement factor of aroud 35, while that to upstream and Ein<65MV/m is 95. It should be noted that the acceptance of downstream side is one order of magnitude smaller than that of upstream side. Fig. 6 shows typical energy spectrum of dark current toward downstream side. It was found that the most of the electrons gain less than a half of the full acceleration voltage.

DISCUSSION

It was found from this experiment that the operation at the accelerating gradient less than 50MV/m level is promissing for future linear collider, though a longer structure should be examined before actual use. Considering a difficulty to increase the gradient above 80MV/m, it seems necessary to carefully understand what happens in this field level to realize 100MV/m class acceleration. It is to be noted that a simulation study by Yamaguchi [4] shows that the emitted electrons can be captured to input RF field only in the field level higher than 80MV/m in case of 11.4GHz.

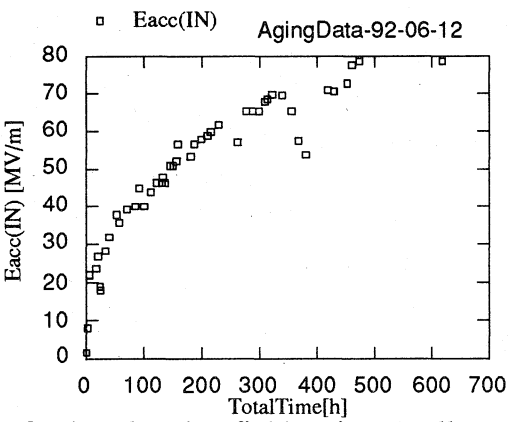


Fig. 3. Accelerating field at input cell vs. time.

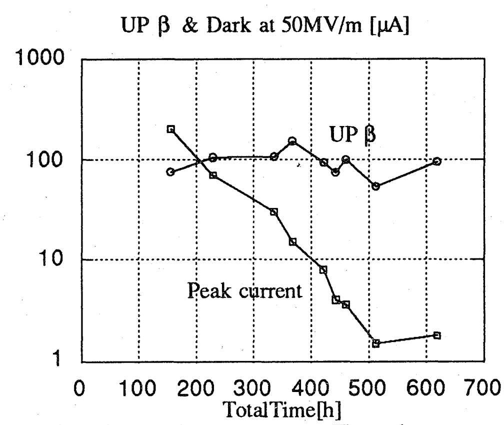


Fig. 4. Dark current to Faraday cup.

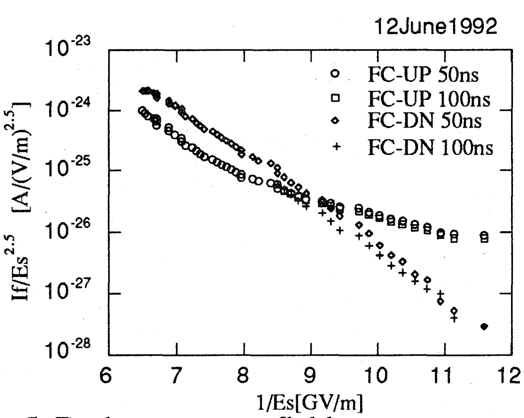


Fig. 5. Dark current vs. field.

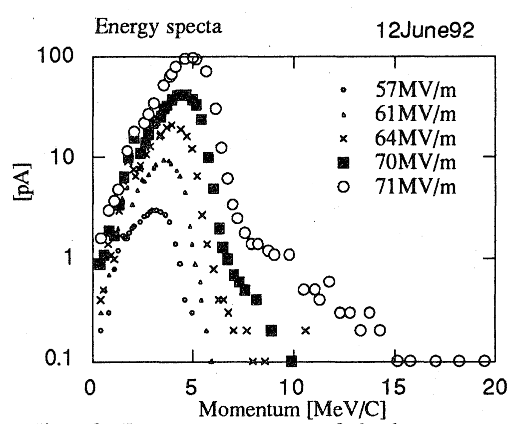


Fig. 6. Energy spectra of dark current.

ACKNOWLEGEMENT

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