LASER SWITCHED RF SOURCE "LASERTRON"

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Abstract

R&D on a laser switched RF source "LASERTRON" proceeded. A prototype of the LASERTRON was fabricated and the measurements of the fundamental properties were carried out. The RF-power of 1.6 kW was generated successfully at the RF-frequency of 2884 MHz by applying an accelerating voltage of 30 kV.

§1. Introduction

RF sources with a peak power output of the multi-GW and relatively short pulse length will be required for future electron-positron linear collider in the multi-TeV region.[1,2] This peak power is much beyond the level which can be achieved with conventional technologies. There are several candidates for this power source such as Klystrons, Gyrotrons, Magnetrons, Photocathode, Microwave Source, etc.[3] Among them, we proposed and started the studies on the laser switched RF sources, LASERTRON[4], which produces a RF current by direct emission modulation of the photocathode.

In order to realize the high power LASERTRON, many studies were started on such items as photocathode, laser system, beam dynamics, power supply, output power extraction. Detailed discussions on beam dynamics and photocathode will be given in the present meeting by Nishimura[5] and Miyao[6], respectively.

A prototype of the LASERTRON, Mark-I, was fabricated and the measurements of the fundamental properties were carried out. The detailed descriptions on Mark-I and its experimental results and discussions will be given in the following sections.

§2. Phototype LASERTRON Mark-I

A cross sectional drawing of the LASERTRON Mark-I with the experimental arrangement is shown in Fig. 1. The LASERTRON mainly consists of a photocathode electron gun[7], an output cavity and a mode-locked laser. The cathode is made of a bi-alkali and the effective area of the photocathode is 1.33 cm^2. The gap distance between the cathode and the mesh anode is 0.75 cm. The resonant frequency of the output cavity is adjusted to 2884 MHz and the measured Q-value is 75. The output coupler consists of a SMA-connector and a loop, and the experimental value of the coupling coefficient is 0.3. The photocathode is irradiated with the laser light through the glass window, a collector mesh, partition meshes and the anode mesh.

The triggering laser is a passive and active mode-locked YAG laser. After the amplification, the wavelength is converted from 1.052 to 0.526 μm with a KD*P crystal in order to shift the wavelength to the sensitive region of the photocathode. The maximum output energy of the laser is about 50 μ-joule per burst. In a burst, there is a pulse train with the frequency of 169.6 MHz, and the frequency of the laser is converted using a etalon to 2884 MHz. The width of the laser pulse is 30 psec.

A high DC-voltage was applied to the cathode through a coaxial cable which form a capacitor to feed charge with a fast time response.

§3. Experimental results and discussions

Measurements were made on the return current I_e of the power supply and on the RF-output power P_{out} of the LASERTRON, as a function of the applied voltage for the fixed laser power. It was found that the current I_e and the power P_{out} depend on the applied voltage V differently from a conventional klystron, as shown in Figs. 2 and 3. Figure 2 shows that the emitted current I_e is proportional to V in the present experiment and is represented by

$$I_e = kV \qquad (1)$$

where k is a constant.

The linear dependence of the limitation current is a characteristic property for the bunched beam[5]. At the maximum applied voltage of 30 kV, which was limited by the breakdown, the emitted current and output power were about 10 A and 1.6 kW, respectively. Since the pulse width of the one burst at the half maximum is 50 nsec, the emitted electrons at this voltage is 500 nC and the peak current density is 75 A/cm^2.

The output power P_{out} is represented by

$$P_{out} = f(V)kV^2 \qquad (2)$$

where f(V) is the conversion efficiency of the beam power to the RF-output, including the beam coupling with the cavity and the output coupler. The observed dependence of P_{out} on the applied voltage V in the present experiment is 2.8 power.

§4. Conclusion

R&D on a new RF-source "LASERTRON" proceeded. A prototype LASERTRON, Mark-I, was fabricated and studied. RF-power of 1.6 kW was generated successfully at the RF-frequency of 2884 MHz by applying the accelerating voltage of 30 kV, which was limited by the breakdown.

Further experimental studies on a new prototype LASERTRON with improvements on the voltage immunity and output cavity are currently underway.

References

1. H. Hirabayashi, et al.: Proc. of the First Tristan Phase II Workshop (KEK, Tsukuba, 1982).
2. P. B. Wilson: SLAC-PUB-2884 (1982).
3. P. B. Wilson: SLAC-PUB-3227 (1983).
4. T. Shidara, et al.: Proc. of the meeting on linear accelerators in Japan (1983) 66.
5. H. Nishimura: Contributed paper at this meeting.
6. M. Miyao: Contributed paper at this meeting.
7. K. Oba (Hamamatsu Photonics Inc.): The quantum efficiency of the photocathode measured by Hamamatsu Photonics Inc. is 3% for the wavelength of 500 nm.

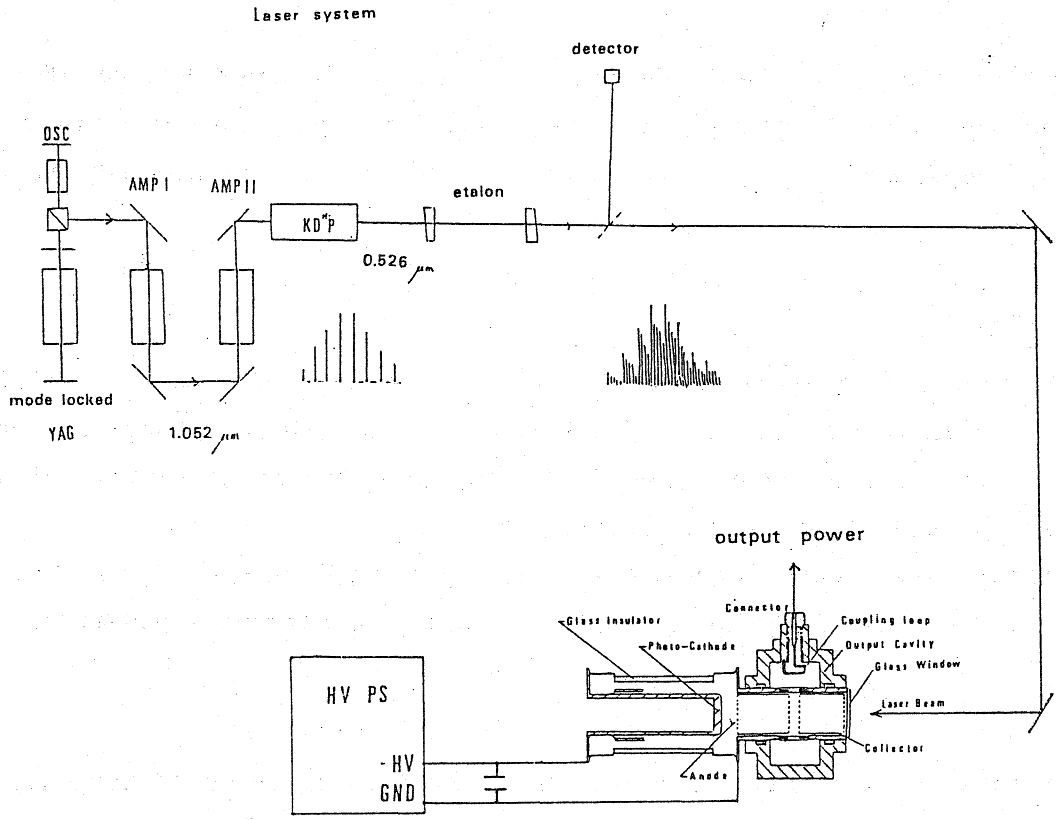

Fig. 1 A cross sectional view of the LASERTRON Mark-I and the experimental arrangement.

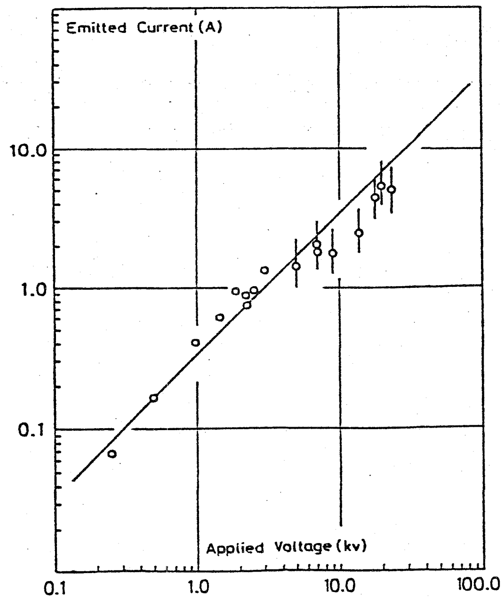

Fig. 2 The average emitted current from the cathode per burst of laser versus the applied voltage.

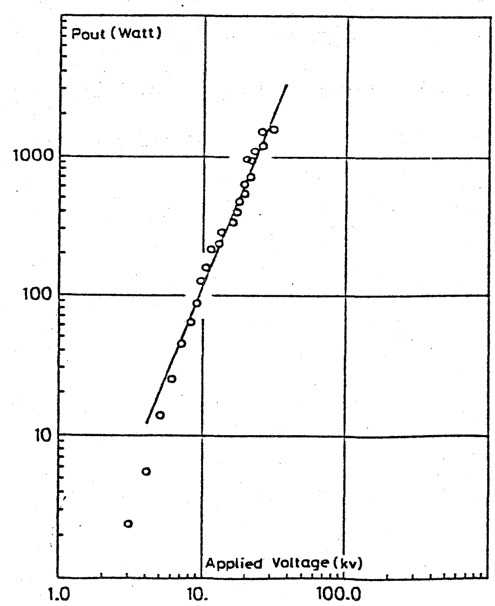

Fig. 3 The output RF-power versus the applied voltage.