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LASERTRON RF SOURCE*

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Abstract

The "Lasertron" is an RF amplifier in which an RF-modulated laser is used to illuminate a photocathode. The resulting RF-modulated electron beam is accelerated through a diode and then passed through a conventional RF output gap. This talk will describe the R and D program at SLAC in which the initial goal is to develop an S-band lasertron with 35 MW output power and 70% efficiency.

Introduction

The lasertron R and D program at SLAC results from the need for an efficient, high-peak-power, RF amplifier for a future high energy (TeV range) electron-positron linear collider. Present thinking is that such a future collider should operate at higher frequency (8-10 GHz) than present S-band linacs and that the peak power per RF station should at least be comparable with the 50 MW or so achieved with present klystron technology.[1] The lasertron concept is covered by a patent issued to Wilson and Tallerico of LANL.[2] The Japanese have actually built and operated a prototype lasertron.[3]

The R and D Program

Interest in the lasertron concept has grown from the development of high current photocathodes. The SLAC program is concentrating on cesium activated gallium arsenide photocathodes. Most of the present effort is directed at establishing that high currents can be extracted from the photocathode in an environment that is practical for an RF source. Figure 1 shows the prototype device which is presently being constructed. The first model will not have the RF output cavity and thus will simply be a test of photocathode performance. The cesium source shown only hints at the equipment needed to clean and activate the gallium arsenide photocathode. The ultrahigh vacuum requirements of

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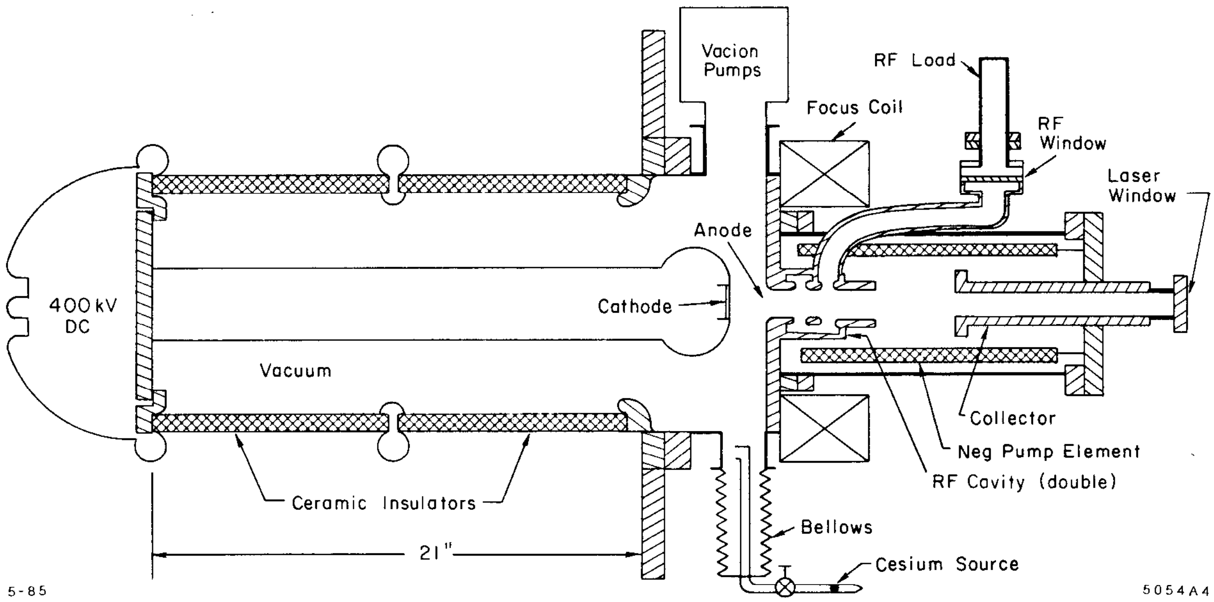

Fig. 1. The layout of the prototype 35MW lasertron.

the photocathodes are severe and the test device must include all the apparatus needed for in situ reactivation.

After the cathode life tests are completed with the diode, an RF cavity will replace the straight drift tube and a mode-locked, frequency-doubled, Nd:YAG laser, modulated to produce a 1 microsecond comb of 60 ps pulses at a 2856 MHz rate, will be used to illuminate the photocathode.

MASK Simulations

Figure 2 shows the geometry used for simulations with the particle-in-cell program MASK. In simulations including the RF output cavity in the position indicated on the figure, it is found that it is only possible to obtain about 50% efficiency with a single output cavity of the type used on typical high power klystrons. However, if a double output cavity, similar to that shown in Fig. 1, is used, the simulations yield up to about 70% efficiency. At this level, a Fourier analysis of the MASK current shows that very nearly all of the fundamental frequency RF current has been removed from the beam. Only DC and higher harmonics remain in the beam going to the collector.

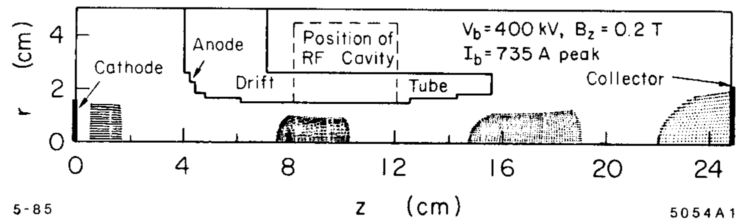

Fig. 2. MASK simulation of the lasertron diode. Shown are four pulses in four sequential positions from the cathode through the drift tube and on to the collector. The pulses are spaced by 350 ps intervals, corresponding to 2856 MHz, and are about 60 ps long. The cathode-to-anode voltage is 400 kV and the beam power is 50 MW.

Future Objectives

The primary attraction of the lasertron is the promise of higher efficiency, at high power, compared with conventional klystrons. Even though the hope is to achieve these characteristics at higher frequency, the present program is being conducted at S-band because of the amount of equipment and experience available at that frequency. In order to maintain the present design power level at higher frequencies, it is expected that some combination of higher voltage and/or a converging beam geometry will have to be used.

Part of the hope for achieving high efficiency rests in the promise that the lasertron can be run with a DC power supply, thus avoiding the cost and inefficiency of a pulsed modulator. Demonstrating that the lasertron can be run with a DC power supply is a very high priority of the present program.

Because efficiency is so important to the goals of the lasertron project, it becomes equally interesting to evaluate competing RF sources for possible improvements in efficiency. If the double output gap is used in SLAC's present production klystron, it appears that efficiencies between 60 and 70% should be realized. If so, then the advantage of the lasertron would depend on the "peripherals" such as the cathode heater power in a klystron, the power to the electromagnet, which is probably much larger than the electromagnet for the lasertron, and the possible elimination of the modulator. On the other side, the cost and power required for the laser must be included.

For the future program aiming at higher frequencies, it will be necessary to increase the frequency of the comb of pulses from the laser and simultaneously, to reduce the pulse length proportionately. It is possible that the lasertron is more amenable than conventional klystrons to such configurations as hollow beams which might permit high power at higher frequency.

References

1. P. B. Wilson, "High Pulse Power RF Sources for Linear Colliders," 12th International Conference on High Energy Accelerators, Batavia, Illinois, August 1983, SLAC PUB 3227.
2. M. T. Wilson and P. J. Tallerico, US Patent No. 4,313,072, January 26, 1982.
3. See papers by Nishimura and Yoshioka in Proceedings of the 1984 Linear Accelerator Conference, GSI-84-11, Darmstadt, September 1984.