STATUS OF THE NOVOSIBIRSK HIGH POWER FREE ELECTRON LASER

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Abstract

A 100-MeV 8-turns accelerator-recuperator (AR) intended to drive a high-power infrared free electron laser (FEL) is under construction in Novosibirsk now. The FEL will provide up to 100 kW average power radiation in the wavelength range 2 - 50 µm. As building up the full-scale machine takes a long time and much resources, it is reasonably to divide the project into two stages.

The first-stage machine includes the AR with the full-scale RF-system and only one turn of electron beam, so the maximum energy of electrons is 14 MeV. A submillimeter-wave FEL will be installed on the single backward track of the AR. The expected FEL parameters are: wavelength of emitted radiation 100...200 µm; pulse duration 20...100 ps; peak power 1...7 MW; average power 0.6...7 kW. Thus, one gets an operating FEL after commissioning the first stage of the project. Some aspects of these two projects and possible applications are discussed.

1 INTRODUCTION

The efficiency of the conversion of the beam power to the radiation power is rather small in an FEL, being typically not more than a few percent. For high power applications, therefore, it is necessary to recover the beam power after the FEL interaction [1,2]. The main reason for the energy recovery, except of simple energy saving, is the dramatic reduction of the radiation hazard at the beam dump.

One of the possible methods of the beam energy recovery is to return the beam to the radiofrequency (RF) accelerating structure, which was used to accelerate it. If the length of path from the accelerator through the FEL to the accelerator is chosen properly, the deceleration of particles will occur instead of acceleration, and therefore the energy will return to the accelerating RF field (in other words, the beam will excite RF oscillations in the accelerating structure together with the RF generator). Such a mode of accelerator operation was demonstrated at the Stanford HEPL [3]. The first high power free electron laser using such accelerator-recuperator was successfully commissioned recently [4]. An obvious development of such an approach is the use of multipass recirculator [5,6] instead of simple linac. By increasing of the number of passes, cost and power consumption can be reduced. However, the threshold currents for instabilities also decrease, so the "optimal" number of passes exists [7]. The general scheme of such FEL is shown in Fig.1.

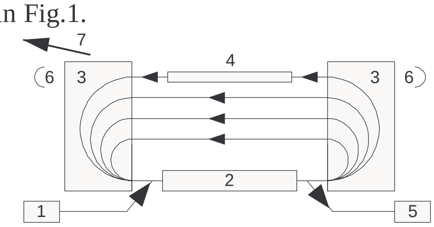

Figure 1: The scheme of the FEL with the accelerator-recuperator. 1-injector; 2-RF accelerating structure 3-180-degree bends; 4-FEL magnetic system; 5-beam dump; 6-mirrors; 7-output light beam.

The high power infrared FEL for the Siberian Center of photochemical research, which is under construction now, is the implementation of this approach.

2 FIRST STAGE OF THE FEL

A 100-MeV 8-turns accelerator-recuperator intended to drive a high-power infrared FEL is under construction in Novosibirsk now [8]. The first stage of the machine includes one turn accelerator-recuperator, that contains full-scale RF-system, but reduced number of turns (Fig. 2). Main parameters of the accelerator-recuperator are listed in Table 1.

The FEL is installed on the single backward turn of the accelerator-recuperator. It consists of two undulators, a magnetic buncher, two mirrors of optical resonator, and an outcoupling system. Both undulators are identical.

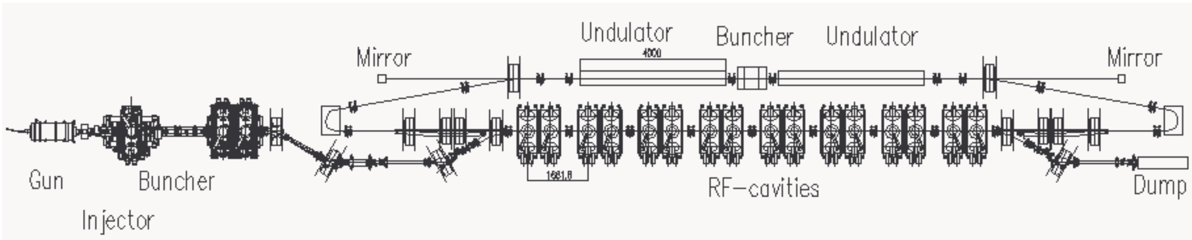

Figure 2: Scheme of the first stage of the high power free electron laser.

They are electromagnetic planar ones, of length 4 m, period is 120 mm, gap is 80 mm, and deflection parameter . K is up to 1.2. One can use one or both undulators with or without the magnetic buncher. Both mirrors are identical, spherical, made of polished copper, and water cooled. The outcoupling system contains four adjustable planar 45 copper mirrors (scrapers). These mirrors scrape radiation inside the optical resonator and redirect small part of it to user. This scheme preserves the main mode of optical resonator well and reduces excitation of higher modes effectively. The buncher is simply a three-pole electromagnetic wiggler. It is necessary to optimize the relative phasing of undulators.

Table 1: Parameters of the accelerator-recuperator

RF wavelength, m	1.66
Number of RF cavities	16
Amplitude of accelerating voltage at one cavity, MV	0.8
Injection energy, MeV	2
Final electron energy, MeV	14
Bunch repetition frequency, MHz	2 - 22.5
Average current, mA	4 – 50
Final electron energy dispersion, %	0.2
Final electron bunch length, ns	0.02-0.1
Final peak electron current, A	50 – 10

The expected radiation parameters are shown Table 2.

Table 2: Expected radiation parameters

Wavelength, mm	0.1...0.2
Pulse length, ns	0.02...0.1
Peak power, MW	1...7
Average power, kW	0.6...7

3 CONCLUSION

The reliable operation of the 2 MeV injector at average current 50 mA was achieved last year. The measured beam parameters are suitable for the beginning of the commissioning. The assembly of the all systems is in progress. The commissioning of the accelerator-recuperator is scheduled by the end of this year.

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