A LINAC FOR FREE ELECTRON LASER AT JAERI

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ABSTRACT

Design and construction of a 25 MeV superconducting linac has been started for a free electron laser oscillation at 10 ~ 20 μm infrared wave lengths.(Phase I) The linac consists of a 250 kV grid pulsed gun, an 84.7 MHz sub-harmonic buncher, a 508 MHz buncher, two 508 MHz superconducting pre-acclerating cavities, and a 508 MHz superconducting multi-cell linac. Beam pulsing will be made by using a triode gun with a repetition rate of 12.1 MHz with 4 ns micro-pulse width. Design parameters of the injector and the bunchers are briefly described.

Introduction

Research and developing program for free electron laser(FEL) has been started at JAERI, aiming at a powerful light source with variable wave length. For the oscillation of FEL, a very high quality electron beam is required : the relative energy spread $\Delta E/E$ of 1% or less, high current density, and the emittance ($\pi x x'$) less than the wave lenght of the laser light. As the normal conducting linac may have difficulties to maintain beam energy homogenity and stability during fairly long beam pulse of about 100 μs to build up the laser oscillation, we did not adopt the improvement of the existing s-band 120 MeV linac.

In the phase I of this project, we will construct a superconducting linac which is suitable for the long pulsed beam or the CW operation. The maximum beam energy is expected to be 25 MeV to oscillate infrared wave length of 10~20 μm. Two kind of operation modes are considered, CW mode and a pulse mode with 1 ms macro-pulse width and a repetition rate of 10 pps. The system will be constructed in a retired Van de Graaff accelerator target room. In the following, design specifications of the phase I stage are described briefly.

Electron Gun

The shape of the electrode structure, which directly contributes the quality of the beam, is designed to produce a small diameter(~2mm), low emittance (10π mm mrad) beam with a current 100 mA at the accelerating voltage of 200 to 250 kV.[1][2] A thermionic cathode with a grid structure (Eimac Y646B) is used to emit beam pulses of 2-4 ns micro-pulses with a repetition rate 12.1 MHz. The grid pulsing is driven by a pulse amplifier using microwave triode tubes.[3] The SF6 insulation gas will be filled around the gun high voltage equipments.

Sub-harmonic Buncher and Buncher

To increase the current density in the micro-pulse, and to reduce the energy spread due to phase spread in the main accelerator, the beam from the injector is compressed by a sub-harmonic buncher of 84.7 MHz and a buncher of 508 MHz.[4] The latter is used as a debuncher. The maximum gap voltage of the sub-harmonic buncher is ~60 kV, and that of the buncher ~10 kV. The 2-4 ns, 100mA beam from the gun will be compressed to 20 ps, 10-20 A beam at the end of the buncher.

Pre Accelerator

The beam energy from the buncher is centered at 200-250 KeV with modulation of several tens kV. This beam is accelerated to about 2 MeV by a pre-accelerator, of which frequency is 508 MHz. The accelerating cavity is designed to be composed of two superconducting cavities with β= 0.9 and 1, respectively.

Main Accelerator

A main accelerator will be a superconducting accelerator, which has the same structure of the TRISTAN main Ring accelerator developped by Kojima et al.[5] of National Laboratory for High Energy Physics(KEK) and the Mitsubishi Heavy Industry Co. The energy gain of this accelerator is expected to be about 20 MeV.

RF source

The RF source of the 84.7 MHz sub-harmonic buncher with 5 kW power level will be supplied by solid state amplifiers. For the 508 MHz source, a UHF CW klystron of several tens killo-Watt will be used. Phase lock of the RF system is made by dividing the reference frequency signal of 508 MHz.

Conclusion

The outline of the Linac in phase I of the FEL project is described. However the specifications are not completely fixed up. The beam transport system, the radiation shielding, the undulator, and the optical cavities will be designed in a couple of years. The phase I of the FEL project starts at 1987, and will end at 1991 after completion of the infrared light production. In the phase II of the FEL project, the beam energy and current will be increased to oscillate visible and ultra-violet light, aiming at powerful light source for the isotope separation.

References

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