

FIRST LASING OF THE JAERI FEL DRIVEN BY THE SUPERCONDUCTING RF LINAC

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Abstracts

First and stable laser oscillation has been obtained at a wavelength of 24 μ m using the JAERI (Japan Atomic Energy Research Institute, Tokai) superconducting rf linac based FEL driver. Electron beam energy and resolution are 15.8MeV, and 0.6% respectively, the beam current and pulse width a few mA and 0.8ms or less, respectively. The optical resonator with a 52 period hybrid planer undulator (K=0.7) is 1.7m long and uses Au coated Cu mirrors of 120mm diameter. The optical axes and distance of the mirrors is adjusted by remotely controlled actuators in order to coincide with the electron beam and micro pulse repetition rate, respectively, before the oscillation. The power is scattered from 10^7 to 10^8 times higher than that of the spontaneous emission. During the first successful operation, the highest FEL power was measured to be several tens watts in average. The FWHM of the FEL spectrum is less than 0.6 μ m, which corresponds to $\Delta\lambda/\lambda=2.5\%$. The tuning range of the cavity is about 15 μ m.

1 INTRODUCTION

A prototype for a quasi-cw or long-pulse, and high-average power free electron laser (FEL) driven by the 15 MeV superconducting rf linac has been developed, and constructed at Tokai, JAERI (Japan Atomic Energy Research Institute) since 1989[1-8]. Cryogenic (stand-by loss < 3.5W at 4.5K) and accelerating fields' performances (Eacc < 8MV/m and Q < 2 x 10⁹) of four JAERI superconducting accelerator modules were realized without any serious vibrational problem in the FEL accelerator vault.

Since modification and related maintenance of the cryogenic refrigerator system for the driver were completed in the middle of October 1995, the system has run with no trouble, and the driver has been continuously run very successfully up to now. The optical resonator system and related electron beam transport system were modified to realize larger acceptance than the old for both of the undulator radiation and energetic electron beam. An alignment and distance measurement system was newly developed, and successfully applied to actual preparatory measurement for lasing in the JAERI FEL. A far-infrared light transport line and detector room was built to realize a low-loss and low-noise measurement near the

accelerator vault in April, 1996.

In order to realize the quasi-cw and long-pulse operation, we have improved the electron gun grid-pulsar and high voltage power supply, and rf amplitude and phase control systems for the JAERI superconducting rf linac. The improvements in the electron gun and the related with the rf system were still under way.

A beam test and commissioning of the JAERI superconducting rf linac as an FEL driver was successfully performed to get an electron beam ranging from 10 to 23 MeV with a nearly full transmission and a full current, and relatively short macro pulse of 0.01ms. Strong and stable oscillation in the wavelength of around 24 μ m have been observed by using the Ge(Cu) detectors and home-made fast current amplifier system. As shown in Fig.1, a sudden increase of the light signal were observed after a few tens of μ sec later from the beginning of beam current pulse.

2 EXPERIMENT

Fig.1 shows the first and stable laser oscillation with the JAERI superconducting rf linac based FEL. The average current for a macro pulse is measured to be around 4mA. The lower trace of the figure is a far-infrared light signal waveform of a Ge-Cu detector. The total cavity loss and the FEL gain are 3% or less and around 16%, respectively, which are obtained from decay and rising times of the output pulse. The FEL spectrum was measured with a grating spectrometer during the operation. The FWHM of the FEL spectrum is less than 0.6 μ m, which corresponds to $\Delta\lambda/\lambda=2.5\%$. The tuning range of the cavity is spanned over about 15 μ m.

Stable laser oscillation has been obtained at a wavelength of 24 μ m using the JAERI superconducting rf linac based FEL driver. During the first successful operation, the highest FEL power was measured to be several tens watts in average. The JAERI superconducting rf linac operational parameters are summarized in the following; 1) Electron Beam Energy 15.8MeV, 2) Micropulse width 20ps and Peak current 10A, 3) Macropulse width from 0.2 to 0.8ms, 4) Beam current ranging from 2mA to 4mA, 5) Energy resolution around 0.6%, and 6) Repetition Rate 10.4125MHz.

The optical resonator with a 52 period hybrid planer undulator (K=0.7) is 1.7m long and uses Au coated Cu

mirrors. The optical axes and distance of the mirrors is adjusted by remotely controlled actuators in order to coincide with the electron beam and micro pulse repetition rate, respectively, before the oscillation. The power is scattered from 10^7 to 10^8 times higher than that of the spontaneous emission.

3 PREFERENCE

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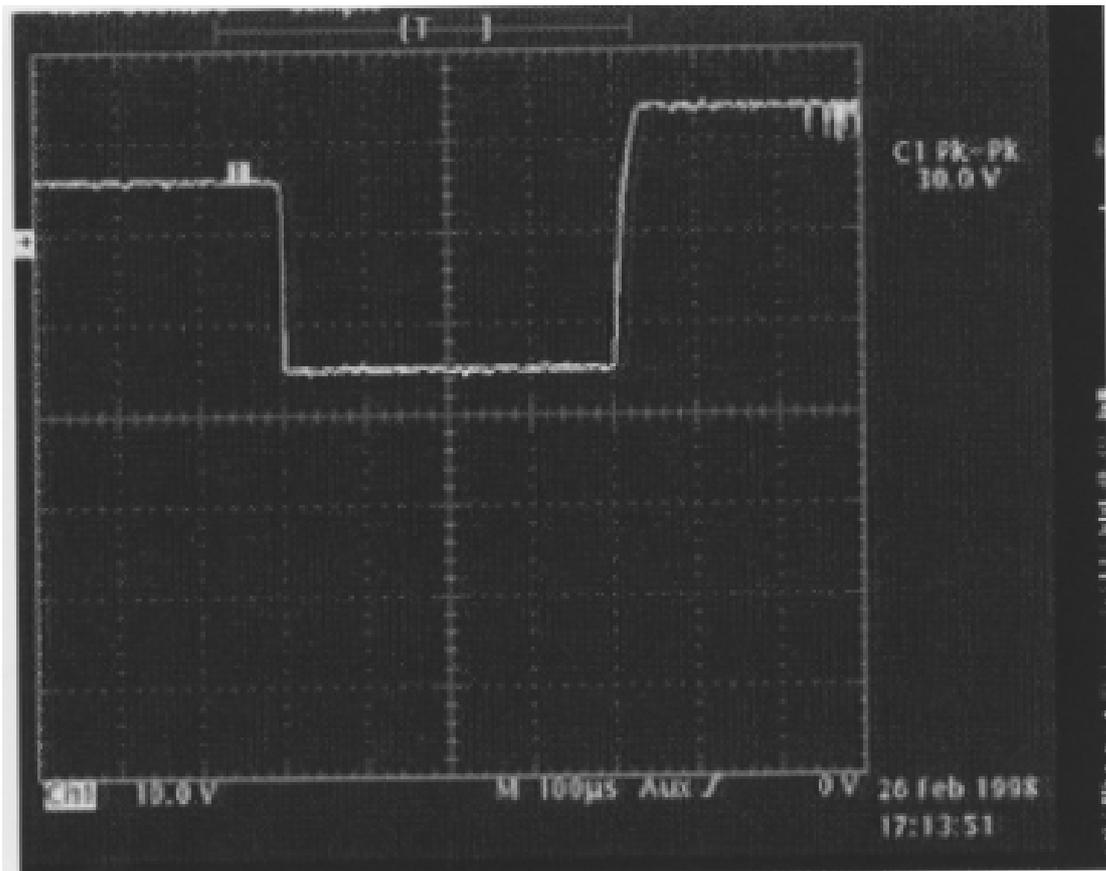


Fig.1, Stable oscillation in the wavelength of around $24 \mu\text{m}$ has been observed by using the Ge(Cu) detectors and home-made fast current amplifier system. Macropulse width is about 0.4ms, beam current ranging from 2 to 4mA, and laser power of several tens watts in average.