THE DRIVE LASER SYSTEM FOR CFEL

Li Weihua,Chen Yanan
Institute of Applied Electronics,CAEP,China

Abstract

A reliable and compact drive system is one of the key components for the stable operation of FEL.We have developed a solid-state drive laser system to meet the requirements of the CFEL(CAEP FEL) research.The system consisted of a passive mode-locked oscillator with a timing stabilizer,a regenerative amplifier and a frequency conversion part.After the 4-th harmonics,the duration of 15 picoseconds Gaussian pulses with wavelength 266nm at a repetition rate 54.17MHz were obtained.These micropulses were contained within a macropulses envelope as long as 1 to 6μs,which was emitted from the drive laser at a repetition rate at 3Hz,6Hz or 12Hz,one single micropulse energy as large as 4μJ was achieved.The design specifications, configuration and diode-pumped amplifier of the drive laser system are also described.

INTRODUCTION

A reliable and compact drive laser system is one of the key components for the stable operation of FEL.It will strongly affect the performance of the FEL,such as the specifications as following:the micropulse duration of electron beam,the micropulse current of electron beam,the jitter of micropulse-peak-current,and so on[1].We have developed a all-state-solid drive laser system to meet the requirements of the CFEL research,as shown in table 1.The laser stablility,e.g.,energy stability,timing stability and the pointing stability,was also requested stringently during the course of the research[2].

DRIVE LASER SYSTEM

The drive laser system,which was shown in Fig.1,was consisted of a passive mode-locked oscillator with a timing stabilizer,a regenerative amplifier and a frequency conversion part.

Oscillator

The seeding laser GE-100-XHP,is a passive mode-locked laser with a semiconductor absorber mirror (SESAM),developed by Time-Bandwidth Products Ltd, Switzerland[3].Its repetition rate is 54.167 MHz,equal to 1/24 of 1300MHz L-band radio frequency, which was used for the photocathode RF gun.The timing stabilizer measured the phase and the frequency offset between the laser pulses and the reference RF signal,and adjusted the cavity length to synchronize the two signals[4].

Regenerative Amplifier

It was composed of one-double-pass and two-single-pass stages.A Pockels Cell captured a “maropulse” from the continuous pulses output to increase the pulse energy.Every “macropulse” contains 50 to 300 micro-pulses,as long as 1us to 6us.

Harmonics Generator

This component coverted the fundamental output to the 4-th harmonics,which would illuminate the photocathode Cs_2Te.The net conversion efficiency was close to 20% from the fundamental to the 4-th harmonics.The UV energy was obtained up to 1.2mJ per “macropulse”,4uJ per micropulse.

LASER PERFORMANCE

Amplitude Uniformity

The amplitude uniformity from micropulse to micropulse in the same macropulse was quested stringent-ly for the CFEL research.We have measured it at the port of regenerative amplifier,2-th harmonics and 4-th harmo-nics,as shown in Fig.2,Fig.3,Fig.4.The variation of amplitude uniformity from micropulse to micropulse was 3% rms or less.

Energy Stability

UV energy stability was measured for 300 shots by a power meter.The statistical results showed that the Energy fluctuation was 2.8%rms or less.The curve of energy deviation from the mean value was shown in Fig.5,which were 84 data from the 300 shots.

Timing Jitter

The timing jitter of the laser oscillator was estimated from the output of the phase detector in the feedback loop.A phase detector measured the phase difference between the fast photodiode signals of laser pulses and the reference RF signal,and generated an “error signal”.This phase difference was related to the timing jitter between the laser phase and the reference RF phase.The timing jitter of the oscillator was estimated as 0.4ps rms.

Pointing Stability

The pointing stability of 266nm output pulses was measured by a CCD camera.Beam profiles were measured on a screen plate at 30 meters away form the laser output port.Pointing stability of the beam centroid was estimated to be 0.1mrad rms in Y direction,and 0.01mrad rms in X direction,as showed in Fig.6 and Fig.7.The scale between the pixel to actual dimension was 13.7 pixels to 1mm.Fig.8 was the beam profile.

Other specifications and the laser performance were listed on Table 2.

CONCLUSION

The all-solid-state drive laser system has been developed on the basis of the laser diode pumping,the passive mode-locked oscillator with SESAM and the feedback timing stabilizer.The drive laser was reliable,compact and satisfying to meet the requirements of the CFEL research.

REFERENCES

[1] Li Zhenghong,Hu Kesong,Yang Maorong etc.The RF Photoinjector Research,High Power Laser and Particle Beams,2000,12(3):366
[2] F.Sakai,M.Yorozu,Y.Okada etc.All-Solid-State Picosecond Laser System for Photocathode RF Gun.
[3] High Power Mode-locked Diode-Pumped Picosecond Laser,User Mannual,Time-Bandwidth Ltd,Switzerland.
[4] Timing Stabilizer Feedback System Accessory,User Mannual,Time-Bandwidth Ltd,Switzerland.
[5] A.R.Fry,M.J.Fitch etc.Laser System for The TTF Photoinjector at FERMILAB.IEEE,1998
[6] J.Early,J.Barton etc.The Los Alamos FEL Photoinjector drive laser,Nuclear Instruments and Methods in Physics Research ,A318(1992)381-388

Tab.1 The Parameters of CFEL

1	Electron Energy/MeV	35-40
2	Beam Pulse Current/A	>30
3	Beam Pulse Duration/ps	3-5
4	Pulse Repetition Rate/MHz	54.17
5	Maropulse Duration/μs	1-6
6	Maropulse Rep. Rate/Hz	3-6-12
7	Pulse Timing Jitter/ps	<2
8	Micropulse Amplitude Jitter/rms	<3%
9	Energy Spread	<1%

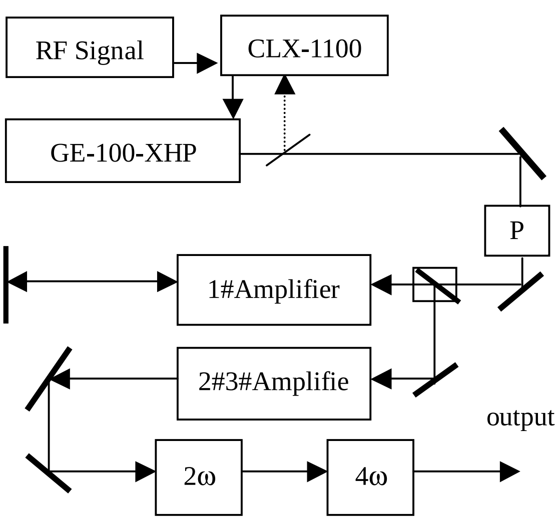

Fig.1 Layout of the Drive Laser System for CFEL

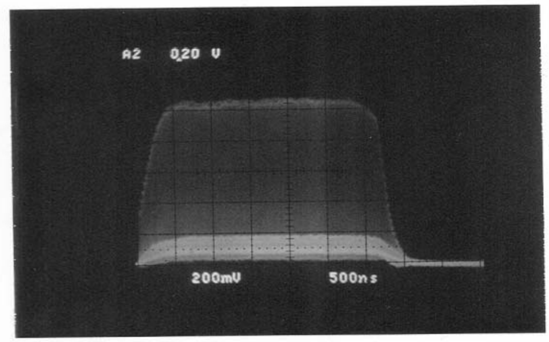

Fig.2 The amplitude uniformity at the port of amplifier

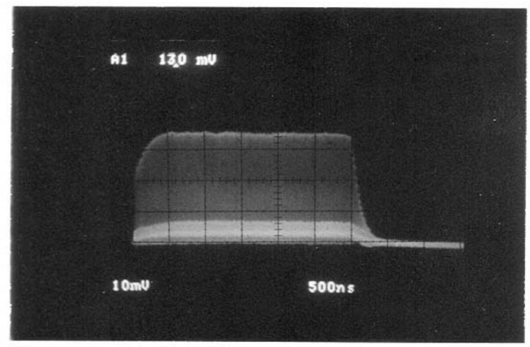

Fig.3 The amplitude uniformity at the port of 2-th harmonics

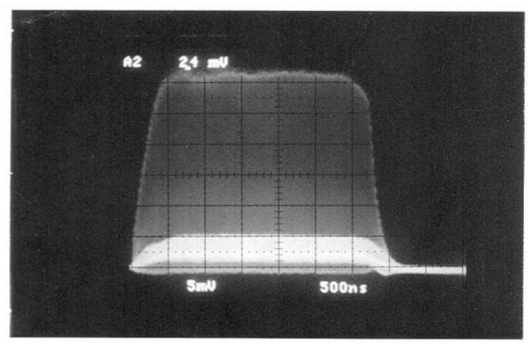

Fig.4 The amplitude uniformity at the port of 4-th harmonics

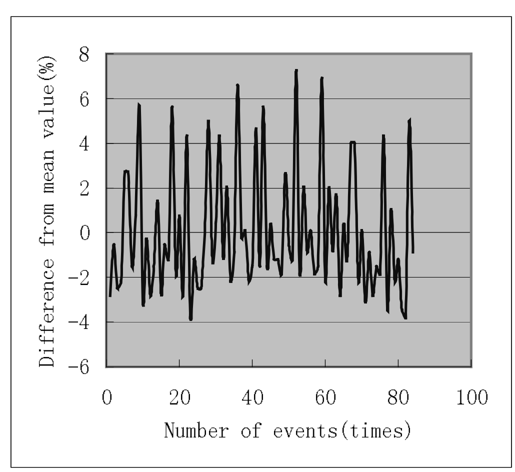

Fig.5 The UV energy fluctuation from mean value

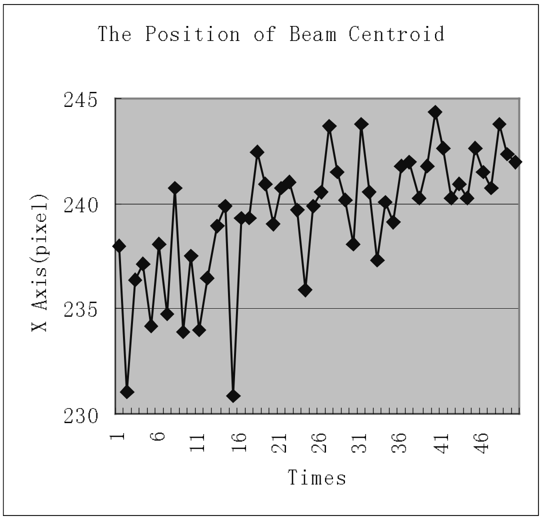

Fig.6 The pointing stability at X direction

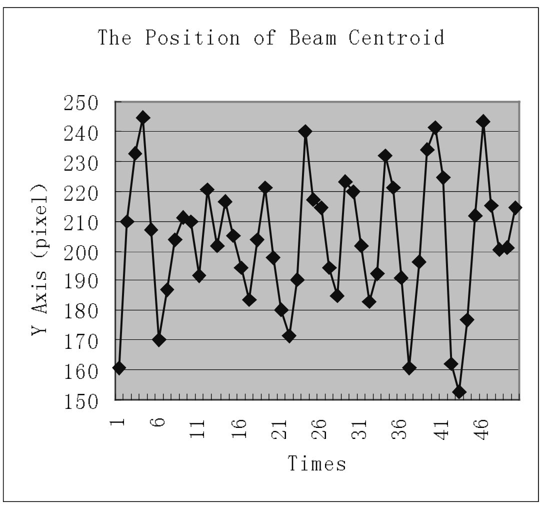

Fig.7 The pointing stability at Y direction

Tab.2 The performance of the drive laser system

1	Wavelength/nm	266
2	Pulse width/ps	10-15
3	Frequency/MHz	54.17
4	Pulse Energy/μJ	3-5
5	Maropulse duration/μs	1-6
6	Maropulse repetition. rate/Hz	3-6-12
7	Micropulse timing jitter/ps	<2
8	Amplitude jitter/rms	3%
9	Pointing stability/mrad	0.11

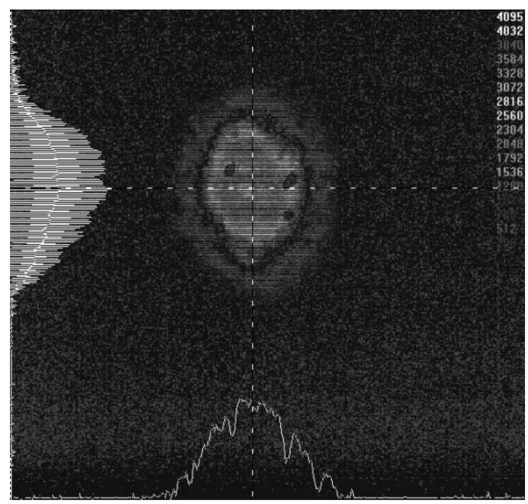

Fig.8 The profile of UV pulse spot