THE DRIVING LASER FOR FEL-THz

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Abstract

A solid-state driving laser system have been developed to meet the requirements of the FEL-THz research. The design specifications, configuration and diode-pumped amplifier of the drive-laser system are also described. The laser system can generate continuous or 10μs-20μs pulses light with wavelength 1064 nm, 532nm, 266nm at a repetition rate 54.167MHz. The average power of the driving laser system is more than 25W, 8W, 1W at wavelength 1064nm, 532nm, 266nm respectively. The cathode material is GaAs. The second harmonic is used, of which average power is 8.55W, pulse width is about 12ps, power stability is 0.72% and pointing stability is 46urad。

INTRODUCTION

The first lasing of a thermionic RF-gun injector driving FEL-THz facility was realized in March 2005 in CAEP, whose FEL wave length is 115μs, but the saturation of the FEL can not be achieved, mainly because of the low electron current and the instability of the facility, so we decided to develop a high performance photo-cathode RF-gun injector. The photo-cathode RF gun injector developed from 1985[1], comparing with the thermionic cathode RF-gun injector, it is easy to get short pulse with high current and small energy spread, and at present it is the stand way to provide high brightness beam to generate high current and low emittance beam. The photo-cathode RF-gun is more adaptive to the research of FEL.

The compact and credibility driving laser is important to the photo-cathode RF-gun, which decides the capability of FEL, such as the micro-pulse length, current intensity and peak value jitter of electron beam. We have developed a solid-state driving laser system to meet the requirements of the FEL-THz research. While capabilities of driving laser including timing jitter, long term stability of the average power and pointing stability are needed.

THE SYSTEM OF DRIVING LASER

The cathode material is GaAs and the second harmonic light is used. The cathode-driving laser system(shown in Fig.1) of the RF photoinjector includes a mode-locked oscillator(from Time-Bandwidth), timing stabilizer,diode-pumped amplifier and second harmonic generation. The driving laser needs RF signal timing synchronization[2], which is extremely important for FEL-THz research. The output characteristics of oscillator are listed in table 1.

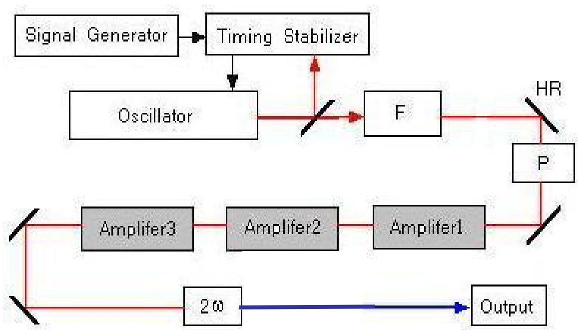

Figure 1: The cathode-driving laser system.

The laser system can generate continuous or 10μs-20μs pulses light with wavelength 1064nm, 532nm, 266nm at a repetition rate 54.167MHz. Fig.2 displays the diode-pumped amplifier and second harmonic generation system.

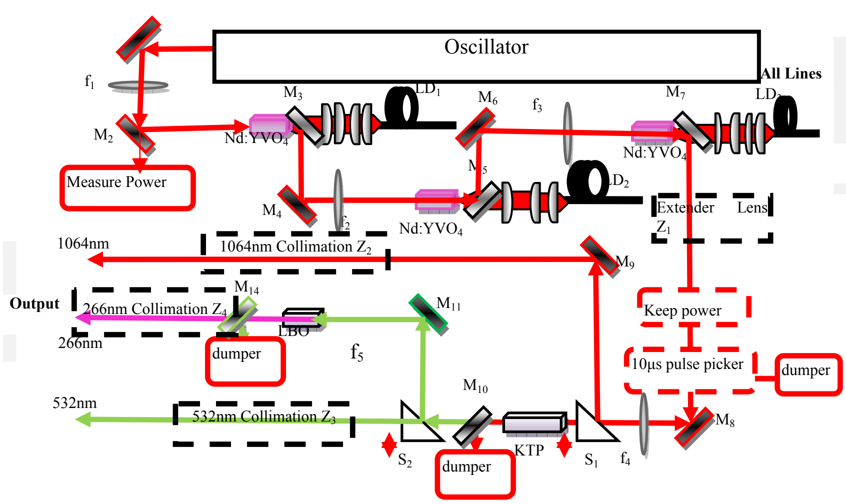

Figure 2: The diode-pumned amplifier system.

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Table 1: The Output Characteristics of Oscillator

Parameter	Value
wavelengh/nm	1064
Pulse repetition rate/MHz	54.167
Output power/W	10.7
Pulse Width (FWHM)/ps	11.9±1
Stability of power /rms	<1%
Timing jitter/ps	<1
Beam quality	TEM_{00}
Pointing stability /mrad	0.03

THE OUTPUT CHARACTERISTICS OF DRIVING LASER

Power Stability

Output powers of the driving laser with wavelength 532nm and 1064nm were measured by laser meter. Output average power is 8.55W and 26.6W respectively . The power stability of the 532nm laser during four hours is 0.72% (shown in Fig. 3).

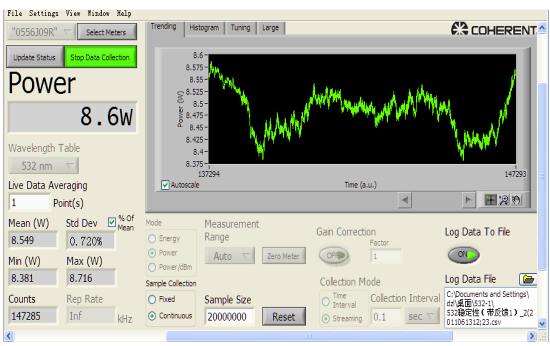

Figure 3: The output power.

Pulse Width

Pulse width of the driving laser with wavelength 1064nm was measured by femtochrome autocorrelator. Pulse width is 14.8ps by calculation.

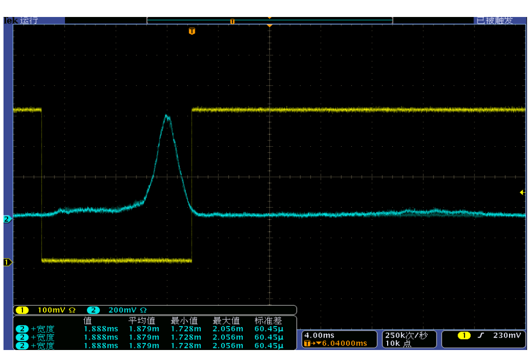
Figure 4: Autocorrelator measurement output waveform.

Beam Circulatity

Beam circulatity was measured in Coherent Beam View analyser. Beam circulatity(Ganssian fit) is 90.1%. The distribution of the 532nm light was showed in Fig. 5.

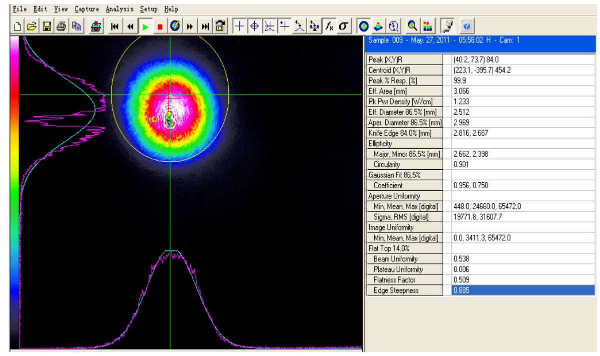
Figure 5: The distribution of the 532nm light.

Beam Quality Factor M^2

Beam qualilty factor M^2 was measured in M^2-200 analyser. The result M_x^2=1.32 and M_y^2=1.32 of the 532nm light was showed in Fig. 6.

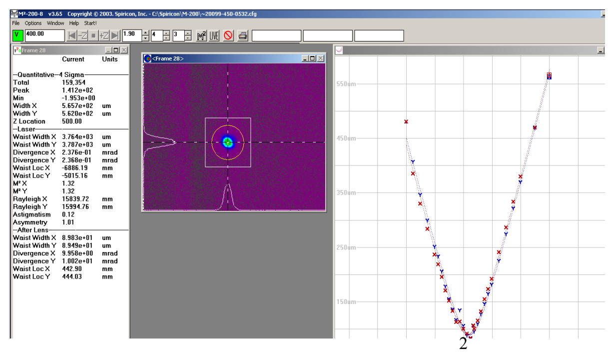
Figure 6: The beam quality M^2.

Pointing Stability

Pointing stability is measured by Coherent Beam View analyser. The 532nm light was focused in 1m where Beam View analyser have been laid . Pointing stability is 46μrad by measurement.

The Function of Macro-Pulse

The laser system can generate 10μs-20μs pulses light at a repetition frequency 1Hz-20Hz by abjusting current source control system. The waveform of the 20μs macro-pulse was showed in Fig. 7.

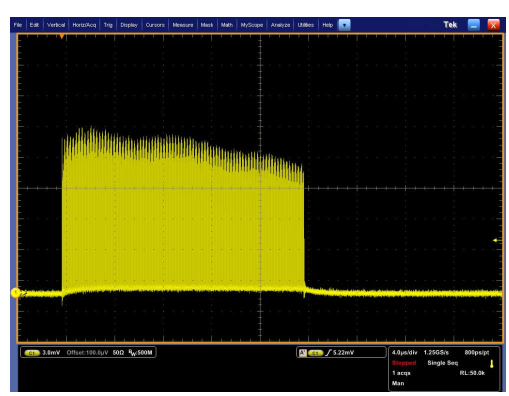
Figure 7: The waveform of 20μs macro-pulse.

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CONCLUSION

We have developed a solid-state driving laser system to meet the requirements of the FEL-THz research. The output characteristics of the driving laser system were listed in table 2. The next step we will be taking the beam experiment and it is expect to achieve the results .

Table 2: The Output Characteristics of The Driving Laser System

Output power @1064nm/W	26.6
Output power@532nm/W	8.55
Power stability（RMS4hour）@532nm/%	0.72
Pulse width @1064nm/ps	14.8
Beam circulatity/%	90.1
Beam qualilty factor M^2@532nm	M_x^2=1.32;M_y^2=1.32
Pointing stability /µrad	46

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[1] A. Westenshop, J.M.J.Madey, “Microwave Electron Gun”, Laser and Particle Beam, 1984,2(2),p223.

[2] Rodwell M J W, Bloom D M, Weingarten K J. Subpicosencond laser timing stabilization[J].IEEE J Quantum Electron, 1989,25(4):817～827.

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