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Ultra-fast Electron Diffraction Imaging Based on Laser Wakefield Acceleration
レーザー航跡場加速電子源を用いた超高速電子線回折

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We have constructed a beamline of ultrashort electron bunch from laser wakefield acceleration for single-shot ultrafast electron diffraction. This beamline is consisted from two doublets of quadrupole magnets and a pinhole to select particular electron energy using chromatic aberration in focusing. We have succeeded to deliver the electron beam in this beamline and make the beam with narrow energy spread for high spatial resolved imaging. We start the experiment of single-shot ultrafast electron diffraction.

1. Introduction

In recent years, laser-driven acceleration of electrons has been studied actively. Laser wakefield acceleration (LWFA) has great potential to generate ultra-short electron bunches with high charge [1]. Such electron bunches have the wide applications such as the ultrafast electron imaging to observe the ultrafast transient phenomena in material science. High intense laser pulse is tightly focused on the gas target, and it excites plasma wave by its ponderomotive force, that is caused by gradient of laser intensity. Its cavity has strong electric field more than 100 GV/m, and the electron beam from LWFA has a high energy more than MeV order [2].

For single-shot ultrafast electron imaging with high temporal and spatial resolutions, electron source with high charge, ultra-short pulse duration, low emittance, and high monochromaticity is required. LWFA can be a candidate for the electron source due to its characters. We have succeeded to generate low emittance electron beams with excellent pointing stability using plasma micro-optics by applying an external magnetic field to gasjet[3]. We can also control the pointing of electron beams by using the plasma micro optics. Thanks to the stability and controllability the electron beams from LWFA can be transport with using conventional beam optics.

However, the stability of electron beam spectrum from LWFA is not enough for the applications. To obtain the particular energy electrons with the narrow energy spread repeatedly at the imaging position, we use two set of quadrupole magnets and a pinhole in the beamline.

In this paper, we present the status of electron transport in the beamline. We succeeded in transport of the electron beams from LWFA to the screen for the imaging at 6.5 m from electron source. Furthermore we also succeeded in the selection of the electrons with particular energy and narrow energy spread by two set of quadrupole magnets and a pinhole.

2. Experimental Setup

The experiments have been performed with a Ti:sapphire laser system at Osaka university. Pulse energy is 1J, and pulse duration is 30 fs. Gas jet target is He, 3MPa. We show the experimental set up in Fig.1. Laser pulse is focused by off axis parabolic mirror (f=1000[mm]) on the He gas target. The electron beam from LWFA travels in the beamline for the ultrafast electron diffraction. The

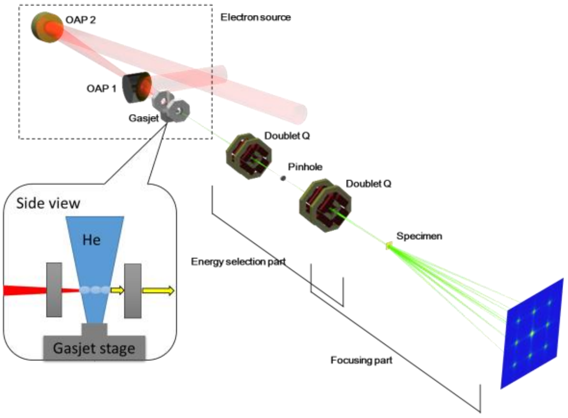

Fig.1. Schematic of experimental set up

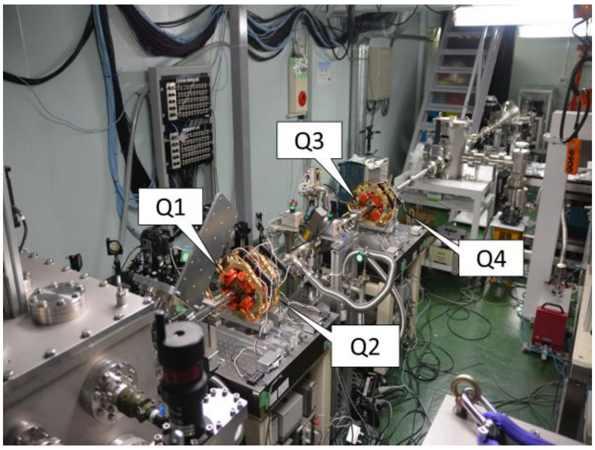

Fig.2. Beamline for single-shot UED

schematic of the beamlineis shown in Fig.2. We put two set of quadrupole magnets and a pinhole to select particular energy electrons. Thickness of the pinhole is 1 mm, and the diameter of the hole is 0.5 mm. The field strength of quadrupole magnets can be changed by the current. The electron beam is focused on the pinhole by first doublet of quadrupole magnets(Q1 and Q2), and the electrons with particular energy can transport through the pinhole. Second doublet(Q3 and Q4) focus the selected electron beam on the phosphor screen (DRZ) for the electron diffraction. The profile of the electrons on the screen is captured by EMCCD.

3. Experimental Results

The profiles of electron beams on the screen are shown in Fig.3. The pointing of the electron beam is quite stable. In addition, the electron beams after transport in the beamline have narrow energy spread due to the set of quadrupole-magnets and a pinhole. The spectrum are also stable. Furthermore we succeeded to change the central energy of the quasi-monoenergetic electron beam by changing

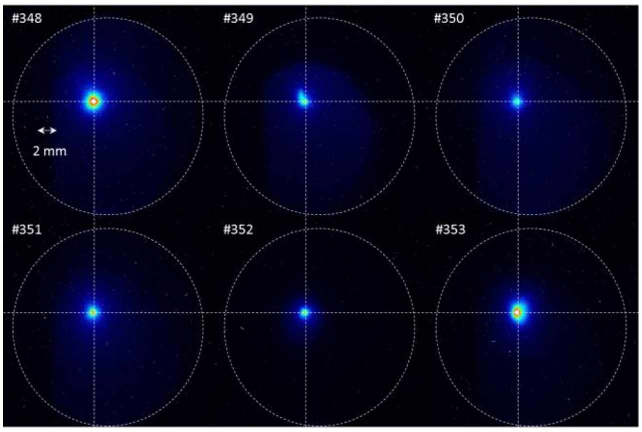

Fig.3. electron spots at the imaging point

position of pinhole and strength of magnetic field. These results enable us to start the experiment for electron diffraction imaging.

4. Summary

We succeeded in transport of the LWFA electron beams to the screen at 6.5 m with using quadrupole-magnets. Furthermore we also succeeded in the selection of the electron energy with narrow spread by using two set of quadrupole magnets and a pinhole. The pointing and spectrum are repeatable, which are enough for the imaging. We just start the experiment of the single-shot ultrafast electron diffraction with this system.

5. References

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