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Development of small diameter plasma channel for laser-plasma-acceleration and density measurement by laser Thompson scattering

レーザープラズマ加速のための小直径プラズマチャンネルの開発と、レーザートムソン散乱によるプラズマ密度測定

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The plasma based laser wakefield acceleration attracts attention due to the large gradient of acceleration. The 1TeV scale beam acceleration needs stable long (~meter scale) plasma channel of which the diameter is less than 1mm and the electron density is $10^{16}cm^{-3}$. We are trying to realize it by inductive RF plasma. Now, we produced RF plasma use a small diameter capacitive quadrupole and report the result of primary measurement of the plasma density and the diameter distribution by Laser Thompson scattering as primary stage.

1 Introduction

The plasma based laser wakefield acceleration (LWFA) attracts attention to a next generation accelerator for particle physics and various applications due to the large gradient of particles acceleration. Recent experiments by using ultrashort pulse intense laser (few tens ,40Tw) have demonstrated to be the acceleration of electron acceleration up to 1 GeV. The acceleration was achieved by using high density (~$10^{18}cm^{-3}$) plasma channel of several cm length [1]. The 1TeV scale beam acceleration needed by high energy science needs stable long (~meter scale) plasma channel with the diameter which is less than 1mm and the electron density is 10^{15}~$10^{17}cm^{-3}$. we are developing to produce such plasma by the application RF of discharge. Electron density profile measurement of such narrow plasma channel is important in LWFA [2]. We are preparing the measurement by the Thompson scattering method.

2 Experimental equipment

The experimental equipment is shown in Fig. 1(a) A quadrupole electrode is consist of 1.2ϕ

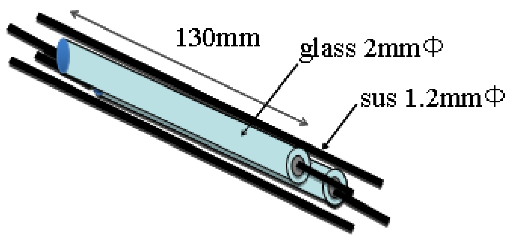

Fig. 1.(a) quadrupole of antenna system

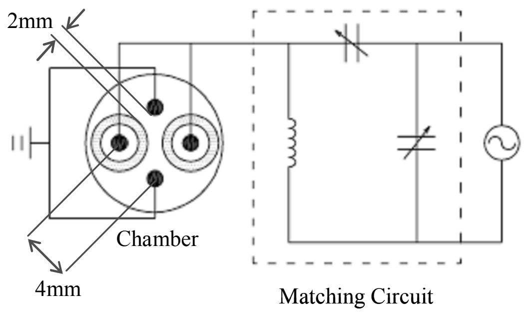

Fig. 1.(b) schematic of rf and antenna system

stainless-steel rods of 1.2mmϕ un duaneter and

130mm in length. To avoid the RF break down l-c-----ed on the antennas, one pair of antenna rods are inserted by glass tube (2mmϕ). RF system for the capacitive quadrupole discharge circuit figure is shown in Fig. 1(b), where frequency and maximum power of RF are 13.56MHz and 5kHz, respectively. Figure 2 shows the schematics of Thompson scattering diagnostic system. Nd:YAG laser(2ω) light is focused and by, irradiated into the plasma channel. Scattered light perpendicular is to detected the incident laser light goes through the triple-grating spectrometer and is detected by ICCD camera.

3 Preliminal results of RF plasma channel production

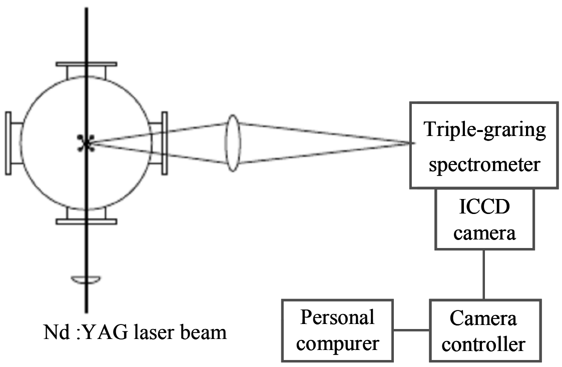

Fig. 2. An arrangement of Thompson laser scattering equipment

It is said that the next-generation LWFA expected beam acceleration of 1TeV scale need narrow plasma density profile (10^{15}~$10^{17}cm^{-3}$)of which the diameter is less than 1mm [2].And it is said that LWFA need guiding laser driving a particle and without being scattered by plasma straight, for that purpose it needs hollow electron distribution[3]. A quadrupole is expected to be possible to obtain hollow electron density distribution because its center electric field is 0, and forms an extensive electric field close to the electrode.

We impressed RF (5kW, 13.56MHz, pulse width 1msec, duty 0.1) in a capacitive antenna and

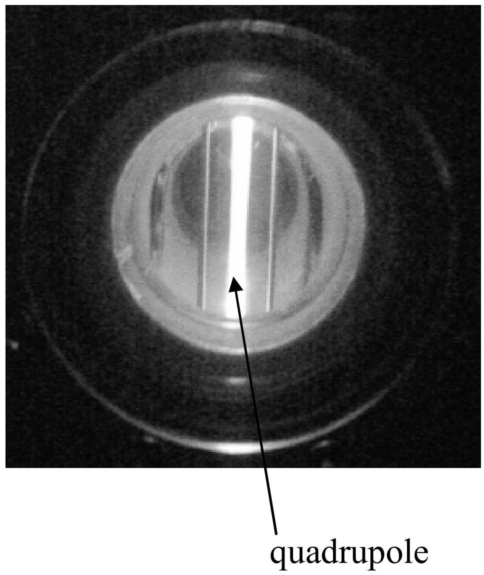

Fig. 3. An photo example of narrow RF discharge
(P_{rf}=1kW, f=P13.56MHz, P_{Ar}= 30 torr)

produced narrow plasma. Figure 3 shows a photo of the plasma. Used Gas is Ar, we can see narrow plasma produced in the electrode in the vicinity of 30 torr. Plasma density measured by Thompson scattering is in progress assiduously.

Abstract

References

[1] W. P. Leemans, B. Nagler, Cs. Toth, K. Nakamura, C. G. R. Geddes, E. Esarey, C. B. Shroeder, and S. M. Hooker, Nat. Phys. 2, 696 (2006).

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