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Development of electromagnetically driven atomic hydrogen target for beam interaction experiment
ビーム相互作用実験にむけた電磁駆動解離水素標的の開発

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Heavy-ion-driven high energy density physics experiments require the precise quantitative evaluations of the stopping power with dependences on target density and temperature. The stopping power with the dissociation effect is interesting, which has not been experimentally investigated. We proposed the coaxial electro-magnetically driven shock wave to establish a well-defined dissociated target. The shock velocity was measured by the high-speed framing camera and the laser refraction. The experimental results showed that the shock velocity was not enough to dissociate hydrogen completely. The angular distribution of the discharge plasma was not homogeneous in the shock tube, which indicates that the non-uniform discharge current sheet could not accelerate the hydrogen gas efficiently.

1. INTRODUCTION

Grisham [1] proposed that high homogeneity of the energy deposition in a sub-range target is obtained when ion beam energy around the peak (Bragg-peak) of the stopping power curve is deposited within the thin target. The scheme using the moderate energy ion beams is utilized for beam-driven-high-energy density physics experiment. The target condition changes due to the beam irradiation, which causes changes of the stopping power [2-8]. The precise quantitative evaluation for the energy loss of charged particles in matter is an important issue to evaluate the target condition after the beam irradiation. However, the few experiments are performed for the changes of the stopping power induced by transition from molecules to dissociated atoms. The goal of our study is to measure the stopping power with the dissociation effect. The change by the dissociation effect can be measured most significantly for hydrogen since hydrogen has only valence electrons.

In order to establish a well-defined dissociated hydrogen target for beam interaction experiment, a coaxial electromagnetic shock tube was developed [9]. In the shock tube, the discharge plasma is accelerated by the electromagnetic force (***J*** x ***B***). The shocked region between the discharge plasma and the shock front can become the dissociated hydrogen. Shock velocity measurement is important since a shock velocity of about 30 km/s is required to dissociate hydrogen completely [9]. The experimental results including the velocity measurement is presented.

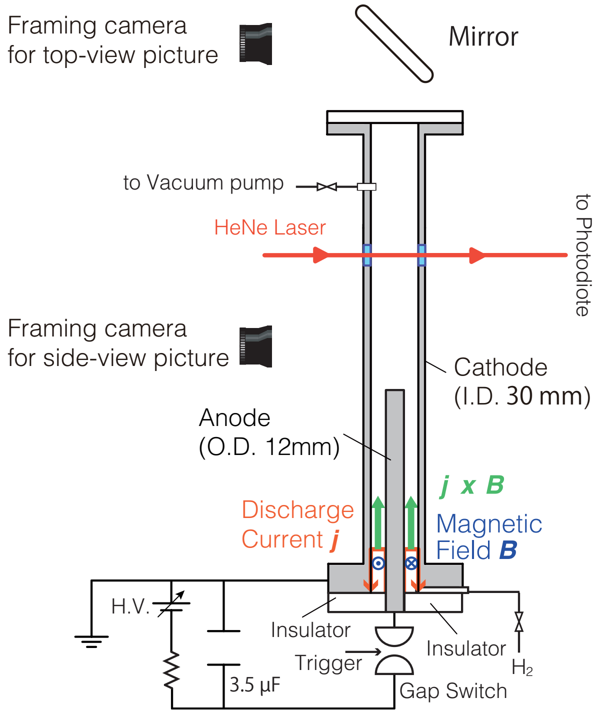

Fig. 1. The coaxial electromagnetic shock tube with the high-speed framing camera and laser refraction system to measure the discharge plasma and the shock velocities.

2. EXPERIMENTAL SETUP

The experimental setup is shown in Fig. 1. We filled hydrogen gas with initial pressure from 100 to 1000 Pa in the shock tube. A gap switch and capacitors with a total capacitance of 3.5 μF was connected to the central electrode. The both positive and negative voltages of 16-17 kV were applied. The current monitor (PEARSON, Inc., 5664) and the high voltage probe (Tektronix, Inc., P6015A) were placed. The maximum discharge current was about 25 kA. The trigger signal to the gap switch controlled the spark discharge.

The framing camera with CCD cameras (Hamamatsu, Inc., C6558) and high-speed gated image intensifier units (Hamamatsu, Inc., C2925-01) could have two pictures for the single discharge. The framing camera had two positions for side and top-view pictures as shown in Fig. 1.

The He-Ne lasers, which passed through the shock tube, were led to the photodiodes. We had the signal changes due to the laser refraction when the shock front with the density gradient passed. The laser refraction system could measure the shock velocity [10, 11].

3. RESULTS

The laser refraction and the side-view pictures by high-speed framing camera showed [10, 11] that the shock and discharge plasma velocities were less than the requirement to dissociate the hydrogen gas completely.

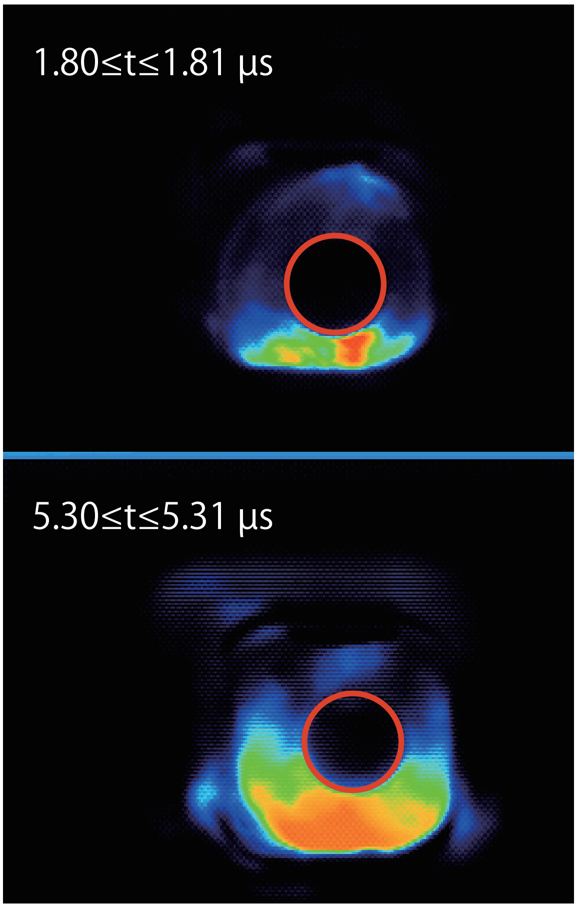

Fig. 2. The top-view discharge plasma by the high-speed framing camera. The red circle means the central electrode position. The discharge started at t=0. Each exposure time was 10 ns. The initial pressure and the charging voltage were 1000 Pa and 17 kV, respectively.

Figure 2 shows the top-view self-emissions by high-speed framing camera to understand the angular distribution of the discharge plasma. We observed non-uniform discharge plasma profiles. The discharge current sheet could push the hydrogen gas inefficiently.

4. SUMMARY

We developed the coaxial electromagnetic shock tube to obtain the well-defined dissociated hydrogen target for beam interaction experiment. The velocity measurements showed that the shock velocity could not satisfy the requirement for the dissociated hydrogen. The non-homogeneous angular distribution of the discharge plasma was observed, which could not accelerate the hydrogen gas substantially. We need to improve the discharge uniformity which may results in the higher shock velocity.

Acknowledgments

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