Advanced Core for Energetics, Hiroshima University Vol. 78

HU-ACE NEWS LETTER

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Activities of the Core

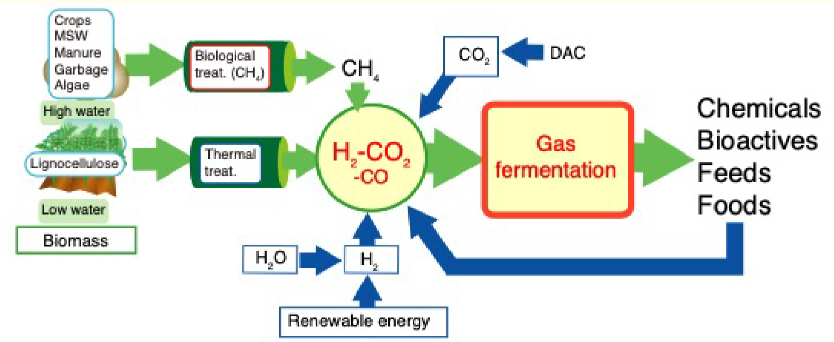
June. 15, 2023	The 80th HU-ACE Steering Committee Meeting.
June. 24, 2023	The 1st Higashihiroshima Energy Eco Seminar "Why does the temperature of the earth rise? - Global warming- "(co-organized).
June. 28, 2023	The 10th Hiroshima University Biomass Premium Evening Seminar (co-organized).

Bioproduction from CO_2 and H_2

Since ancient times, mankind has used biomass not only for food, but also as energy and raw materials for manufacturing. Biomass is a carbon recycling product produced by fixing CO_2 using solar energy. Biomass production is the origin of bio-manufacturing from CO_2. On the other hand, in the energy field, it is expected to produce and use H_2 using sunlight. H_2 demand to replace current energy usage is enormous and needs to be cheap. Carbon recycling technology that converts CO_2 using this inexpensive H_2 is being studied.

As one of such technologies, bio-production technology using gas fermentation is attracting attention. This technology uses autotrophic microorganisms that grow using H_2 as an energy source and CO_2 as a carbon source. Among them, there are "aerobic hydrogen bacteria" that require oxygen and "homoacetogen" that do not require oxygen. In our laboratory, we are conducting research on bio-production from CO_2 and H_2 using homoacetogen (Fig) 1,2). Looking at the adopted projects of "NEDO Green Innovation Fund Project/Promotion of Carbon Recycling Using His CO_2 Directly Using Bio-Manufacturing Technology", at least four of the six adopted projects are the development of carbon recycling technology using these microorganisms as a platform..

In this way, the development of new bio-manufacturing technology suitable for a hydrogen society is currently underway, going beyond the framework of conventional carbon recycling technology that uses biomass as a raw material.



1) K. Takemura, et al., J. Biosci. Bioeng. *In press* (2023).
2) K. Takemura, et al., J. Biosci. Bioeng. **132**, 569-574 (2021).

Related events

The 7th International Symposium on Fuels and Energy (ISFE 2023) will be held on July 3-4, 2023. Please visit the following ISFE 2023 website for more details.
https://symposium2023.isfe.hiroshima-u.ac.jp
Dead-line for Standard registration: June 29, 2023

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Research Topics No. 43

Evaluation of self-absorption effect of He I resonance line by measurement of forbidden emission in helium arc jet plasma

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Research fields: Plasma diagnostics
Keywords: line intensity ratio, plasma parameter, radiation transport

Abstract

Background

Electron density and temperature are fundamental parameters in plasma physics; therefore, the establishment of an accurate measurement method of these values is a significant issue. To determine electron density and temperature, the line intensity ratio of visible line emissions is compared with those calculated using a collisional-radiative (CR) model, which is utilized as an attractive and simple method because it does not disturb the plasma itself. However, high-density plasma is typically classified into an optically thick environment, and thus, radiation trapping (self-absorption) has a considerable effect on the population kinetics due to an increase in the population inflow from the ground state into the upper levels by vacuum ultraviolet (VUV) photoabsorption. Therefore, the line intensity method is not longer applicable for high-density plasmas, such as nuclear fusion plasma and thermal arc plasma.

Methods

We have developed a high-density He cascade arc discharge plasma source and investigated the radiation trapping effect in a recombining plasma produced by the introduction of He gas into the expansion chamber. VUV spectroscopic measurements for the He I 58.4 nm allowed and 59.1 nm forbidden (intercombination line) emissions were performed in cascaded arc discharge plasma to investigate the effect of radiation trapping in a high-density recombining He plasma. The self-absorption effect (optical thickness) for the He I 58.4 nm resonance line is evaluated by comparing the measured intensity ratio with that calculated using the CR model.

Results

He I 59.1 nm forbidden and 58.4 nm resonance lines were observed. By exploiting these two lines, we have proposed that the optical thickness associated with radiation trapping of VUV resonance lines and effective spontaneous transition probability could be evaluated. For pressure from 1.6 to 8.70 Pa, the 58.4 nm allowed transition was decreased exponentially. The intensity ratio of the allowed 58.4nm transition to the forbidden 59.1nm transition was utilized to give the effective spontaneous emission probability and the optical thickness. To this end, the CR model was also employed, which yielded the 58.4 and 59.1 nm intensities.

Comparison of the experimental and calculated ratios facilitated the successful evaluation of the optical thickness for various plasma conditions. For example, the optical thickness of 1^1S-2^1S for a gas pressure of 12.8 Pa was 3.5, which indicates that significant self-absorption occurred. Therefore, the results obtained in this study showed that the intensity ratio method using the allowed and forbidden transitions has significant potential for the determination of the electron temperature, density and optical thickness in dense plasmas.

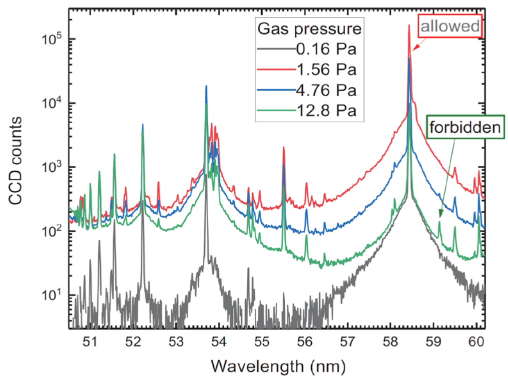

Figure: The VUV emissions of He I 59.1 nm forbidden and 58.4 nm resonance lines were observed.

References

"Evaluation of self-absorption effect of He I resonance line by measurement of forbidden emission in helium arc jet plasma", Ryo Shigesada, Md. Anwarul Islam, Hayato Kawazome, Kosuke Okuda, Yuta Sunada, Ohshi Yanagi, Masato Sumino, Kazuho Hatta, Naoki Tamura, Kotaro Yamasaki, Jun Kawata, and Shinichi Namba, Physics of Plasmas **29**, 113505 (2022); doi: 10.1063/5.0109171