18PB-054

Measurements of the active species produced by minimally invasive plasma for medical applications

医療用途の低侵襲プラズマにおける活性種計測

Hiromasa Yamada[1, 2], Hajime Sakakita[1, 2], Jaeho Kim[2], Yuzuru Ikehara[3], Toshiya Okazaki[4], Satoru Kiyama[2], Yusuke Yamagishi[1, 2] ,Masanori Fujiwara[2], Sanae Ikehara[3], Hayao Nakanishi[5], Nobuyuki Shimizu[6], Masao Ichinose[7], Toru Niwa[8]

山田大将[1,2]、榊田創[1,2]、金載浩[2]、池原譲[3]、岡崎俊也[4]、木山學[2]、山岸祐介[1,2]、藤原正純[2]、池原早苗[3]、中西速夫[5]、清水伸幸[6]、一瀬雅夫[7]、丹羽徹[8]

[1] Graduate School of Systems and Information Engineering at the University of Tsukuba, 305-8577, Japan,
[2] Innovative Plasma Technologies Group, Energy Technology Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), 305-8568, Japan,
[3]Biomedical Resarch Institute, AIST, 305-8562, Japan,
[4]Advanced Functional Nanotube Team, Nanotubu Research Center, AIST, 305-8568, Japan,
[5]Division of Oncological Pathology, Aichi Cancer Center Research Institute, 464-8681, Japan,
[6]SANNO Hospital (International University of Health and Welfare), 107-0052, Japan,
[7] Wakayama Medical University, 641-8509, Japan
[8] Hashimoto Municipal Hospital, 648-0005, Japan

[1]筑波大学システム情報工学研究科，〒305-8577 茨城県つくば市天王台1-1-1
[2]産業技術総合研究所(産総研)，エネルギー技術研究部門，〒305-8568 茨城県つくば市梅園1-1-1
[3]産総研，バイオメディカル研究部門，〒305-8568 茨城県つくば市梅園1-1-1
[4]産総研，ナノチューブ応用研究センター，〒305-8568 茨城県つくば市梅園1-1-1
[5]愛知県がんセンター研究所，〒464-8681 名古屋市千種区鹿子殿1-1
[6]山王病院(国際医療福祉大学)，〒107-0052 東京都港区赤坂8−10−16
[7]和歌山県立医科大学，〒641-8509 和歌山県和歌山市紀三井寺811−1
[8]橋本市民病院，〒648-0005 和歌山県橋本市小峰台2-8-1

The cauterization has been conducted in many surgical procedures as a hemostasis method. The cauterization typically induces tissue damages due to the heat ablation. However, a hemostasis method using a low temperature plasma is possible to perform minimally invasive treatment without tissue damage. Recently, this phenomenon has been paid attention, but blood coagulation phenomena has not been fully understood yet. It is very important to understand blood coagulation mechanism, because the reaction phenomenon under low temperature would become new technology. Therefore, we have tried to measure active species produced by low temperature plasma. We will present the results on the spectroscopic measurement of the plasma emission under several conditions using a “gas components controlled chamber”.

1. Introduction

Hemostasis equipment is indispensable in many surgical procedures such as gastrointestinal surgery. High-frequency electrical coagulator is being used as typical stop bleeding method. The hemostasis equipment currently being used for controlling the bleeding of capillaries by heat (cauterization). This is one of the effective procedures, but it induces tissue damages, and causes post-operative disorders. Therefore, minimally invasive hemostasis procedures that minimize the tissue damages have been studied. Argon plasma coagulator as a high temperature plasma has been used for an endoscopic surgery which is categorized in the cauterization method. Recently, a medical equipment using a low temperature plasmas has been tried to treat the stop bleeding [1, 2]. It was reported that the “plasma flare” defined as the visible region from the equipment to the treated area is accelerates the blood coagulation. Moreover, the histopathological observations show that tissue damage was not found around the treated area, in the case of treating by the low temperature plasma, here called as minimally invasive plasma “MP”.

However, the acceleration mechanism of blood coagulation by the MP has not been understood. To study what kind of reactive species are produced on the surface of the blood, the emission spectrum has been measured by using spectrometers from UV to near infrared region.

In this paper, the results on plasma treatment to typical atmospheric air is described. Here, a flat

copper plate is used as a target material. In the conference, following results also presented. To control the gas component of ambient circumstance around plasma flare during the treatment, a vacuum chamber is prepared. Plasma flare is induced into the chamber whose gas is filled with air, nitrogen, helium, or oxygen controlled, respectively. Amount of oxygen gas and humidity in the chamber are monitored. Gas pressure is controlled from a vacuum to an atmospheric pressure. Discharge state and emission spectrum show completely different features. Detail results of production rate such as OH, oxygen atoms and other species under several conditions will be presented at the conference.

2. Experimental Setups

Experimental setup of the plasma flare treatment to typical atmospheric pressure region is shown in Fig. 1. The emission lines during a plasma flare treatment to the target has been measured using spectrometers for UV, visible and infra-red region. As a target material, copper, or polyimide are used to compare the difference between metal and dielectric. The measured point is varied from x = 0~12 mm. Here, x indicates the distance from the nozzle exit. 99.995 % purity of helium gas is used for the plasma treatment using MP [2].

3. Experimental Results

In the case without a target material, the emission intensity decreases as the distance from the nozzle exit increases. While in the case with the target material, the emission intensity increases around at the surface of the target. This result concludes that the amounts of OH species (308.9 nm) increase around the surface of the target.

Experimental setup of the plasma flare treatment system in gas components controlled chamber is shown in Fig. 2. MP is installed on the top of the chamber, and the vacuum is shield by a viton-ring. As a gas control procedure, at first, the chamber is evacuated by a turbo molecular pump. Then, gases of helium, nitrogen, oxygen, or air is feed into the chamber. Inner pressure of the chamber is controlled from the vacuum to atmospheric pressure by a bulb which is connected to a diaphragm pomp. Plasma flare is treated to the grounded copper target which is located from 15 mm from the nozzle exit. The emission of a plasma flare is measured using spectrometers through the anhydrous quartz window at the side port of the chamber. Detail results will be presented at the conference.

Acknowledgments

This work was supported by Grants-in-Aid for Scientific Research on Priority Area (24108006) from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

References

[1] Y. Ikehara, H. Sakakita et al., "Formation of membrane-like structures in clotted blood by mild plasma treatment during hemostasis", Journal of Photopolymer Science and Technology 26 (4), 555-557 (2013).

[2] H. Sakakita, Y. Ikehara, and S. Kiyama, Plasma Irradiation Treatment Device, WO2012/005132.

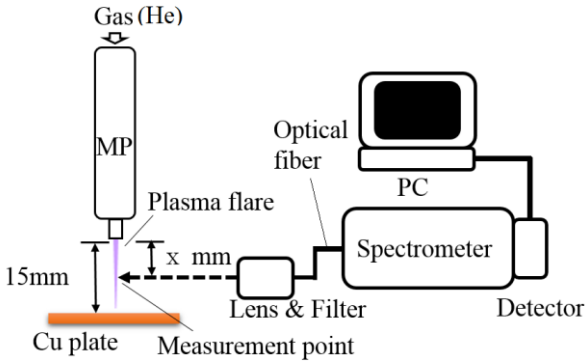

Fig. 1. Experimental setups of the spectroscopic measurement system.

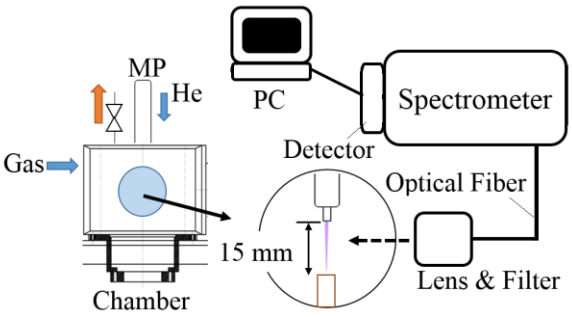

Fig. 2. Experimental setups to control gas components of the ambient region of a plasma flare using a vacuum chamber. Arrangement of spectroscopic system is also drawn.