22P076-P

Internal sterilization of a narrow tube using ECR plasma
ECRプラズマを用いた細管内部の滅菌

Daiki Anraku, Raiki Ichikawa, Akira Yonesu and Nobuya Hayashi
安楽大輝, 市川礼記, 米須　章, 林　信哉

University of the Ryukyus
1 Senbaru, Nishihara, Okinawa 903-0213, Japan
琉球大学　〒903-0213　沖縄県西原町千原１番地
Saga University
1 Honjyo, Saga, 840-8502, Japan
佐賀大学　〒840-8502　佐賀県佐賀市本庄町１番地

Internal sterilization of a narrow tube using the Electron Cyclotron Resonance (ECR) plasma has been investigated. We succeeded in generating ECR plasma only inside a silicon narrow tube of 5mm in inner diameter without a inner electrode. The existence of an effective UV and oxygen radical for sterilization from the observation of the emission spectrum were able to be confirmed. From sterilization experiments, it was found that our method can sterilize the spore of *Geobacillus stearothermophilus* of 7.9×10^4 CFU in the narrow tube for 20 sec.

1. Introduction

In plasma sterilization method, bacterias can be killed by the effects of UV radiation and active radicals that are generated in the plasma [1]. The plasma sterilization method is safer and more short time process than a conventional sterilization method. Therefore this method attracts attention as a new sterilization method of the medical device. However, it is thought that the plasma sterilization method is unsuitable for internal sterilization of a narrow tube such as a catheter, because the plasma generation is generally very difficult in a small space.

In order to solve this problem, several methods to sterilize the inside of the tube by generating a dielectric barrier discharge, using wire electrode is installed in the tube, has been studied [2, 3]. We propose a new method to sterilize the interior of the narrow tubes using ECR (Electron Cyclotron Resonance) plasma that requires no electrode. ECR plasma is preferentially produced around the resonant region where the magnetic field strength is corresponding to an ECR frequency.

Thus, it is thought that we can produce the ECR plasma in the narrow tube by means of locating the resonant region inside the tube. In this work, internal sterilization of the narrow tube using ECR plasma, have been investigated.

2. Experimental apparatus

Figure 1 shows a experimental apparatus. The experiment was performed in the vacuum chamber which contains a rectangular magnet (77×32×24mm). This magnet has a flux density of 3.7KG at it's surface, so that the region of the resonant magnetic field for ECR (875G) exists near the magnet surface. We set a silicon tube with an inner diameter of 5mm and a length of 250mm at the resonant region (see Figure 2). The microwave with a frequency of 2.45GHz is introduced into the chamber through a tapered waveguide.

The tube temperature was measured by thermo labels that change color according to temperature. Strip type of biological indicator (6×2mm) which are coated with the bacteria *Geobacillus stearothermophilus* with a population of 7.9×10^4 were used to assess the ability of sterilization. After plasma irradiation, the irradiated B.I. samples were cultured in a culture tube with tryptic soy broth for 72 hour at 60°C. Then we evaluated the success of the sterilization by the presence of color change of the culture solution.

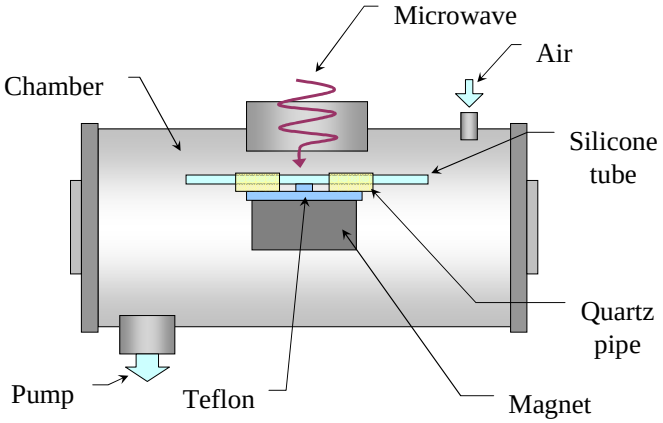

Fig.1. Schematic of Experimental apparatus.

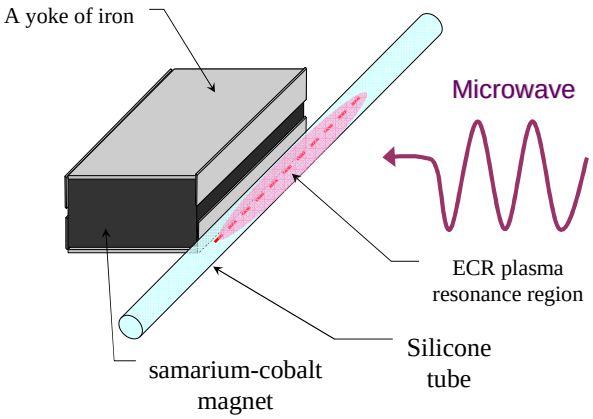

Fig.2. Layout of the magnet and silicone tube

3. Result and Discussion

Figure 3 shows the photograph of the ECR plasma generated in the narrow silicon tube with an inner diameter of 5mm. As shown in the figure, ECR plasma exits only inside the narrow tube. The advantage is that there is no pressure difference between the outside and the inside of the narrow tube, and no electrode inside it.

In order to evaluate the presence of plasma species responsible for antimicrobial effects, we investigated the optical emission spectra of the ECR plasma. As shown in the typical emission spectrum in Fig.4, excited oxygen atomic lines (777.2nm, 844.6nm) and UV radiation were observed. It is generally accepted that the principal agents responsible for bacterias killing in the plasma are active radicals and UV radiation.

For the sterilization test of the narrow tube by ECR plasma, the biological indicator was located in it. The ECR plasma was generated in the narrow tube under the following conditions; Air pressure of 1.0×10^{-1}Pa, microwave power of 100W. The result of the sterilization test was shown in table I. We confirmed that the biological indicator located in the narrow tube was sterilized for only 20 sec plasma exposure time.

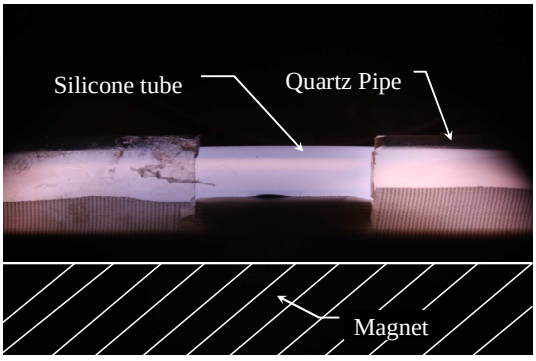

Fig.3. Photograph of the ECR plasma generated in the silicone narrow tube (Air pressure of 1.0×10^{-1}Pa, microwave power of 100W).

The temperature of the tube for exposure time 20 sec was 60-75°C. The heat resistance of the catheter is about 90°C. Therefore thermal damage to the tube by ECR plasma sterilization is considered to be low.

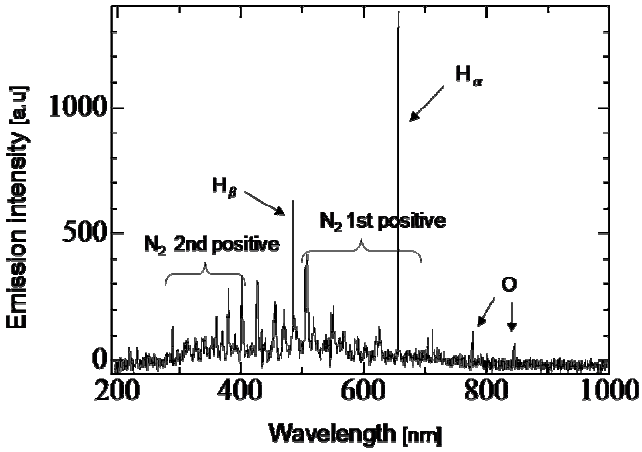

Fig.4. The typical emission spectrum of ECR plasma (Air pressure of 1.0×10^{-1}Pa, microwave power of 100W).

Table I. The result of sterilization

exposure time [s]	sterilization results	Temperature[°C]
3	××	
4	○×	
5	×○○○	50~55
10	○○×○○	60~70
15	×○○○	60~70
20	○○○○○	60~75

○: sterilized ×: failed

4. Conclusion

We succeeded in generating ECR plasma inside the silicon narrow tube of 5mm in diameter, and sterilizing the spore of *Geobacillus stearothermophilus* of 7.9×10^{4} CFU for 20 sec in it. We consider this sterility was caused by the main effect of oxygen radicals and UV radiation. The temperature of the tube for exposure time of 20 sec was 60-75°C. Therefore thermal damage to the tube by ECR plasma sterilization is considered to be low.

References

[1] M. Moisan, J. Barbeau, M. Crevier, J. Pelletier, N. Philip and B. Saoudi: Pure and Applied Chemistry **74** (2002) p.349-358

[2] H. Eto, Y. Ono, A. Ogino and M. nagatsu: Plasma Prossess. Polym. **5** (2008) 269

[3] T. Sato, O. Furuya, K. Ikeda and T. Nakatani: Plasma Prossess. Polym. **5** (2008) 606