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Development of LF-Microwave Hybrid Plasma Source for Surface Sterilization

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Introduction

It is well known that the plasma sterilization method has superior characteristics such as a non-toxicity, short treatment time and low thermal damages on materials to be sterilized [1]. Variety of plasma sources for surface sterilization have been developed. We have developed a new type of atmospheric-pressure non-equilibrium plasma source which combine microwave plasma with the LF (Low Frequency) plasma as a hybrid plasma. The aim of this study is investigate the surface sterilization effect using our self-designed LF-Microwave hybrid plasma at atmospheric pressure. Moreover, we examined sterilization effect of wet oxygen (O_2+H_2O) plasma in the bubbling method.

Experimental setup

A schematic diagram of experimental apparatus is shown in Fig.1 and Fig.2. The LF-Microwave hybrid plasma source is composed of rectangular wave guide which contains a cylindrical slotted microwave antenna surrounding a quartz discharge tube, and LF discharge system which was installed in the quartz discharge tube (outer diameter 8mm, inner diameter 6mm). At the start of the operation, an LF plasma is generated by applying a LF high voltage (10kHz, 7kV) to a cylindrical electrode at the atmospheric pressure. After the ignition of LF plasma, LF-MW hybrid plasma is produced by introducing the pulsed microwave in the rectangular waveguide. The mixture gasses of argon and oxygen were used for discharge gas. Moreover, oxygen gas was bubbled through water stored in the bottle. Argon and oxygen gas flow rate were used at 6 L/min and 0.1 L/min, respectively.

Ability of the surface sterilization was investigated by using biological indicators (B.I.): spore of Geobacillus Stearothermophilus, ATCC7953, of population of $3x10^6$ CFU/carrier adhered on the stainless plate. The biological indicator was setup at 10 mm from the discharge tube nozzle.

Experimental results and discussions

Table 1 shows the effect on the sterilization at different treatment time in case of using CW (continuous-wave) microwave power and pulsed microwave power.

As shown in the table, spore forming bacteria were sterilized in 3 min at the treatment temperature of 100~105℃ for CW microwave power. On the other hand, longer sterilization time of 10min and lower treatment temperature of 75~80℃ were obtained for pulsed microwave power.

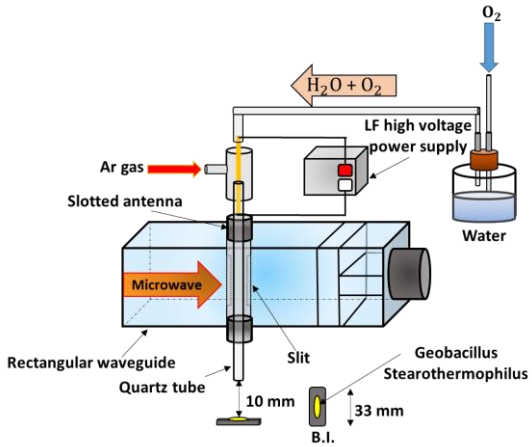

Figure 1. Experimental setup

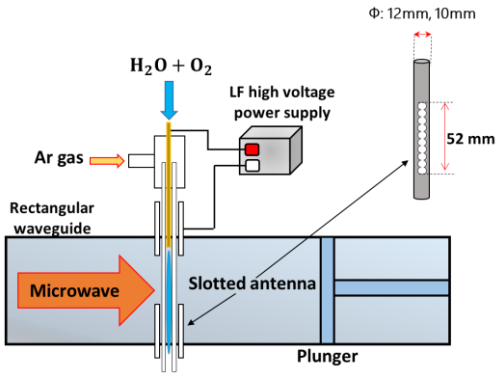

Figure 2. Cross sectional view of the hybrid plasma source space

Table 1. Experimental results of sterilization test

Type of plasma		LF-Microwave Hybrid plasma	
Microwave power		Continuous wave 100W	Pulse wave 200W
Treatment time	2 min	×	×
	3 min	○	×
	5 min	○	×
	7 min	○	×
	10 min	○	○
Processing temperature		100℃~105℃	75℃~80℃

References

[1] S. Patil, T. Moiseev, N.N. Misra, P.J. Cullen, J.P. Mosnier, K.M. Keener, P. Bourke, “Influence of high voltage atmospheric cold plasma process parameters and role of relative humidity on inactivation of bacillus atrophies spores inside a sealed package” Journal of Hospital Infection 88 (2014) 162-169