Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 86 (2016) 321 – 324

Procedia Computer Science

2016 International Electrical Engineering Congress, iEECON2016, 2-4 March 2016, Chiang Mai, Thailand

Atmospheric Cold Plasma via Fringe Field Enhanced Corona Discharge on Single Dielectric Barrier for Large-Volume Applications

Natthaporn Khamsen[a], Aric akkarachanchainon[a], Kamonpun fookiat[b], Jaraspong Srisala[b], Suvit Chomchuen[a], Weerawoot Kanokbannakorn[a], Siwapon Srisonphan[a]*

[a]*Department of Electrical Engineering, Faculty of Engineering, Kasetsart University 50 Ngam Wong Wan Rd, Ladyao Chatuchak Bangkok, 10900 Thailand*

[b]*Department of Mechanical Engineering, Faculty of Engineering, Kasetsart University 50 Ngam Wong Wan Rd, Ladyao Chatuchak Bangkok, 10900 Thailand*

Abstract

This paper is to design and discuss on homogenous atmospheric cold plasma technique. Instead of using the needle tip with a small radius of curvature, this work utilized the twin tips with the sharp edge that can concentrate electric field around the edge of tips, allowing micro-discharge plasma at low power consumption. Our design structure shows a uniform atmospheric-air cold plasma for large-scale surface treatment applications. Furthermore, the designed large-scale atmospheric cold plasmas also provide a great benefit to environmental utilization.

Peer-review under responsibility of the Organizing Committee of iEECON2016

Keywords: Atmospheric Cold Plasma; Corona Discharge; Dielectric Barrier Discharge; Ozone, High Voltage

*Siwapon Srisonphan. Tel. 66-2-797-0999 Ext. 1578
E-mail address: fengspsr@ku.ac.th

Peer-review under responsibility of the Organizing Committee of iEECON2016
doi:10.1016/j.procs.2016.05.087

Here Plasma as a fourth state of matters which naturally occurs in suitable pressure condition at very high temperature [1]. There are many reports, demonstrating that plasma can be generated under the atmospheric conditions at room temperature [1-2]. Therefore, non-thermal plasma brings extremely beneficial to the broad area of applications [3]. With relatively low-power and atmospheric pressure generation, corona discharge has been extensively utilized in several applications, such as electrostatic precipitation, ozone production, and electrophotography [4]. Plasma is usually classified according to its gas temperature: non-thermal (cold) plasma and thermal plasma. Cold plasmas is suitable for biological-medical applications, food sterilization, and surface modification [3-4]. This paper herein proposes the design of cold plasma generation technologies for economically large-scale industrial applications. The key configuration of our gas discharge plasmas is to use corona discharge plasma in conjunction with single dielectric barrier discharge (SDBD). However, corona discharge is difficult to control and quickly proceeding to arc-flash with extremely high temperature up to some thousand kelvins [5-7].

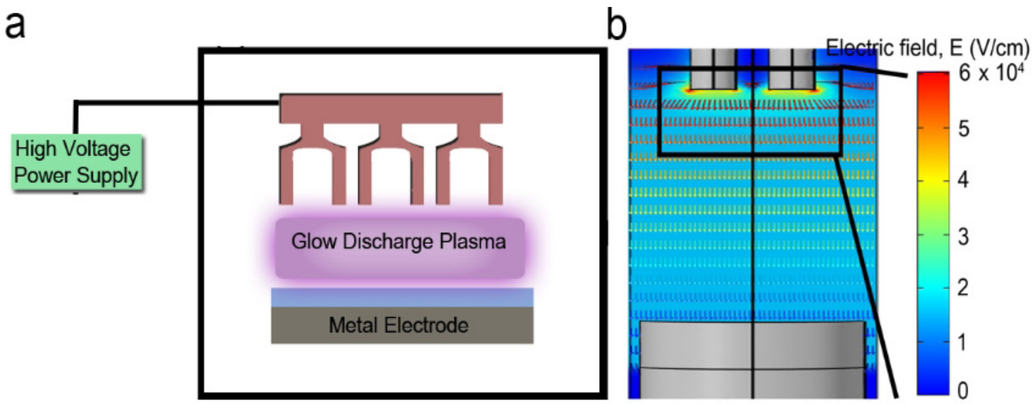

Fig. 1. (a) Schematic diagram of corona discharge plasma in conjunction with single dielectric barrier discharge (SDBD), (b) Electric field distribution

Fig. 1a shows a schematic of the overall experimental configurations used to generate the atmospheric-cold plasma. Metal tips served as top electrodes and connected to a low-frequency high voltage sinusoidal source. The metal counter electrode covered by a dielectric layer was directly grounded. Each top electrode comprises of two stainless steel tips. In this work, the atmospheric cold plasma under air ambient was accomplished by using a combination of single dielectric barrier discharge and corona gas discharge on the edge of stainless steel tips. Tips are wired together by epoxy holders. The gap distance between the top electrode and dielectric layer is designed to be adjustable for proper applications, typically in the range of ~5 mm to ~1 cm. The main gas utilized in this work is air. All the photos are taken by using a digital optical microscope. The commercial software COMSOL Multiphysics, Finite Element Method was employed to illustrate the electric field distribution between the two electrodes under plasma operation (Fig. 1b). The main electrodes were simulated with the similar dimension as in experimental design (Fig. 1). It is obvious that, under air ambient, there was no electrical breakdown or spark occurred because the 7 kV peak voltage with ~5 mm gap spacing yields the average electric field only $\sim 1.4\times10^4$ V/cm whereas the typical air breakdown voltage is $\sim 3\times10^4$ V/cm. However, by using the advantage of the localized fringe field at the edge of the tips, the localized electric field can be built up to $\sim 5\times10^4$ V/cm. The average field is relatively low and not damaging the organic materials.

Fig. 2a-d (left) illustrate the air diffuse plasma treated on objects with the gap spacing ~5 mm: Atmospheric-air cold plasma treated on (a) without sample, (b) rice grains, (c) Mung Bean and (d) flour wafer under the mixture of Ar/air. The corona streamer appears as a faint filamentary with UV radiating outward from electrodes, proving the