Experimental Investigation of the Effect of Isolalted and Non-Isolated Dust Particles on Glow Discharge of Air Plasma in Direct Current System

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ABSTRACT

In the present work, the effect of isolated and non-isolated dust particles on glow discharge of main air plasma charactasrics are investigated experimentally. Our results illustraited that the present of dust particle in the air plasma did not effect on Paschen minimum. This fact means that, the present of both types of dust particles did not effect on the plasma properties in high and low pressure regions (i.e. reight and left regions of Paschen minimum) . As well as, the discharge current is increases when the both dust types are immersed in a plasma column with rate rapidly in the copper oxide dust greater than copper dust particles.

Key words: Dusty Plasma, Glow Discharge, Pachsen Curve, Isolated Dust, Non-Isolated Dust.

دراسة عملية لتأثير جسيمات الغبار العازلة وغير العازلة على تفريغ التوهجي لبلازما الهواء في منظومة التيار المستمر

الخلاصة

في هذا البحث, تم اجراء دراسة عملية لتأثير كل من جسيمات الغبار العازلة وغير العازلة على خصائص بلازما الهواء. ان نتائج هذا البحث قد بينت ان وجود الغبار في البلازما الهواء ليس له تأثير على منحني باشن. ان هذه الحقيقة تعني ان وجود كلا النوعين من الغبار ليس له تأثير على خصائص البلازما في منطقتين الضغط العالي والواطيء(المنطقة اليمنى واليسرى في منحني باشن). بالاضافة

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الـى ذلك, لـوحظ بـأن تيـار التفريـغ يـزداد عنـد ادخـال كـلا نـوعي الغبـار و بمعدل عـالي فـي حالـة غبـار اوكسيد النحاس اكثر من غبار النحاس لبلازما الهواء في منظومة التيار المستمر.

INTRODUCTION

Plasma is found in many natural environments, particularly in astrophysics, and is also used for their versatile properties in various industrial processes. They often exist with dust particles (solid bodies with sizes rangeing from a few nm to cm) and these new media are then called dusty (or complex) plasma [1-3]. Most of dust part icles can acquire a positive or negative charge due to collisions with the plasma, and tend to be negatively charged due to the increased mobility of electrons as compared to the ions. The charge on a dust grian in plasma in which photo-electron emission can be ignored is determined by the requirement that the number of electrons absorbed by the grain per second equals the corresponding absorption rate of positive ions. Since typically the electrons move considererably more rapidly, they collide more frequently with the dust grains than the positive ions, and for a blance to occur, the grain will acquire a negative potential relative to plasma, so that the electrons will be repelled and the positive ions attracted [4-6]. The dust grain charge q_d is determined by $dq_d/dt=\sum_j I_j$ where j represents the plasma species (electrons and ions) and I_j is the current associated with species j. At equilibrium the net current flowing onto the dust grain surface becomes zero, i.e. $\sum_j I_j=0$. The dust grian charge q_d is related to the potential difference $\phi_d= \phi_g- \phi_p$, where ϕ_g the grian potential and ϕ_p is the plasma potential, i.e. $q_d=C\ \phi_d$, where C is the capacitance of the spherical dust grain in a plasma which equal to $r_d \exp(-r_d/\lambda_d)$ [5].

Interesting in the field of plasma-particle interaction with regard to dusty plasma has grown enormusly during the last decade. At present, the interest is mainly caused by applied research related to material science and, recently, also with regard to plasma diagnostics [7]. In industry, dust particles are often considered as fatal for the processes, in particular in microelectronics where extreme cleanliness is required. Thus, important investments are engaged in order to work under a controlled and filtered environment, free of dust particle contamination [1].

EXPERIMENTAL SET UP

In this work, the simplest and least expensive method of producing a dusty plasma is to use a dc. Glow discharge. The chamber (which made of stainless steel) of this system is consistes of two elctrodes which were made from the Aluminum. A schematic of the chamber of such a device is shown in Figure (1).

The diameter of the both electrodes is 8cm and of 2cm thickness. The chamber which was pumped by two stage rotary pump to a base pressure of about $2x10^{-2}$ mbar. Two types of dust particles are immeresed in a plasma, which are copper and copper oxide. Where the dust particle size of copper and oxide copper is 3.75 µm and 5.0 µm, respectively. Both types of dust particles are dispersed (dropped) into a plasma column by mechanical devicesee Figure (1). This device (i.e. duster) consisted from d.c. motor which is work by applied 3 d.c volt and a disc which used as a container of dust particle. The motor was work by remote contol system, this motor will give two motions to the disc rotation and vibration motions. The weight of both dust particles which immereses into the plasma is equal 0.2gm.

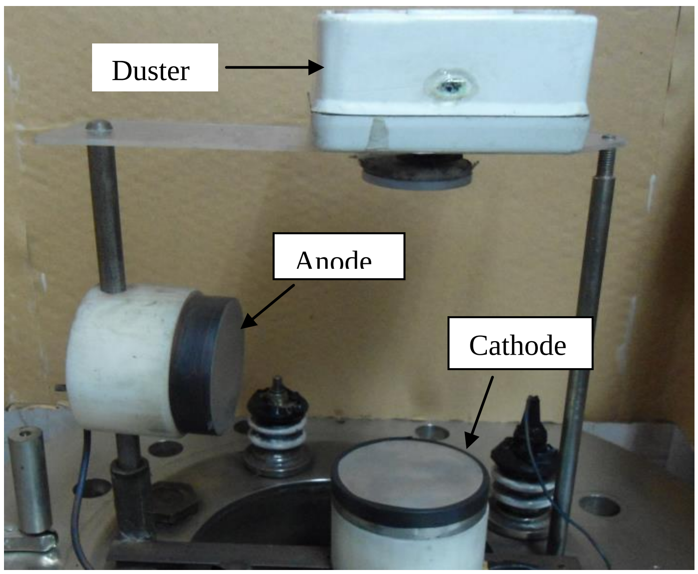


Figure (1) Photograph of the chamber system.

The glow discharge is formed between an anode and a chathode when a d.c. constant voltage of about 2 kV is applied between two electrodes. As a results to this applied voltage, the electrical breakdown is formed in air gas at relative pressures, of about ≈ 0.1-1Torr.

RESULTS AND DISCUSIONS

EFFECT OF DUST ON PLASMA COLUMN

Figure (2) shows the plasma column at different pressures without dust particles. It is pointed out from this figure that when the pressure is increase cathode regions are compressed while the anode regions and the positive column increses. This behavior is due to the mean free bath of electrons is inveresly proportional to the gas pressure.

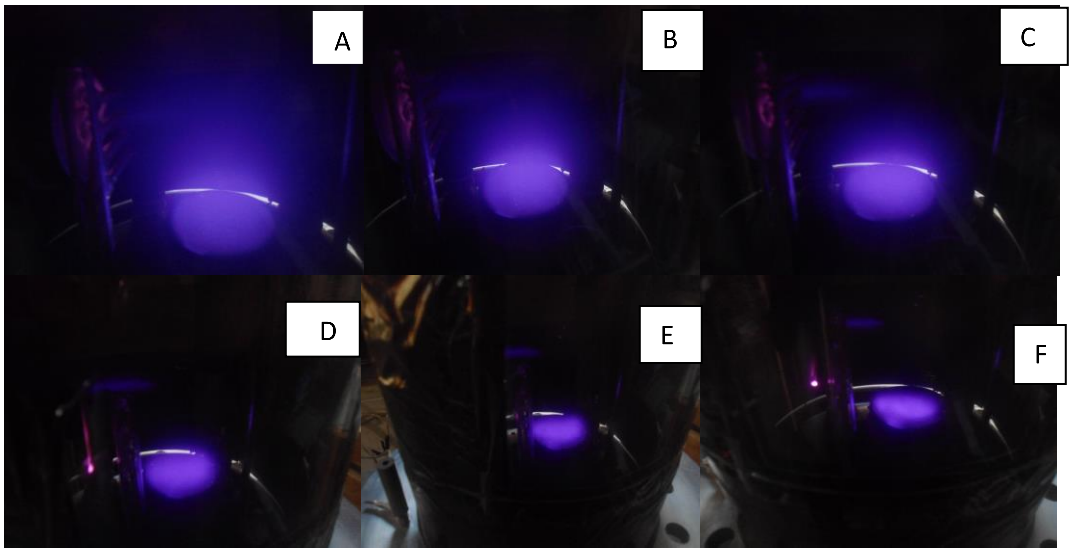


Figure (2) The photography of the plasma discharge without dust particles at different pressures: A)0.2 Torr ,B)0.3 Torr,C) 0.4 Torr, D) 0.6 Torr, E) 0.8 Torr,F) 1Torr.) .

When dust grains are immersed in a gaseous plasma, the plasma particles (electrons and ions) are collected by the dust grains which act as probes. The dust grains are chaged by the collection of the plasma particles flowing onto their surfaces. Figures (3 and 4) shows the photography of the effect of non-isolated dust particle (copper dust particle) and isolated dust particle (copper oxide dust particle) on the plasma discharge. Both figures indicate that the plasma discharge shows different behavior depending on the types of dust particles. Because of the presence of dust particles in plasma often leads to considerable changes in the plasma charge composition. The point is that the dust particles are the ionization and recombination centers for the plasma electrons and ions. Particles that emit electrons and are turned positively charged may increase the electron concentration in the plasmas. Conversely, when the particles absorb electrons from the plasma they become negatively charged and reduce the number of free electrons.

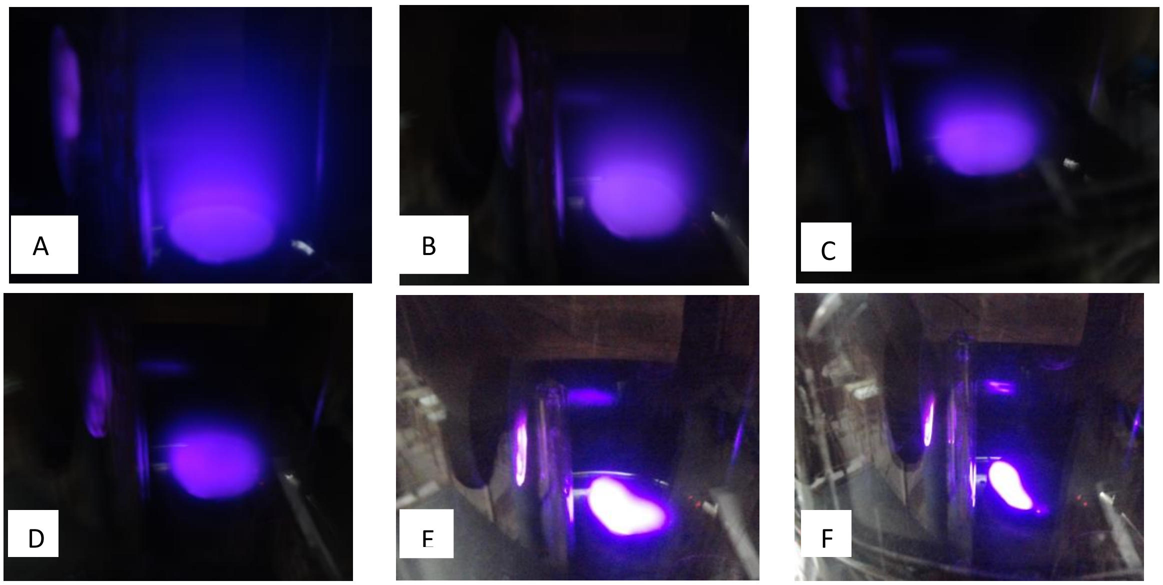
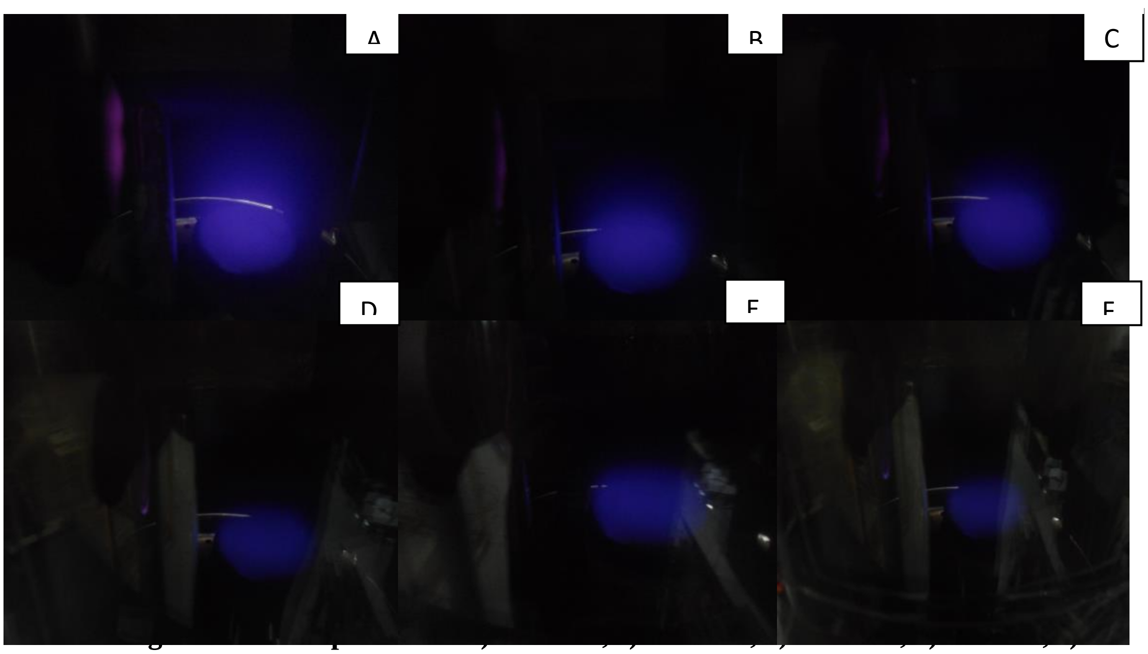


Figure (3) The photography of the copper dust particle on plasma discharge at different pressures: A)0.2 Torr ,B)0.3 Torr,C) 0.4 Torr, D) 0.6 Torr, E) 0.8 Torr,F) 1Torr.

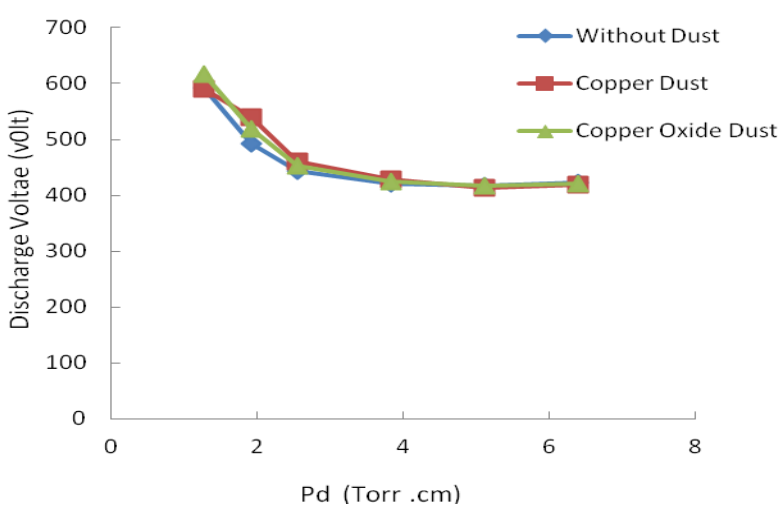


0.8Torr, F) 1Torr.

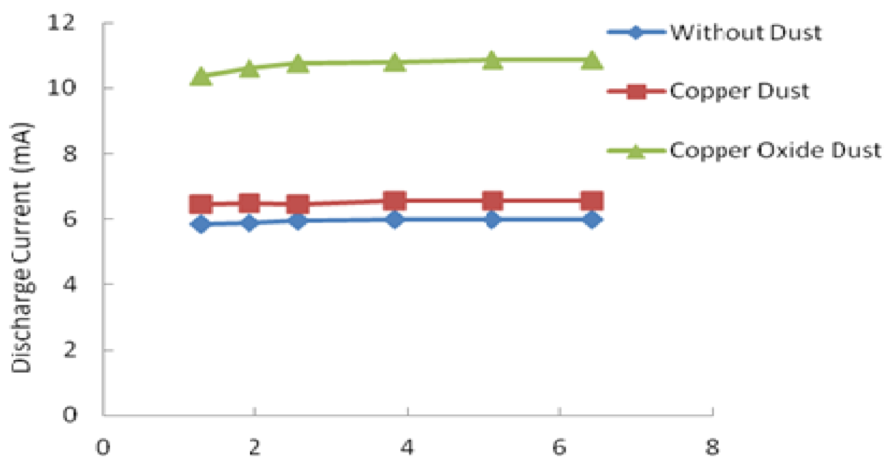
plasma with rate rapidly in the copper oxide dust greater than copper dust particles. These behaviors in both Figures (5) and (6) can explain as; since the dust grain charging processes are (i) interaction of dust grains with gaseous plasma particles, (ii)

EFFECT OF DUST ON CURRENT AND VOLTAGE DISCHARGE

Figure (5) shows effect of dust particles on Paschen curve. This figure illustrated that, both types of dust particle (copper and copper oxide) which are not effect on the voltage discharge. In addation, Figure (6) shows the effect of isolated and non-isolated dust particles on the discharge current. The comparison of the curves in this figure shows the fact that the discharge current have the same behavior in all cases. As well as, the discharge current is increases when the both dust types are immersed in a plasma with rate rapidly in the copper oxide dust greater than copper dust particles. These behaviors in both Figures (5) and (6) can explain as; since the dust grain charging processes are (i) interaction of dust grains with gaseous plasma particles, (ii) interaction of dust grains with energetic particles (electrons and ions), (iii) interaction of dust grains with photons [5]. When energetic particles (electrons or ions) are incident onto a dust grain surface, they are either back scattered (reflected) by the dust grain or they pass through the dust grain material. During their passage they may lose their energy partially or fully. A portion of the lost energy can go into exciting other electrons that in turn may escape from material. The emitted electrons are known as secondary electrons. The release of these secondary electrons from dust grain tends to make the grain surface positive. The interaction of photons incident onto the dust grain surface causes photoemissions , may become positive charged [5]. So that, these secondary electrons will causes to increases of current discharge in the present dust particles in plasma column.



Figure(5) Effect of dust particles on Paschen curve.



P (Torr)

Figure (6) Effect of dust particle on the discharge current at different pressure.

CONCLUSIONS

In this paper, an attempt to achive a better clarify some point that came up to study the effect of conductivity of dust particle on the I-V discharge plasma curve. The results indicated the fact that the immeresed of dust particle (both isolated and non-isolated dust particles) into the plasma column has influence on the discharge current. Where behavior of discharge current is increases in the present both types of dust particles (copper and copper oxide) with rate rapidly in the copper oxide dust greater than copper dust particles. On the other hand, the observed discharge voltage curves did not affected by the present both types of dust particles. This behavior means that, the particles are charged by their interaction with the plasma but do not change the plasma in any observable way. Merlino [8] observed the same results.

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