بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها

علي هذه الأفلام قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأفلام بعيدا عن الغبار

في درجة حرارة من ١٥-٢٥ مئوية ورطوبة نسبية من ٢٠-٤٠%

To be Kept away from Dust in Dry Cool place of 15-25- c and relative humidity 20-40%

بعض الوثائق الاصلية تالفة

بالرسالة صفحات

لم ترد بالاصل

Benha University
Faculty of Science
Physics Department

PLASMA DEPOSITION USING COAXIAL DISCHARGE

A THESIS SUBMITTED FOR THE DEGREE
OF
DOCTOR OF PHILOSOPHY IN SCIENCE
(EXPERIMENTAL PHYSICS)

BY

MOHAMMED ABD AL-MONAME MOHAMMED
(M.Sc. Physics)

SUPERVISORS

Prof. Dr. A. A. Rabie,
Physics Department,
Faculty of Science,
Benha University.

Prof. Dr. M. M. Masoud,
Plasma Physics and Nuclear,
Fusion Department,
Atomic Energy Authority.

Dr. H. A. El-Gamal,
Plasma Physics and Nuclear,
Fusion Department,
Atomic Energy Authority.

Dr. M. A. Hassouba,
Physics Department,
Faculty of Science,
Benha University.

2005

Acknowledgement

I am deeply thankful to ALLAH, by the grace of whom this work is completed.

I wish to express my deepest gratitude and indebtedness to my dear parental supervisor Prof. Dr. Ali Rabie, Physics Department, Faculty of Science, Benha University for his continuous support, encouragement interest, inspiring guidance, stimulating and invaluable advice throughout the entire course of this project, without which it would not have been possible for me to complete this work.

I wish to express my sincere gratitude to my dear parental advisor Prof. Dr. Mohammed Masoud, Plasma and Nuclear Fusion Department, Atomic Energy Authority, for supervising, useful advises, valuable guidance and illuminating discussion during this work. He has created an extraordinary environment at Plasma Department where students are afforded the freedom to pursue their own projects while at the same time fostering a sense of team where the successes and failures of each person is shared by all. For a good many years, Prof. Dr. Masoud has kindly and oh-so-patiently shared his time and knowledge in an effort to help me reach this point.

Grateful appreciation of thanks to Dr. Hoda El-Gamal, Plasma and Nuclear Fusion Department, Atomic Energy Authority, for her support, illuminating discussion, and guidance in pursuing this research. She kept me free of financial worries and provided the much needed encouragement over the last seven years. She provided an excellent research atmosphere that was very helpful in the successful completion of this work.

The author would like to express his deep thanks to Dr. Mohammed Ali, Physics Department, Faculty of Science, Benha University, for his effort supervising, helpful suggestions, constant help, encouragement interest, and invaluable advice throughout the entire course of this project and the writing of this stimulating,.

The author would like to express his deepest appreciation to the Head of the Physics Department, Faculty of Science, Benha University and to all staff members.

I wish to express my deep thanks to Prof. Dr. Mostafa Diab, Physics Department, Faculty of Science, El-Mansora University.

I would like to thank all the staff of the Plasma and Nuclear Fusion Department, Atomic Energy Authority, especially to Prof. Dr. Yosry Ahmed Head of the department, and Dr. Hoda El-Tayeb, Head of the Plasma Applications Laboratory.

I wish to express my thankful to Dr. Azzah Talab, Plasma and Nuclear Fusion Department, for her great helpful in the spectroscopic measurements and providing me with the scientific papers. And grateful appreciation of thanks to my dear brother, Dr Abd El-Fattah Dawood, Biophysics Laboratory, Physics Department, Faculty of Science, Benha University, for encourage and helpful in the usage of the optical microscope.

I would like to express my deepest appreciation to my dear brothers Dr. Reda Mahsoub El-Naby and Dr. Ahmed Samir for prividing me with the recent papers.

Thanks also to the technical and administrative staff of Plasma and Nuclear Fusion Department specially to Mr. Nasef Kassem. Mr. Nabil El-Sarrag, and Mr. Samir Elawah for their cooperation during the course of this work and supplying the experimental facilities.

Finally, I would like to thank my family. Thanks to my father and mother for encouraging me to seek my own path in life and providing the religious upbringing, love and support that have helped me to succeed all along the way. And I would like to express my heartfelt thanks to my sisters, and especial thankful to my wife who gave me the strength to finish this work when I thought I was never going to. All of my family have believed in me and supported me in every way humanly possible, so thankful for them all.

ABSTRACT

ABSTRACT

In the present work, a plasma coaxial discharge system has been used with a new method for studying the deposition applications using different materials include gas, liquid, and different powders, to get a thin film. The new in the present study is that the depositing material has been placed at the breach.

The discharge current and voltage were measured. The first peak current reached 18 kA after 11 μs at 6 kV capacitor bank charging voltage. The deposited energy was 0.36 kJ/pulse at 6 kV charging voltage for air at 0.2 Torr pressure while the maximum peak power achieved was 40 MW.

The electron temperature and plasma density which has been measured by using double electric probe were found to be 12 eV and 1.7×10^{15} ion/cm^3, respectively at 6 kV charging voltage for air at 2 Torr pressure. While the electron temperature which has been measured by spectroscopic techniques was found to be 17.7 eV for air and about 0.8 eV for butane gas.

The plasma sheath velocity measured by magnetic probe has been found in the order of 10^6 cm/s , while that the double electric probe measurements has shown that some portion of the plasma has been created at higher position in front of the breach.

A new model (MASOUD MODEL) describing the plasma focus system was made. This model overcome some troubleshooting appeared in Lee model, which namely; the non continuity in the calculated plasma velocity between the axial phase and the radial phase, the non realistic calculated values for many conditions especially when the current was small, the non real values appears as a result of dependence of the shock wave velocity on the current value, and the disturbance appeared on the current and the voltage values results of the insertion of the anomalous resistivity in the equations.

In the radial phase, it has been assumed that the plasma move in the angular direction according to the snowplow model rather than the use of the slug model as the main equation system to establish the continuity of the plasma sheath motion between the axial and the radial phases. The angle of motion has inserted in all of the used equation of motion and the circuit equation. Then, after the plasma sheath position and velocity has been calculated numerically from the previous equations, the slug model has been used to calculate the shock wave velocity, and hence the electron temperature could be calculated.

Values of the discharge current, axial speed, axial position, spike voltage, radial piston speed, radial piston position, plasma column length, and plasma temperature, have been obtained by using the new model.

By comparing the calculated results of the new model with the published experimental results, a good agreement has been obtained. Then it has been concluded that the new model is the most suitable model for describing the plasma focus devices.

The plasma coaxial discharge system was used to deposit different materials, which include graphite powder, Al_2O_3 ceramic, MgO, CaO, and ZnO. Also butane gas and liquid kerosene were used as an active materials.

The deposited material thickness has been measured using the laser interferometer arrangement and microdensitometer device. Also, the magnification and photography of some substrates surfaces has been obtained using optical microscope to calculate the grain size and its distribution. The study has shown a linear relation dependence of the deposited material thickness with number of pulses. Also the deposited thickness has been found to increase exponentially with capacitor bank charging energy. The deposited layer reaches a maximum thickness of 13 μm at 8.4 kV charging voltage, 0.2 Torr of air pressure, and 75 pulses.

For graphite powder the deposited film grains size has been found to have approximately, a Maxwellian distribution, with almost three grains diameter peaks at 0.5 , 1.25, and 1.5 μm for different pulses number. The relations have shown some oscillations on each curve that may be due to phase changes for certain diameters. The study of the deposited graphite has shown also the formation of light color grains that may be referred to a phase transition. These grain size has shown a Maxwellian distribution with grains peak diameter at 0.5 and 0.8 μm at charging voltage of 8.5 and 11.2 kV , respectively at 0.8 Torr pressure.

When liquid kerosene has been used in the deposition, the produced carbon grain size distribution in this case has shown more oscillations than that appeared in graphite powder. The effect on the thickness of the amount of deposited material, when butane gas was used as an active gas was very weak. When the substrate was placed close to the muzzle, to increase the film thickness a shatter process has been observed on the substrate. The reason of this shatter appearance on the substrate surface can be retained to the high energy plasma sputtering effect that ejects electrode material atoms toward the substrate.

The grain size distribution for the ceramic has shown a Maxwellian grain size distribution with a diameter peak of 0.5 μm at 6 kV charging voltage , 0.06 Torr of air pressure, and 100 pulses. The study has shown that more than 60 % of the grains size lies in the diameter range from 0.2 to 0.8 μm . In the case of ZnO thin film, the grain size has shown approximately a Maxwellian distribution with two peaks at 0.8 and 1.3 μm. at 6 kV charging voltage , 0.1 Torr of air pressure, and 100 pulses. These peaks may also refer to that the plasma may have two groups of electrons in different temperatures.

The grain size distribution for a mixture of MgO and CaO has been studied for powder and solution. It has been found that the solution has more homogeneous Maxwellian distribution than that of the powder. The grain size in the case of the solution has been found to have a diameter peak at 0.7 μm, while for powder, was at 1.1 μm.

CONTENTS