International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 3, Issue5 (September-October 2015), PP. 123-126

APPLICATION OF THE PLASMA TECHNIQUE IN ENERGY GENERATION BY PLASMA ENHANCE CHEMICAL VAPOR DEPOSITION METHOD (PE-CVD)

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***Abstract*— Consumption Infinitive of fossil sources to energy generation has been caused more expanding of the science of using from reproducible energy sources. Solar energy is one of the most important reproducible energy sources which is absorbed and converted to the electric energy by solar cells technology. These solar cells are formed from Si by deposition on the special substrate by chemical vapor deposition (CVD) which this process is much vulnerable in the high temperatures interaction. Hence the technology of production of these solar sheets in the low temperature pronto grown and one of the most common methods to build of solar sheets is chemical vapor deposition (CVD), which has been developed with using of plasma techniques in this method with decreasing the temperature used in synthesis interaction. In this paper has been pointed to applications of plasma technique in coating film by CVD method which named plasma-enhance chemical vapor deposition (PE-CVD) which is very common to producing the solar sheets in large scale.**

***Index Terms*— plasma, PE-CVD, temperature, coating film**

I. INTRODUCTION

A. Brief history on Plasma:

At the first time a physiologist who named Jan Evangelista used of the Greek word to define the clear fluid which remains after separating all of the blood cells from the blood which that was “plasma” [1]. Then an American scientist Irving Langmuir in 1920 proposed the electrons, ions and neutrals atoms in an ionized gas could be similarly to the clear fluid which remains after separate all of the materials from the some fluids so he christen the medium plasma this type of the material which was clearly unlike blood [2]. Thus plasma science began and got greater with the opinion for producing a great type of energy which is called nuclear fusion by plasma [3]. But in this paper has been studied the application of the plasma in coating field as an aid technique in chemical vapor deposition method

B. *What is the plasma:*

Plasma is a gas which in has occurred the interaction between their atoms. These occurrences happen when the environment temperature increases. It causes the atoms of the gas become ionized, so that the electrons and atoms are separately produced free. there is a balance between collision ionization and recombination [4].

But not all the atoms have to be ionized hence there are two types of plasma which named cool and hot plasma. In the cooler plasmas used in plasma processing are only 1-10% ionized and the other of parts of the gas could remain as molecular and neutral atoms, however in the hot plasmas at the higher temperature all of the gas has been ionized [4]. Ionization needs an energy which it named threshold energy however recombination hasn’t any energy but is much probable [5]. The less energy is for Hydrogen (H2) which is equal 13.6eV [5]. Furthermore the most energy is for He which is about 24eV. But forming of plasma occurs in our surround environment every day for example ionized belt surrounding earth, Magnetospheres of planets and starts. Solar wind stars, Stars, Pulsars, Radiation processes, Surface treatment for hardening, Crystal growing, Ion beam doping, plasma etching and sputtering, plasma discharges pumped laser: He, CO2, Ne, Fluorescent lights, spark gaps, arcs, welding, lighting controlled fusion and etc which occur in Ionosphere, interplanetary medium, stellar astrophysics, materials and semiconductor processing, gas laser, gas discharges and etc [4, 5], which has been shown in figure.1 [4].

C. The role of plasma in Nanotechnology:

Fundamental of the plasma enhance chemical vapor deposition (PE-CVD) method is putting the substrate on the minus pole in a vacuum environment and body of the environment usually roles as the positive pole. Then a type of minus gas is became entered to the system afterword a potential different causes ionized the atoms of gas, so that the electrons and ions are separately free and the plasma is formed.

This plasma covered surround of the substrate and it bombard the surface of the substrate. This bombardment makes warm the substrate surface also that is prepared for coating by sputtering effect, so a type of special gas is entered to the system as precursor which is usually mixture with Ni, H, Ar, As, Ga, methane (CH4), acetylene, TiCl4 and etc [6] finally coating the surface along with controlling the other parameters done by these precursors. Every of these precursors could be used for production a type of film and in variety applications [7] which some of themes were shown in table.1. The effective parameters in plasma enhance chemical vapor deposition is the temperature, pressure, time, frequency and width of pals and etc which has been shown in figure.2 [8] and you could read more about the effective parameters in plasma enhance chemical vapor deposition method in [8].

As is watched in the figure.2 [8] the film formed by plasma enhance chemical vapor deposition method (PE-CVD) has some properties which have been caused using of this method would get greater between the scientists for variety field proportion with its applications. Mechanical, optical, electrical and tribological are some of these properties that were pointed.

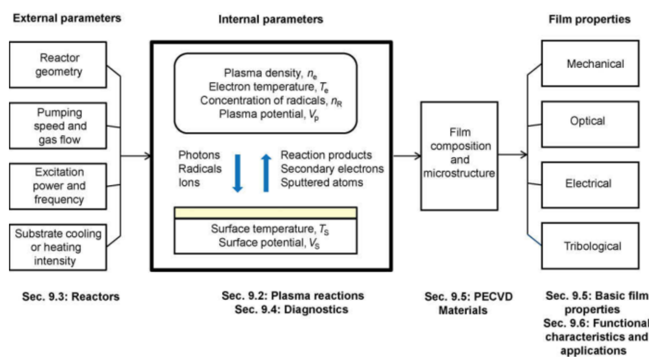

Figure.2 internal and external processes parameters in plasma enhance chemical vapor deposition (PE-CVD) method [8]

Film	Precursors system	Application
SiO2	SiH4+N2O	Dielectric[9]
a-Si	SiH4+H2	Solar cell, thin transistors memory switches[10]
GaAs	(CH3)3Ga, AsH3	Epitaxial layer[11, 12, 13]
a-Ca	CH4, acetylene	Thermal conductor, electrical insulator, mechanical hardness[14, 15, 16]

Table.1 some of precursors used in variety applications which was produced by plasma enhance chemical vapor deposition (PE-CVD) method [6]

Now the advantages and disadvantage have been discussed [6].

Figure.1 a. most of the sun is in a plasma state, b. the earth plows through the magnetized interplanetary plasma created by the solar wind, c. plasma at the birth of stars, d. gaseous nebula are plasma [4]

Advantages:

The main score of plasma enhance chemical vapor deposition (PE-CVD) method proportion other chemical vapor

deposition methods which has been caused this excellently from other chemical vapor deposition methods is that the deposition can occur at relatively lower temperatures. This ability lets me that used a lot of variety material as substrate for coating film for variety application. Hence the substrates which are sensitive to high temperature could even been used in this method. Instance for deposition Si_3N_4 film a temperature between 800 and 900C° is required in chemical vapor deposition process, however you shouldn't forgot that this temperature prevent using of thermally activated CVD to deposition Si_3N_4 on integrated circuit at final passivation layer because the metallization is Al(m.p.660C°). whereas in plasma enhance chemical vapor deposition method can deposit high quality of Si_3N_4 films in about 350C° using a mixture of SiH_4/NH_3 precursor as thermally activated which has been described by Smith et al[17].

Furthermore has an ability to deposit a film which has a significant amount of Hydrogen (above 10^{21} cm-3) in it and is happened with the deposition of SiN_xH_y films [17]. This Hydrogen amount present in the film will effective on the properties of film such as optical absorption edge, refractive index, electrical conductivity, etch rate and etc. the incorporation of Hydrogen can be minimized effectively using a mixture of NH_3/NF_3 as the nitrogen sources[18,19].

The deposition temperature in plasma enhance chemical vapor deposition can be lowered further by the use of metalorganic precursors (MOPECVD). Instance in a studied which has done by Rie et al [20, 21], deposition temperature has decreased from 450-550C° to about 140C° by using of metalorganic as precursor in the plasma enhance chemical vapor deposition method. Whereas for a similarly deposition in chemical vapor deposition(CVD) method a temperature about 900-1100C° requires, so this ability has widened the scope of substrate that can be used instance TiN, TiCN, ZrCN, ZrBCN, BCN [20,21]. Thus with expanded the solar energy the commercial plasma reactor was first developed in 1970 for the deposition of Si_3N_4 passivation layer [22] replacing the silicon oxide/metal packaging technology and allow to use of plastic packaging. With this ability which made able the scientists and producers for production in large scale with the reasonable prices caused that have been extended the applications this method (PECVD) in variety fields for example semiconducting, dielectric and metallic film to new application in clouding diamond [18, 23] deposition diffusion barriers, optical filters, abrasion resist that coating on polymer, powered coating and biomaterials [6, 24].

Disadvantages:

Productions that were produced by plasma enhance chemical vapor deposition method need a vacuum system to generate the plasma till finally the coating film been done. Whereas this method is very expensive because generation the plasma needs a vacuum system which its price is high. Another hand the more sophisticate reactor of generation of plasma is caused that becomes more the difficulties of this method.

The impurity of films were produced by this method is another problem. This impurity due to the incomplete desorption of product and inactivated precursor at low temperature, especially Hydrogen that remains presented into the films but it is benefit in some cases. Instance in Si coating which is used in generating the sheets of the solar cells. Hydrogen impurity in these sheets is caused increasing the optical properties of the solar cell, so that is useful in this section [6, 23].

II. SUMMERY

according to this paper that plasma enhance chemical vapor deposition (PE-CVD) method is the most common and best mean to producing the solar sheets because in this method could been coated the Si films at the lower temperature which is not damaged to the Si films and is very good method to production in large scale, however it is impossible in chemical vapor deposition (CVD) because this interaction in this method (CVD) done at the high temperatures about 800- 900C° which is decreased by plasma technique in plasma enhance chemical vapor deposition (PE-CVD) method till about 450-550C°, furthermore this temperature could been decreased with using of metalorganic as precursor (MOPECVD) to about 140C°, so this method is very suitable for production of solar sheets which is formed from Si on a substrate however coating Si in chemical vapor deposition (CVD) method at the high temperature (800- 900C°) has some problem that is pointed in advantage and disadvantage sections.

ACKNOWLEDGMENT

Many thanks from the Teachers of Dr.Chamran Nanotechnology institute.

REFERENCES

[1] A.Grzybowski, K.Pietrzak, J.E.Purkynje, (1787–1869), journal of neurology, springer, j neorol. 2014; 261(10):2048-2050
[2] M.J. Baldwin, M.P. Fewell, S.C. Haydon, S. Kumar, G.A. Collins, K.T. Short, J. Tendys, Rf-plasma nitriding of stainless steel, Surface and Coatings Technology, Volume 98, Issues 1–3, January 1998, Pages 1187-1191
[3] Paul M. Bellan, Fundamentals of Plasma Physics
[4] Francis F. Chen, Jane P. Chang, Lecture Notes on Principles of Plasma Processing
[5] I. H. Hutchinson, Principles of Plasma Diagnostics, second edition, Cambridge
[6] K.L.Choy, Chemical vapour deposition of coatings, Progress in Materials Science, Volume 48, Issue 2, 2003, Pages 57–170
[7] Werner Kern, Thin Film Processes II, edited by John L. Vossen, Werner Kern
[8] L. Martinu, J. E. Klemberg-Sapieha, O. M. Küttel, A. Raveh and M. R. Wertheimer, Critical ion energy and ion flux in the growth of films by plasma-enhanced

chemical-vapor deposition, J. Vac. Sci. Technol. A 12, 1360 (1994)

[9] AC Adams, DE Aspnes, BG Bagley, Method for producing devices comprising high density amorphous silicon or germanium layers by low pressure CVD technique, US Patent 4,357,179, 1982

[10]M. A. Blesa, A. J. G. Maroto, S. I. Passaggio, N. E. Figliolia, G. Rigotti, Hydrous zirconium dioxide: interfacial properties, the formation of monodisperse spherical particles, and its crystallization at high temperatures, Journal of Materials Science, December 1985, Volume 20, Issue 12, pp 4601-4609

[11] T. J. Donahue and R. Reif, Silicon epitaxy at 650–800 °C using low-pressure chemical vapor deposition both with and without plasma enhancement, J. Appl. Phys. 57, 2757 (1985)

[12]WR Burger, TJ Donahue, LR Reif, Growth of epitaxial films by chemical vapor deposition utilizing a surface cleaning step chemical vapor deposition, US Patent 4,579,609, 1986

[13]C.Rosenblad, H.R.Deller, A.Dommann, T.Meyer, P.Schroeter and H.von Känel, Silicon epitaxy by low-energy plasma enhanced chemical vapor deposition, J. Vac. Sci. Technol. A 16, 2785 (1998)Top of Form

[14] W.Kulisch, C.Popov, S.Boycheva, L.Buforn, G.Favaro, N.Conte, Mechanical properties of nanocrystalline diamond/amorphous carbon composite films prepared by microwave plasma chemical vapour deposition, Diamond and Related Materials, Volume 13, Issues 11–12, November–December 2004, Pages 1997-2002

[15] Chiranjeev S. Kalra, Alexander F. Gutsol, and Alexander A. Fridman, Gliding Arc Discharges as a Source of Intermediate Plasma for Methane Partial Oxidation, IEEE Transaction on plasma science VOL. 33, NO. 1, FEBRUARY 2005

[16] Kuniko Urashima and Jen-Shih Chang, Removal of Volatile Organic Compounds from Air Streams and Industrial Flue Gases by Non-Thermal Plasma Technology, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 7 No. 5, October 2000

[17] Donald L. Smith, Andrew S. Alimonda, Chau-Chen Chen, Hsing C. Tuan, Reduction of charge injection into PECVD SiNxHy by control of deposition chemistry, Journal of Electronic Materials, Jan-1990, Volume 19, Issue 1, pp 19-27

[18] Rhett E. Livengood, Mark A. Petrich, Dennis W. Hess and Jeffrey A. Reimer, Structure and optical properties of plasma-deposited fluorinated silicon nitride thin films, J. Appl. Phys. 63, 2651 (1988)

[19] Chorng-Ping Chang, Daniel L. Flamm, Dale E. Ibbotson and John A. Mucha, Fluorinated chemistry for high-quality, low hydrogen plasma-deposited silicon nitride films, J. Appl. Phys. 62, 1406 (1987)

[20] K.-T. Rie , A. Gebauer, J. Wöhle, Plasma assisted CVD for low temperature coatings to improve the wear and corrosion resistance, Surface and Coatings Technology, Volumes 86–87, Part 2, 15 December 1996, Pages 498–506

[21] K.T. Rie, A. Gebauer and C. Pfohl, Deposition of Boron Containing Coatings Using MO-PACVD Process to Protect Aluminium Casting Tools, J. Phys. IV France, Volume 05, Number C5(637-645), Juin 1995

[22]w.kern, Rs rosler, Advances in deposition processes for passivation films, Journal of Vacuum Science and Technology,Volume:14 Issue:5, Sep 1977

[23] Karl E. Spear, John P. Dismukes, Synthetic Diamond: Emerging CVD Science and Technology, Electrochemical Society series

[24] Jansen F. In: Glocker DA, Shah SI, editors, Handbook of thin film process technology. Bristol (UK): IOP; 1995.