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THIN FILM DEPOSITION DURING POLYATOMIC ORGANIC GAS PLASMA DECOMPOSITION

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ABSTRACT
Low pressure gas plasma is a technique for material processing. Plasma polymerization are extensively used in many industrial process. In present investigation organic gas plasma is produced where energetic electrons have high probability of causing ionization and excitation event when colliding with heavier particles. Generation of these particles and their interaction with surfaces in growing films are important due to importance of plasmas in material science. In present investigation amorphous carbon films have been grown on different substrates by Plasma CVD process. Film properties have been studied as a function of plasma parameters like electron temperature, electron density etc. It has been observed that film characteristics can be controlled by controlling the plasma parameters.

KEY WORDS: Thin film, Diamond like carbon Film (DLC), Plasma polymerization .

INTRODUCTION

Thin film deposition by plasma polymerization is well known. Non-thermal low pressure plasma which contains organic compounds is used for thin film deposition. The hard hydrogenated amorphous carbon film (C:H) presently known as diamond like carbon film (DLC) possesses unique combination of useful properties such as hardness, optical transparency over a wide range of wavelengths , high thermal conductivity, low electrical conductivity, chemical inertness to both acids & alkalies and lack of magnetic response (Angus J.C. *et al.* 1988). Due to many useful properties a C:H films are used for corrosion protection and diffusion barrier. In general a C:H film contains predominantly carbon and varying amount of hydrogen which depends upon the film preparation conditions (Akhavan, Behnam; et al. 2013). In present paper thin film deposition on Aluminum, Copper, Stainless steel and silicon substrate are reported. It has been observed that carbon films can be deposited during plasma decomposition of polyatomic organic gases (Clausing R.E *et al.* 1991). The thickness and surface characteristics can be controlled by controlling plasma parameters.

EXPERIMENTAL DETAILS

Among various existing techniques ac/dc plasma glow discharge technique has been of radius 2 cm were fitted inside the chamber.. In present work production of controlled low pressure of the order of 10^{-3} torr was made by a rotary oil pump .The vacuum chamber was made of pyrex glass of radius 10 cm and length 25 cm sealed with Orings at its ends. Separate inlet and outlet were made to connect vacuum pump, vacuum gauge, gas inlet, gas outlet etc. Electrodes made of substrate like aluminium, copper, stainless steel, glass etc were fitted inside the chamber. Johnson's double probes were also fitted in the chamber diametrically opposite to the electrodes. The glow discharge plasma was created between the electrodes using voltage ac/dc field. The discharge currents and voltages were measured with the help of VTVM. Organic gas vapors were produced separately and introduced inside the chamber using on-off valve when required. Vapors of methanol, ethanol, propanol and butanol were used along with benzene (Noeske, 2004, Akhavan, Behnam *et al.* 2013, Ramiasa, et al. 2015). Measurement of electron temperature and densities were made with help of Johnsons double probe method.

The chamber was first evacuated to a pressure of the order 10^{-3} Torr with the help of a rotary oil pump. Before passing organic gas, nitrogen gas was passed through the chamber for at least 10 minutes, so that oxygen molecules were completely replaced by nitrogen molecules. The organic gas were introduced inside the chamber through a

precisely controlled needle valve. Measurements of electron temperature, density and film thickness were made for different discharge parameters. The surface characteristics of electrodes were also investigated. The experiment was repeated for different set of electrodes and for different organic gases.

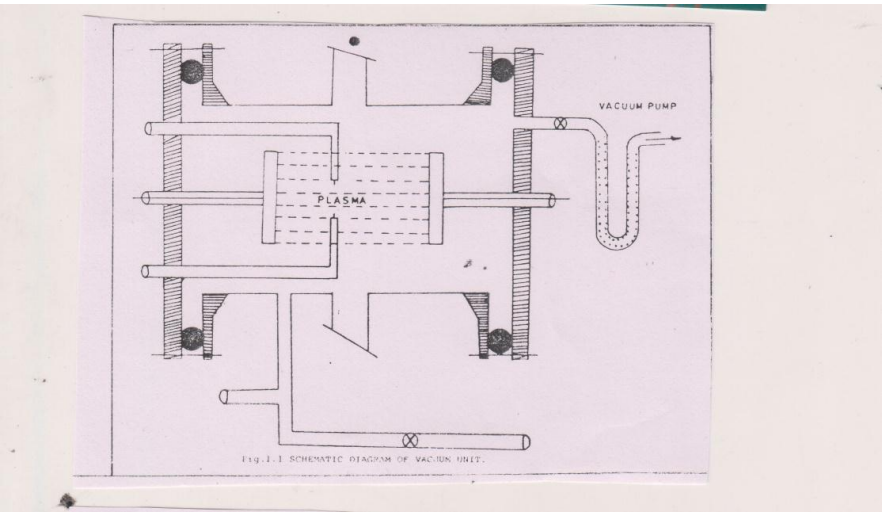

Fig . 1 Schematic Diagram of Vacuumc Uint

TABLE -1.1 Gas Used- Butenol + Benzene

S.No.	Electrode Material	Discharge Voltage (Volts)	Discharge Duration (Mins.)	Film thickness (Å)
1	Copper	620	5	120
		640	5	140
		660	5	170
		680	5	190
		700	5	220
2	Stainless Steel	620	5	60
		640	5	100
		660	5	130
		680	5	150
		700	5	170
3	Aluminium	620	5	120
		640	5	145
		660	5	170
		680	5	220
		700	5	260

TABLE -1.2

Flow : 5.6Sccm
Power : 10 Watts
Gas : Methane
Substrate used: Silicon

Sample No	Pressure (m Torr)	Self-Bias (Volts)	Deposition Rate (/sec)	Refractive Index	Hardness (Kg/mm^2)
1	75	–102.9	0.77	1.626	1057
2	140	–74.3	0.55	1.585	978
3	200	–72.6	0.44	1.534	1106

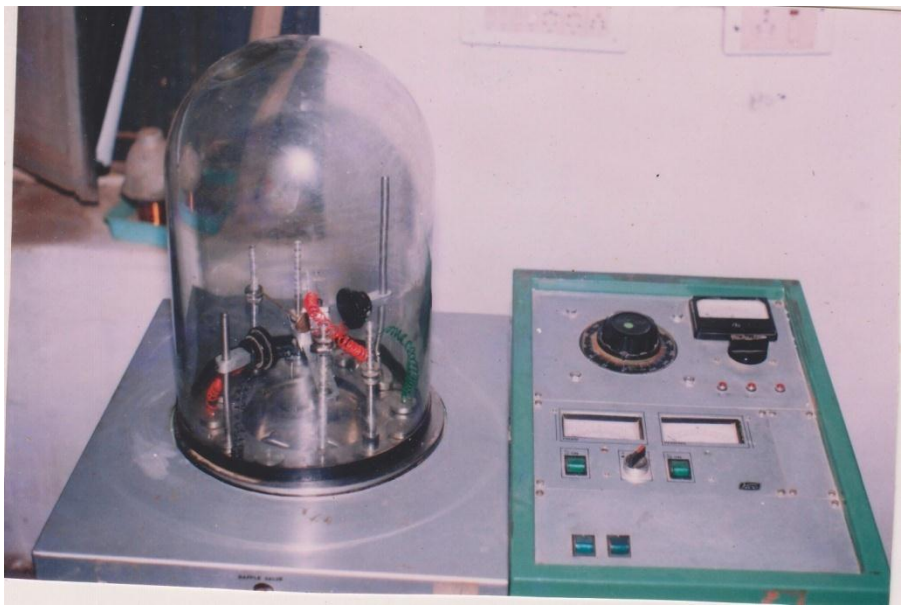

Fig .2 Photgraph of vacuumc unit

RESULTS

Polyatomic organic gas films grown by passing electrical discharge through vapours of methyl alcohol, ethyl alcohol, propyl alcohol, butyl alcohol etc. each mixed with benzene have been studied under controlled conditions. The following important results have been observed:-

1. Values of film thickness as a function of discharge voltage for aluminium, copper and stainless steel substrates are given in table 1.1
2. Table 1.2 presents the measurement of pressure, self-bias , refractive index , deposition rate and hardness of the film deposited on silicon substrate.

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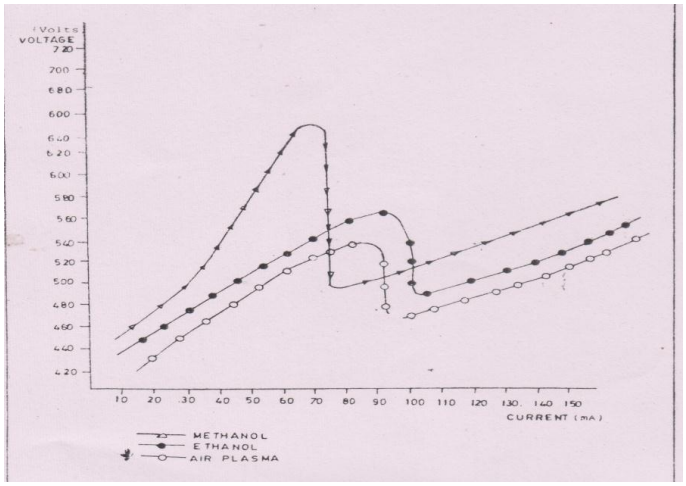

DISCUSSION

The phenomenon of ionization of polyatomic organic gas is not to that of monoatomic and diatomic gases.The higher hydrocarbons produce an extremely complicated array of ions. Investigation of elementary chemical processes inlow temperature plasma has been reported by various workers[3]. The full profile of ions present during discharge can be measured by secondary ion mass spectrometry. The values of electron temperature /density measured by double probe method gives the average values of those of different types of ions such as $C_6H_5^+$,$C_6H_4^+$, OH^-, $C_2H_2^+$ etc. present in plasma. The ions introduced during discharge may have different electron temperature/density .The deposition of ions on a given substrate depends on its electron temperature. In SIMS measurement, the sputtered species can be atomic ions (positive or negative, singly or multiply charged) or cluster.Relative counts of hydrogen, carbon, cluster, and hydrocarbon ions sputtered from the surface can determined by means of depth profiling. SIMS study shows that there can be three types of deposition the substrate. As reported in table 1.1 the film deposits on aluminium, copper and stainless steel seems to be polymer like films because of their low hardness and adhesion .whereas in accordance with the reports given in table 1.2 the film deposited on silicon and conducting glass are comparatively harder and hence can be diamond like carbon deposition.

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