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SOLID STATE CESIUM ION BEAM SPUTTER DEPOSITION

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ABSTRACT

The solid state cesium ion beam sputter deposition system has been developed for negative carbon ion beam deposition. The negative carbon ion beams are effectively produced by cesium ion bombardment. The C-ion beam current and deposition energy can be independently controlled for the deposition of a-D films. This system is very compact, reliable and high flux without any gas discharge or plasma and has been successfully used in the studies of the ion beam deposited amorphous diamond(a-D)

INTRODUCTION

direct matal ion beam process has been currently studied actively as a new approach to the synthesis and the modification of materials particularly using relatively low ion beam energies(10-300eV). Many promision results have been demonstrated using the direct io0n beam process because the kinetinc energy of the ion beam process provides a non-thermal equilibrium process. Under these highly non-thermal equilibrium deposition process produces films by kinetic bonding process which is distinct from the common place thermo-mechanical reaction[1-5]. However, most of the conventional ion beam sources use a gas discharge or plasma generated ion sources. These sources are limited by high deposition pressure, low flux, cdomplicated apparatus, impurities, poor control, unable to operate in the low energy region(10-300eV).

A soild state cesium ion beam sputter deposition system was developed by utilizing a solid state cesium ion source(SKION, CS02) as a primary ion source[Fig. 1]. Direct cesium ion bombardment from the soild state ion source can effectively produce negative ion beams with a negative ion yield of 0.1-0.5[6~7]. Thus, this system is very reliable and high-flux as compared to other sputter type where a plasma generated Xe is sputter-producing the negative ions from the cesium vapor-covered target[8].

A schematic diagram of the system is shown in Fig. 1. Design aspect of the nega-

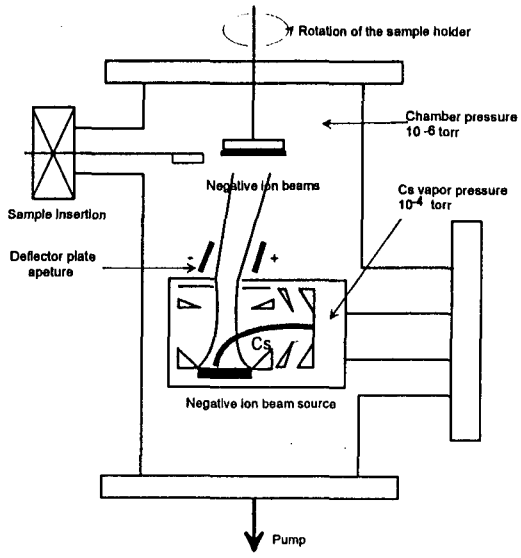

Fig. 1 Schematic diagram of solid state cesium ion beam sputter deposition system.

tiveion source and the deposition of the amorphous diamond (a-D) films are presented in this paper. Since solid state cesium ion beam sputter deposition process is forming materials with high kinetic energy of metal ion beams and the ion beam energy and current can be accurately controlled we are currently using this system for the several research projects such as : formation of carbon nitride films, deposition of polycrystalline silicon films at lower processing temperature than used for conventional chemical vapor deposition and deposition of cesited amorphous diamond films for field emission.

DESIGN OF THE ION SOURCE

The negative ion source utilizes a solid state cesium ion gun. The cesium ion gun consists of a cylindrical solid state cesium ion source heated by a tungsten filament and an electrode system[9-11]. The solid state cesium ion source in alumino-silicate based zeolite which contains cesium. This material is an ionic conductor. A small voltage applied across the pellet produces a Cs^+ ion current flowing through the pellet. The gun produces a cesium ion beam of 1 at 5kV extraction voltage. This sputter ion gun has several unique features setting it apart from the move common gas source ion guns. Since it reauires no gas supply; it can operate in high vacuum using with turbomolecular pump. In high vacuum operation, the sputtered atoms are not losing their energy in gas collisions, They arrive on the substrate with their energy which ranges from 10 to 300eV.

Electrodes of the C^- ion source is designed by the PC based ion trajectory code, "SIMION"[12]. Fig. 2 shows the ion trajectories as computed with the SIMION code. The geometry of the extraction electrode(top electrode) and the beam forming electrode(bottom electrode) of the C^- ions is designed in a way that the electrodes are extracting C^- ion beams as well as deflecting the primary Cs^+ ion beams to the graphite target. Thus, the extracting field is determined by the necwssary deflecting field for the primary Cs^+ ion beams to be properly aimed at the graphite target as seen in Fig. 2. the deposition energy of the C^- ion beams are independently controlled by the energy control electrode.

DEPOSITION OF A-D FILMS

a-D(amorphous diamond) films are deposited on silicon substrates by solid state cesium ion beam sputter system. The deposition energy of the C^- ion beam is controlled by the potential across the graphite target relative to substrate. The primary Cs^+ ion cur-

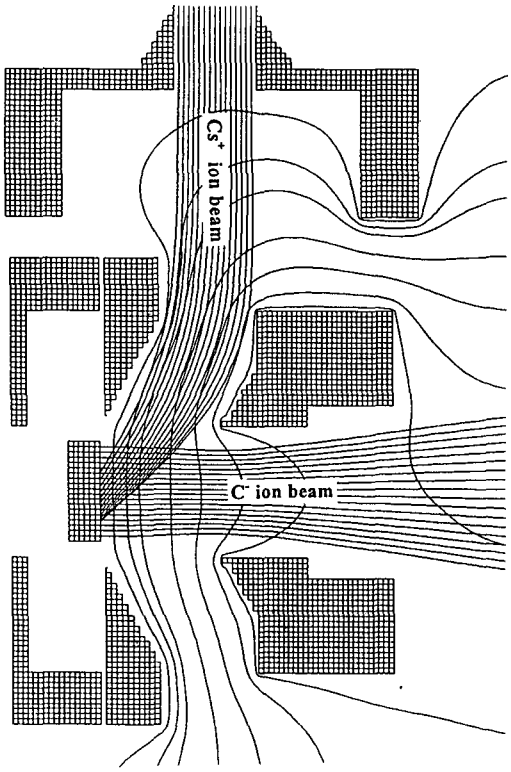

Fig. 2 Computer calculation of the deflection of the primary of Cs^+ ion beam and emission of the negative ion beam(SIMION code)

rents are independently controlled by a biasing current applied across the cesium solid electrolyte source and supplying the cesium to the emitter surface of the Cs^+ ion gun. The important feature is that the primary Cs^+ ion currents can be controlled independently on the extraction potential, which controls the C^- q ion currents without changing the extraction potential. The extraction energy for the primary Cs^+ ion beams is set to be of 4kV which determines the potential for the rest of the electrodes. The independent controllability of C^- ion current and deposition energy is the major advantages of soild state cesium ion beam sputter deposition syst as compared to the other gas discharge type ion sources.

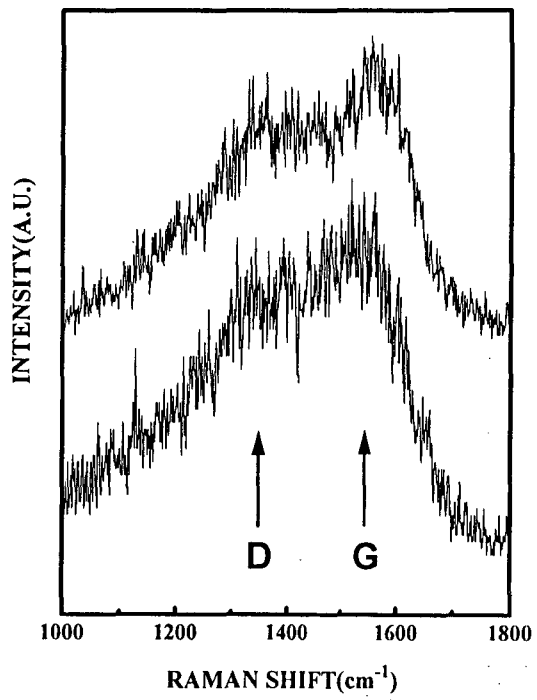

Fig. 3 Raman spectrum of a-D films deposited at C^- ion beam energy 80eV the solid state cesium ion beam sputter deposition system on silicon substrate.

The a-D films were transparent. Fig. 3 shows the Raman spectroscopy of the a-D films for various deposition energy. There are two main features : (1) G peak at $1580cm^{-1}$, (2) D peak at $1350cm^{-1}$ arisen from scattering by disorder.

CONCLUSIONS

Solid state cesium C^- ion beam sputter deposition system was developed and used to deposit the a-D films. The ion current and deposition energy can be independently controlled for the deposition of a-D films. This system is very compact, reliable and high flux without any gas discharge or plasma and has been successfully used in the studies of the ion beam eposited a-D films.

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