Lonsdaleite Diamond Growth on Reconstructed Si (100) by Hot-Filament Chemical Vapor Deposition (HFCVD)

Abstract

In this paper, the growth of Lonsdaleite diamond using hot-filament chemical vapor deposition (HFCVD) on flashed and reconstructed Si (100) is reported Surface morphology studies using seaming electron microscopy (SEM) show that the film is composed of decahedron and icosahedron diamond particles. The X-ray diffraction (XRD) pattern has a strongest peak at 47° and a peak at 41°. which is indicative of Lonsdaleite nature of the grown diamond film. The Raman spectrum of the film shows a broadened diamond peak at wave number of 1,329 cm^{-1}, which has shifted towards the peak position corresponding to Lonsdaleite nature of the diamond (1.326 cm^{-1}).

INTRODUCTION

Smce the detamination of X-ray structure of the diamond it has been known that the diamond is a tetrahedral network of carbon atoms and these atoms are arranged in a cubic lattice. Furthermore, it is also well known that there exist two isomers of diamond i.e., the cubic diamond and the hexagonal diamond (also called Lousdaleite). The Lorisdaleite diamond is found only in the bulk natural diamond It has broadbands and is mostly observed in shock wave produced diamonds. The peaks in the Raman spectra are positioiied in the wave number range fioin 1.315 to 1.326 cnf‘. In fact ianous amorphous metastable and phases of carbon such as diamond. nano-tube. and fulleiene like C6, can exist: and most oftlem have been grown under non-theiinal equihbrium conditions [Spear and Dismukes. 1993]. Diamond is a metastable form of carbcn compared to graphite at low pressure gowth The structure of graphite was fomied by twolayer stacking sequences . . . .offlat hexagonal (0001) carbon atonnc planes. but diamond strumure was formed by three-layer stacking sequences ...ABCABCABC...of the same hexagonal,but puckered (111) carbon atomic planes. It has been reported that the Lonsdaleite diamond is detected in meteorities. Although Lonsdaleite was found in bulk diamonds of meteorities. but it is not clear

whether it exists in the C VD diamond [Lawrence and Kania. 1995]. In thenml equilibrium conditions. The diamond phase is stable under a high temperature of about 2300 ‘C and high pressure of about 40-50IGar. But under a normal chemical vapor deposition (CVD) growth conditiort ie.. under a low pressure of a few tens Torr; the nucleation and growth of diamonds can occur in non-equilibrium conditions, and hence the nucleation and growth will be controlled by kinetic laws rather than by thermodynamics. However, because of relatively large surface free energy of diamond and its small lattice constant compared to other semiconductors, diamond nucleation on semiconductor or non-diamond substrates is hardly achieved [Wurzinger et al. 1996]. Therefore, various methods of nucleation enhancement. i.e.. mechanical scratching (or guiding) and bias enliaiicenieiit nucleation (BEN), surface carburization, ion-implantanon, use of carbon seeding layer, etc. are used [Yugo et al._ 1991; Stnner er al., 1993]. The property of CVD-diamond strongly depends on the nucleation enhancement method and the depositing parameters. Therefore, such flexibility of CVD techniques can enable us to produce the CVD diamond film with various structures, properties and qualities. To our knowledge, reports are not available for the growth of Lonsdaleite diamond except the work of Lee et al. [1998] reporting die growth of Loitsdalate-lilre Carbon using HFCVD. In this paper, we report the evidence of the Loiisdaleite diamond grown by HFCVD on clean (flashed and reconstructed) Si (100) at specific deposition condition based on SEM, XRD and Raman spectroscopy results.