高強度パルスイオンビームによる薄膜生成・表面改質技術

研究代表者　理工学研究部(工学)　升方　勝己
非常勤研究員　Hamid Reza Yousefi

1 Introduction

SiC is a promising material for Si substitution in microelectronics industry, especially in high-power, high frequency and high temperature devices due to its wide bang gap and high breakdown field. Compared with Si (operating temperature ≤250 ◦C), SiC is an excellent material for devices operating at high temperatures (600 ◦C or higher). Moreover, it has been demonstrated that both surface and bulk leakage in SiC devices can be reduced to much lower levels than that of the silicon. In recent years, methods like molecular beam epitaxy, chemical vapor deposition (CVD), sputtering, and ion implantation have been developed to prepare SiC films. Traditionally SiC layer is formed on the surface of a Si substrate by carbonization reaction between the supplied gases and the Si atoms. However, the Si atoms from the substrate diffuse and reach the top of the SiC growing surface, which results in defect formation at the Si–SiC interface. Instead the energetic carbon ion irradiation is used for carbonization reaction.

2 Experiment and results

In this report we have used a dense plasma focus device. Plasma focus (PF), when used as a pulsed plasma device for thin film deposition, has some special features with respect to other methods including high deposition rate, energetic deposition process, which assist the film deposition under a reactive background gas pressure. Commercially available one sided polished Si (100) wafer was cut into square shape biscuits of 15 mm ×15 mm and then was cleaned ultrasonically in acetone. The substrates were blown-dry and then set into the chamber at angular position and different axial positions with respect to the anode axis, r = 100 mm, Z = 50, 90, 130, 170 mm, respectively. High purity graphite was inserted into the hollow type anode as a target and covered the surface of anode at the same time, which effectively avoid the impurity from anode depositing onto the substrates. After PF system reaches the optimum condition, ten fires were chosen for SiC formation. In this experiment, relativistic electrons emitted from PF were used to ablate the graphite target and form the carbon ablation plasma. The ionic, atomic, and molecular carbon species in the ablation plasma offered good carbon ion source for SiC formation. The as-deposited samples were later investigated by X-ray diffractometer (XRD, XRD-6000, Shimadzu), Fourier Transform Infrared Spectroscopy (FTIR,

IRPrestige-21, Shimadzu).

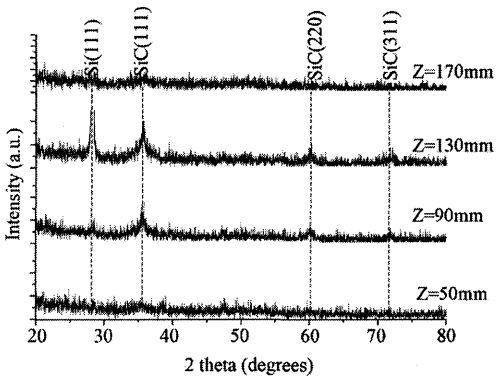

Fig. 1. XRD patterns of samples deposited at different positions.

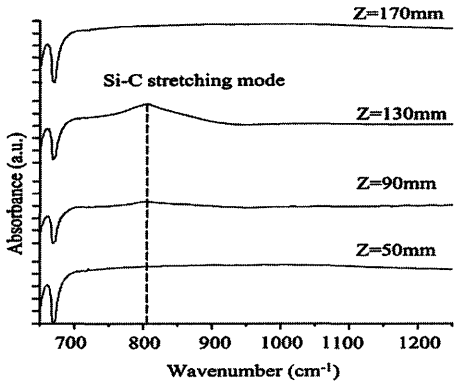

Fig. 2. FTIR spectra for samples deposited at different positions.

In the Fig.1.Three XRD peaks were observed at 2θ = 35.6, 60.0 and 71.7°, corresponding to (111), (220) and (311), of 3C–SiC, respectively. In addition, all the peaks are not very sharp which indicates that amorphous carbon was also formed in the films that causing to broaden the XRD peaks.FTIR spectra of the samples at different positions are shown in Fig.2.The dominant band appearing at around 800 cm^{-1} in the film at the position of Z = 90, 130 mm corresponds to the stretching mode of Si–C vibration.SiC was fabricated on Si (100) substrates using a 20 kJ PF device operated in Hydrogen gas at room temperature. All the results showed coherent conclusion. XRD and FTIR results show that polycrystalline 3C–SiC were formed at the position of Z = 90, 130 mm. SiC was fabricated on Si (100) substrates using a 20 kJ PF device operated in Hydrogen gas at room temperature. All the results showed coherent conclusion. XRD and FTIR results show that polycrystalline 3C–SiC were formed at the position of Z = 90, 130 mm.