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Deposition of SiC Thin Films and Carbon Tips Growth onto SiC Thin Films for NSOM Applications

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Abstract

In this research, we have tried to find the most suitable deposition conditions of SiC thin films as materials for NSOM applications. First, SiC thin films were deposited on Si(100) based cantilever substrates by MOCVD method in high vacuum condition(2.0×10^{-7} Torr) using 1,3-disilabutane as a single source precursor which contains silicon and carbide in 1:1 ratio at various temperature in the range of 700 ~ 1000 °C. Second, a high resolution of probe carbon tips on the SiC coated cantilevers was achieved using electron-beam deposition in a carbon atmosphere. The SiC thin film was deposited epitaxial growth at 950 °C which have carbon rich for silicon and carbon at 1:1.2 ratios. AFM images result show that the SiC thin film has smooth surface at rms = 20nm. We realized that with increasing acceleration voltage and probe current the height of the carbon tips as well as the base diameter are also increased simultaneously.

1. Introduction

In recent years, nanotechnology has become widely aplied in the life sciences, electronics and optoelectronics where it has come to play an increasingly important role. Silicon Carbide is a material with remarkable potential for applications in nanotechnology [1, 2]. Single crystalline SiC thin film has attracted much interest for use in electronic and optoelectronic devices, and circuits designed to operate at high powers, high frequencies, high temperature and high radiation environments. In particular, SiC has a wide band gap of 2.2 eV for the 3C (β)-SiC, at room tem-perature, and has been exploited for SiC-Si heterojunction bipolar transistors [3-5]. AFM cantilevers must satisfy the following conditions to be very important element that decides resolution and gets high resolution: (1) low spring constant; (2) high resonant frequency; (3) radius of curvature is small and sharp tip; (4) small opening angle. Considerable interests have been in fabricating a sub-wavelength aperture for a near field optical sensor due to its potential application for promising near field optical recording and other biological applications.

In this research, we tried to get high quality SiC thin film deposited Si(100) based cantilever substrates using single precursor 1,3-DSB without carrier gas and bubble gas. And we fabricated the small aperture for the better performance such as less noise, higher resonant frequencies and fast imaging. Also, we are gone to manufacture carbon tips which can apply to NSOM by electron-beam deposition method.

2. Experimental details

The epitaxial silicon carbide thin films were grown in a homemade thermal high vacuum metal organic chemical vapor deposition system. The Si(100) based tip-less cantilever was used as a substrate for the growth of the silicon carbide films in this work. Prior to the growth, the substrates surface was degreased in an ultrasonic cleaner containing acetone for 10 min, DI water for 10 min, dipped in 10 wt% HF solution for 15 sec, rinsed in DI water, and flushed in nitrogen flow. The substrates were resistively heated by a DC power supply, and the temperature of the silicon sub-strates was measured with an optical pyrometer through a 4.5 in viewport in the chamber wall. The general deposition conditions are high vacuum pressure (1.0×10^{-7} ~ 5.0×10^{-6} Torr), various temperatures (700 ~ 1000 °C). The 1,3-Disilabutane was employed as a single source for the growth of the silicon carbide films. 1,3-DSB has some ad-vantages over the conventional single sources. 1,3-DSB al-ready has an Si-C bond in the precursor itself, it does not need a further activation energy to make a Si-C bond in the film. Therefore the deposition can be conducted without carrier and bubbler gas for a liquid phase precursor at room temperature. It was transferred into a precursor bottle at-tached to deposition chamber and further purified by freeze-pump-thaw cycles using liquid nitrogen. 3C-SiC films were deposited directly on the clean silicon (100) surface without the carbonization process. The deposition time for Si (100) substrates continued throughout various hours and the growth rate changed depending on the experimental conditions. In this work, we were used different deposition condition, respectively.

3. Results and discussion

The XPS result shows that the SiC thin film grown at 950 °C which have carbon rich for silicon and carbon at 1:1.2 ratio. XRD result shows that the SiC thin film grown at 900 °C which appeared at 2 = 41.6° for SiC (200) reflection at a large intensity and a single shape diffraction peck. SEM images result show that the SiC thin film grown at 900

°C which has influence on the small grain size and single crystallinity. AFM images result show that the SiC thin film has smooth surface at RMS = 20nm.

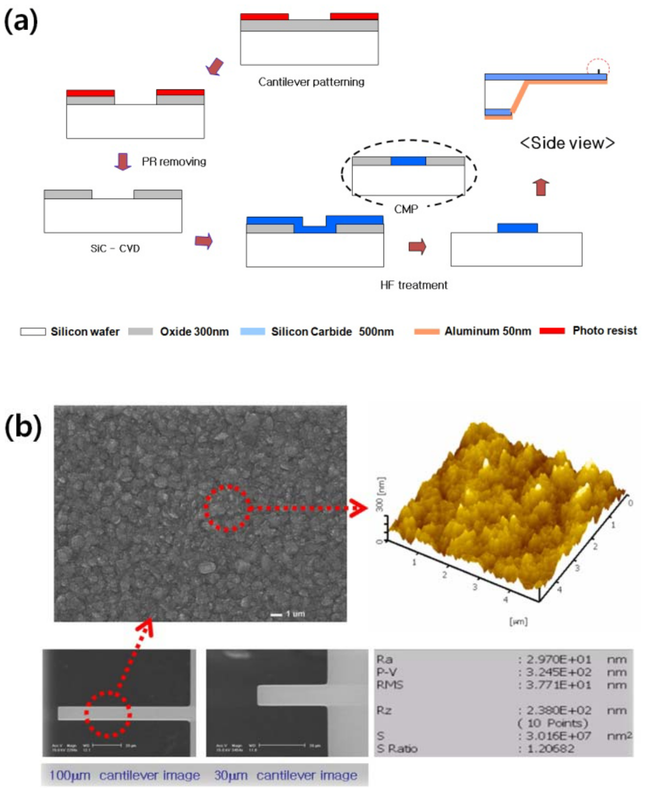

Fig. 1. Fabrication procedure of SiC AFM cantilever (a) and SEM and AFM images of SiC cantilever (b).

Figure 1(a) shows a schematic diagram of the basic fabrication process that applied in this study for making cantilever and nano-aperture array using SiC and SiO_2 thin films grown on Si(100) wafers with 500 μm thickness. Figure 1(b) shows SEM image of the SiC cantilever deposited on Si using 1,3-disilabutane as a single source precursor at 900 °C in 2.0 × 10^6 Torr. This study is basic study for MEMS and NSOM application. SiC thin films deposited on Si cantilever have smooth surface (RMS = 37.7 nm). It is very important factor in the AFM cantilever application. SiC deposited on Si cantilever have better advantages low spring constant, high resonance frequency and small opening angle of Si3N4 used AFM cantilever and NSOM aperture array.

4. Conclusion

The sub-wavelength size silicon oxide aperture array as a near field optical probe was fabricated in order to examine the possible light resonance-tunneling phenomenon. We used various semiconductor fabrication processes including anisotropic Si etching using 20 wt% TMAH alkaline solution and isotropic HF etching technique to open the nano-size pyramidal oxide apertures. HF etching time was proved to be a control parameter for the aperture-opening rate. In this experiment, we studied oxide etch rate is not constant but depends on etch time. Also, deposition thickness of metal such as Al was probed to be a control parameter for the aperture-closing rate. The optimum deposition condition of the epitaxial SiC films was found the deposition pressure of 2.0 × 10^{-6} Torr for 2 hours under the deposition temperature of 900 °C. Finally, SiC thin films deposited on Si cantilever will be making better than AFM cantilever made using the Si_3N_4 film.

Acknowledgements

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