Multilayer SiC/C Thin Film Coating on Fiber Tip for Raman Probe Application

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Multilayer SiC/C Thin Film Coating on Fiber Tip for Raman Probe Application

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Abstract. A novel technique in the fabrication of an optical filter that is made up of multilayer thin film is introduced in this study. Multiple layers of silicon carbide and carbon with high and low refractive index materials respectively will be deposited alternatively with a various thickness on a glass substrate by radio frequency magnetron sputtering of 99% purity of silicon carbide as the target. The variation of structure and optical properties of the films are studied by using X-ray reflectivity (XRR), Raman scattering spectroscopy, and UV–vis-NIR spectroscopy until it reached the desired results and meet the specification as Raman optical filter. The thin film is then placed on a multimode fiber tip as Raman edge filter. Raman fingerprint of specific alcohol (ethanol) obtained is tested using a fabricated filter with the standard spectrum. The preliminary result of SiC thin film fabrication for 30, 60 and 90 minutes by sputtering process showed rate of deposition obtained is 3.17nm/min. The results demonstrate that the optical properties of silicon carbide thin film can be monitored by modifying the condition of silicon carbide and carbon deposition.

Keywords: Optical filter, thin film, Raman spectroscopy, Raman edge filter, fiber optics

1. Introduction

Chemical sensors have been widely used and offer a number of beneficial functions in industrial organizations such as food, educational [1], technology [2], environment and health [2-3]. Chemical sensor can be described as an analyser that gives reaction to analyte and transforms chemical input quantity to electrical signal and the process may take place in a selective or reversible way [4]. Over the years, chemical sensor has been classified into many types according to its particular working principle, such as electrochemical, optical, magnetic, thermal and mass.

Several contributions have been devoted in various technique of fabricating chemical sensor such as high temperature thin film platinum-based electrode [5], cerum (Ce)-doped zinc oxide (ZnO) nanorods [7], Graphene-metal oxide hybrid composites [6], radio-frequency identification (RFID) and near-field communication (NFC) [8], operational-amplifier-based multichannel oscillator [9], nano-particle embedded hydrogels [3] and crystalline 2D-cerium oxide nanoflakes [10].

Among numerous chemicals that being tested on, ethanol has attract quite interest from some researchers, according to that, a lot of studies on detection of ethanol been discovered. Recently, in 2019 a study on detection of ethanol concentration variations in gasoline–ethanol solutions [17] had been carried out. Several research and deeper studies also had been done to achieve the advancement of chemical sensor by developing the sensing material and technique in detecting ethanol. However, other researcher had found results from method detection of ethanol by fiber optics coated with material of high selectivity of ethanol had produce inconsistency in their peak shifts [11]. This is due to various surrounding factors influencing the detection during the experiment, such as temperature, pressure, sample concentration. Therefore, the interpretation becomes more complex [12]. Raman spectroscopy technique using a Raman probe give the advantage to solve this complexity due to detection based on the fingerprint. In Raman spectroscopy, each compound gives a unique Raman pattern without influenced by other factors such as temperature, humidity, pressure and concentration of the mixture. SiC is a good candidate due to its special properties in designing Raman edge filter using quarter-wave stack approach. However non-Raman edge filter had been reported have been fabricated on fiber optic tip. Therefore, this research aims to fabricate Raman edge filter on multimode fiber tip to detect ethanol.

2. Experimental Work

Figure 1 shows the schematic diagram of RF magnetron sputtering. The major part consists of a vacuum deposition chamber and control panel. The deposition chamber consists of magnetic and non-magnetic gun target holder and the substrate holder. Table 1,2 and 3 are used to set the working parameters in the vacuum chamber during the first three deposition process in order to get the deposition rate.

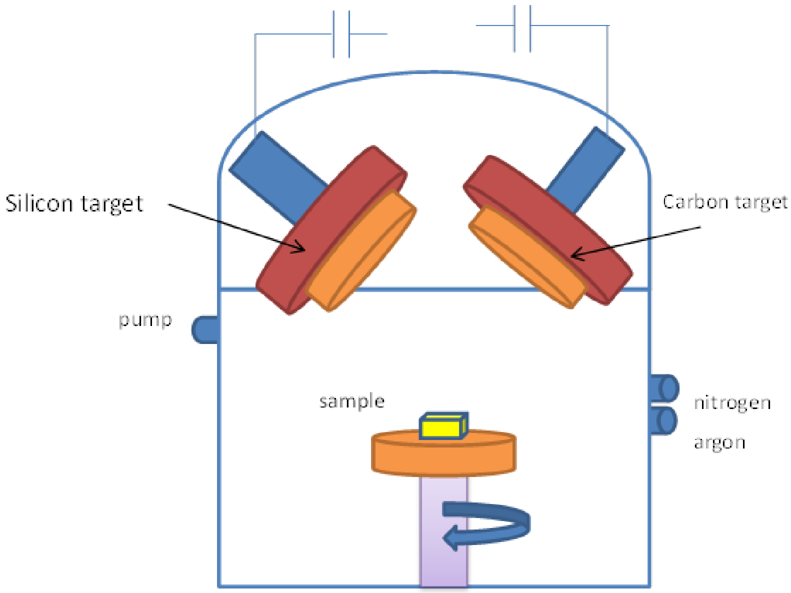

Figure 1. Schematic diagram of RF magnetron sputtering

2.1. Sample Preparation

Silicon wafer is used as substrate, and it is cut into 10x10mm. The substrate will undergo a cleaning process. Firstly, substrate will be washed with deionised water and then immersed in acetone while undergoing ultrasonic bath and then finally dried with nitrogen gas.

2.2. Growth Parameters

The deposition process are done for all three samplers at 30,60, and 90 minutes respectively. RF power was set at 200W, and carrier gas flow is set at 50sscm for every sample. The growth for all sample is held at room temperature. Table 1 shows the growth parameter applied during the deposition process.

Table 1. Growth parameter for all sample

Sample	Target Material	Temperature (^{0}C)	Electron Distance (cm)	Argon (sscm)	Power (watt)	Deposition time (min)
30min	SiC	Room temp	6.5	50.00	200	30
60min	SiC	Room temp	6.5	50.00	200	60
90min	SiC	Room temp	6.5	50.00	200	90

3. Discussion

XRR was used to study the thickness of all samples. Figure 2(a), 2(b) and 2(c) show and the data obtained, and its best-fit XRR curve for 30, 60 and 90 minutes sample respectively, the blue lines represent theoretical curve while the black lines represent the experimental curve. The thickness measured for 30min sample is 95.10nm. Figure 2(b) shows the curve for 60min sample; the thickness measured is 190.20nm. Figure 2(c) shows XRR curve for 90min sample. The thickness measured is 285.32nm. Figure 4 shows a sample profile in the thin layer. It was observed that other than SiC layer was formed during the deposition process, which included SiOC and SiO2.

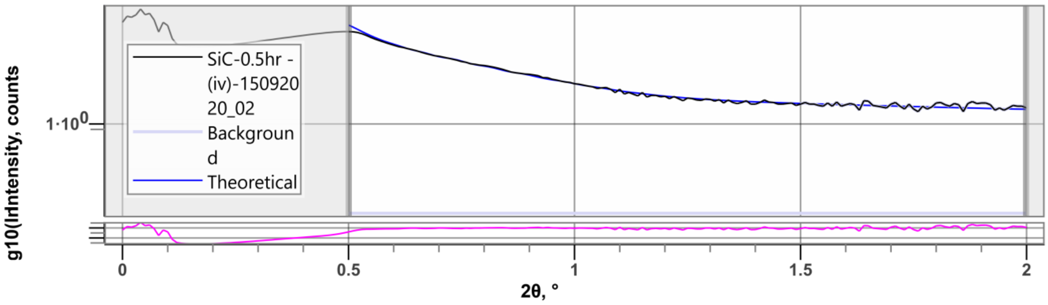

Figure 2(a). XRR curve for 30 min thin film sample

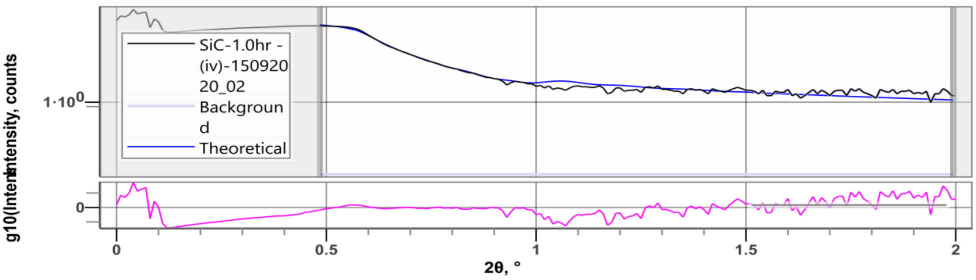

Figure 2(b). XRR curve for 60 min thin film sample

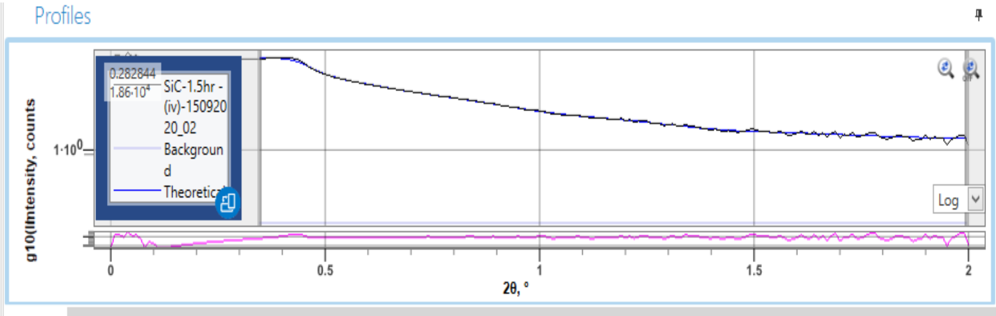

Figure 2(c). XRR curve for 90 min thin film sample

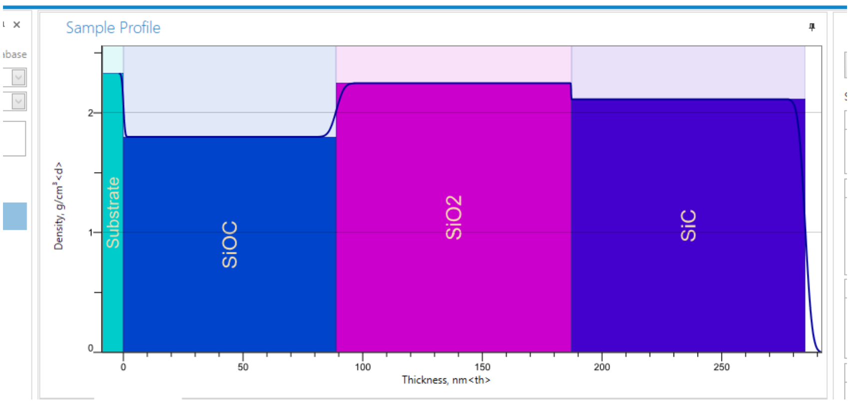

Figure 3. Sample profile of 90min thin film sample

4. Conclusion

XRR analyses of SiC thin films having different thickness prepared by RF sputtering at room temperature have been performed, varying the time of deposition. In this work optical filter for Raman application was proposed, the uniformity of deposition play a crucial role in making this study successful, thus rate of deposition is determined. The study shows the rate of deposition for SiC is 3.17nm/min.

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