Structural Analysis of Graphene Growth on Interdigital Electrodes Micro Supercapacitor for Biomedical Devices

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***Abstract*— Micro supercapacitor, specifically with interdigital electrodes design, has recently gained much interest in fields such as bioMEMS, biomedical implants, power electronic devices and high power applications due to its high charging capacity. Planar interdigital micro supercapacitor with the graphene growth via Plasma Enhanced Chemical Vapor Deposition (PECVD) with the different temperatures has been investigated in this works. In this works, the graphene growth on the interdigital electrodes was investigated in various temperatures from 400˚C to 1000˚C. The graphene growth structure on the interdigital electrodes of micro supercapacitor was characterized by Raman Spectroscopy. A Raman spectrum of graphene was observed on interdigital electrode have identified three peaks which is D band, G band and 2D band. Raman spectra show that the intensity ratio of the 2D band and G band at 1000˚C of 0.43 indicating a good quality of few layer graphene growth.**

Keywords—Micro supercapacitor, interdigital electrodes, PECVD, graphene growth, Raman Spectroscopy.

I. INTRODUCTION

Micro supercapacitor, specifically with interdigital electrodes design, has recently gained much interest in bioMEMS, biomedical implants and high power applications due to its high charging capacity [1]. Recently, many researchers focus on increasing the key performances of micro supercapacitor, namely capacitance, device safety and the charging speed. Graphene is one of the promising materials that could be used to increase micro supercapacitor performance due to its superior properties such as high electrical conductivity, good electrochemical stability and excellent mechanical behavior [2,3]. Graphene sheets are aligned on supercapacitor interdigital electrodes to increase the overall surface area of the electrodes.

II. MATERIALS AND METHODS

A. Materials

A single layer of graphene which has sp^2 hybridized carbon atoms is one of the promising material that has been used for micro supercapacitor electrodes due to several advantages such as high specific surface area, high thermal conductivity and high electron mobility. In this research, graphene growth on interdigital micro supercapacitor electrodes is expected to significantly improve the device's capacitance performance by increasing electrodes functional area.

B. Methodology

The direct graphene growth on interdigital electrodes by the PECVD process continued for 10 minutes at various temperatures from 400˚C to 1000˚C and at fix power of 40 Watt. Among the various techniques in graphene growth, PECVD is considered as one of the best process due to its advantages such as low operation temperature, lower chances of cracking on deposited layer and enhanced control of nanostructure patterning. For PECVD systems, methane (CH_4) is widely used as the carbon source. In PECVD systems, the parameters such as precursors, power of plasma and time play an important role to ensure a good quality of graphene to be grown. In this works, methane (CH_4) has been used as a precursor.

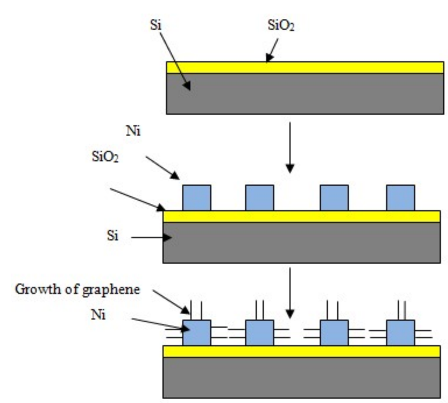

Figure 1: Graphene growth on planar interdigital micro supercapacitor

C. Characterizations

In this work, graphene growth structure was analysed using Raman spectroscopy, Atomic Force Microscopy (AFM) and

X-Ray Photoelectron Spectroscopy (XPS). Atomic Force Microscopy (AFM) was used to analyse the morphology of the growth layer on interdigital electrodes.

III. RESULTS AND DISCUSSION

A. Analysis of Graphene growth formation using Raman Spectroscopy

Raman spectroscopy is an important tool to identify the peaks in the graphene material which is D band, G band and 2D band. Raman spectrum of graphene excited by 532 nm. Based on Fig.2, we can see that a good quality of graphene was produced on the interdigital electrode micro supercapacitor due to low defect which is at D band. From the ratio of $I_{2D}/I_{G,}$ it shows few layer of graphene with good quality was formed.

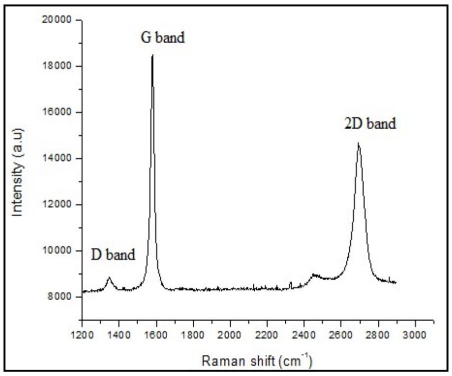

Figure 2: Raman Spectrum at growth temperature 1000˚C

B. Atomic Force Microscopy (AFM)

The AFM is one of the method for surface characterization which does not require sample preparation. From AFM image, we can determine the roughness of the surface via root mean square (RMS) value.

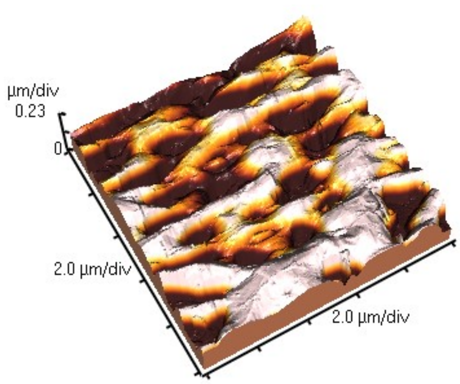

Figure 3: AFM image at a growth temperature 1000˚C

C. X-Ray Photoelectron Spectroscopy (XPS)

Fig.4 shows the XPS Spectrum of the graphene growth on a Ni seed layer. The C-C binding centered at 284.5 eV which indicated the sp^2 hybridized carbon. It was confirmed that graphene was presence on a Ni seed layer on interdigital electrodes micro supercapacitor.

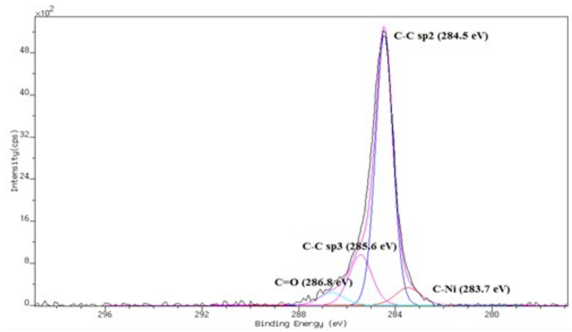

Figure 4: XPS Spectrum of a Carbon on a Ni seed layer

IV. CONCLUSIONS

In conclusion, we successfully produced a good quality of graphene at temperature of 1000˚C based on Raman spectroscopy results. From XPS data,the C-C binding centered at 284.5 eV which indicated the sp^2 hybridized carbon. It was confirmed that graphene was presence on a Ni seed layer on interdigital electrodes micro supercapacitor.

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